A

# MEMOIR

ON

# THE INDIAN SURVEYS;

BY

CLEMENTS R. MARKHAM, C.B., F.R.S.

(*SECOND EDITION*)



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# CONTENTS

## MAPS

# PREFACE

## TO THE FIRST EDITION

THE object of the present Memoir is to furnish a general view of all the surveying and other geographical operations in India from their first commencement, in order that, in reading reports of current work, ready means of reference to the previous history of each branch of the subject may be at hand. In case it should be desired to follow up an enquiry into the details of any particular operation or series of operations, the references in the foot notes have been made as copious as possible.

It has been difficult to bring together a complete record of the marine surveys in consequence of the destruction of documents, and it would have been impossible without the aid of several surveying officers of the Indian Navy, who kindly furnished me with the necessary information.* Nothing has been done for many years to continue and complete the admirable work of the surveyors of the Indian Navy, but this state of things cannot last, and it is hoped that, before very long, the section on Marine Surveys will be useful as a means of reference.

The history of the labours of Major Rennell and his fellow route-surveyors is particularly interesting, as the commencement of the vast operations of which they were the precursors. But their work is still extremely valuable in itself. For the decision of important points in physical geography, and of some engineering questions, it is necessary to compare surveys of the same place made at long intervals. The work done by Major Rennell in 1780 enabled Mr Fergusson in 1863 to argue from data, the absence of which would have left the question he was discussing in doubt, while the want of early observations on the Katiwar coast deprives the present tidal measurements of their comparative interest.

* Namely, Captains Jenkins, Lynch, Felix Jones, Selby, Constable, Taylor, Ward, Heathcote, Sweny, and Cruttenden, and Lieutenants Collingwood and Barker, Mr Marshall, and Dr Carter.

The narrative of the operations connected with the Trigonometrical and Topographical Surveys is an attempt to describe work, the immense value and interest of which admits of no dispute The main objects of these sections of the Memoir are to enable an enquirer to gain a clear and comprehensive idea of the scope and nature of the surveying operations, to furnish him with the means of prosecuting his researches further, and to enable him to refer at once to the previous history of any particular survey The account of the surveys is followed by a Section on the arrangements for the supply of instruments, which have been made by Colonel Strange It contains a brief description of his observatory in Belvidere Road, and some information respecting his plan of examining and testing instruments, and his system of obtaining them

I have endeavoured, in the section on the Geological Survey, to enumerate the writings of those earlier labourers in this field who did such excellent service before the commencement of the Government Survey, and to describe very briefly the operations of Dr Oldham and his accomplished colleagues since that period Besides supplying references to the volumes of the memoirs and records in which the accounts of the surveys are given, a perusal of the Section itself will give a general notion of the nature and extent of the Geological Survey, which has now been so ably and energetically directed by Dr Oldham for upwards of twenty years, and it ought also to convey some idea of the arduous and perilous character of the service, and of the high qualities necessary for its due performance

The researches of archæologists are closely connected with the science of physical geography, and therefore naturally find a place in this Memoir A perusal of General Cunningham's recently published work on the ancient geography of India will show how close is the connexion Moreover, the labours of the archæologist involve very arduous field work, and he therefore belongs to the brotherhood of surveyors and geographical explorers In the section on the Archæological Survey of India I have enumerated the descriptions of ruins and the interpretations of inscriptions by Sir William Jones and his disciples, and have given a sketch of the interesting labours of James Prinsep and his enthusiastic companions in research These earlier investigators prepared the way for our living antiquaries and students of Indian monuments, among whom General Cunningham, Mr Fergusson, Sir Walter Elliot, Dr Wilson, Colonel Meadows Taylor, and Mr Thomas take the lead I have ranged their work under eight heads, and have also given a brief sketch of the recent investigations of General Cunningham, Lieut Cole, and Mr Boswell The Government of India are now fully alive to the value of archæological research, further surveys will no doubt be actively prosecuted, and the foot notes containing references to the various operations mentioned in the text of this section may, I hope, prove useful

There is a strong disposition in India to establish a system of meteorological observing and reporting on a really satisfactory basis, and a review of previous efforts of the kind, and of the labours of former observers, may be of some service in the consideration of future arrangements The meteorological section is merely intended to furnish a history of previous operations, and to be useful for purposes of reference It will serve to show how much conscientious labour is often wasted and lost from want of systematic organization, but it also records much invaluable work, such as that of General Boileau at Simla, and of Mr Broun in Travancor, as well as the earlier most admirable observations and deductions of Colonel Sykes in the Deccan Tidal observations have been much neglected in India The efforts of Dr Whewell bore scarcely any fruit, and there is little that is satisfactory to record, except the useful computations of Mr Parkes for the tides at Karáchi and Bombay A series of careful observations at other selected points round the coast is urgently needed

Indian astronomy dates back for more than a thousand years, and old Aryabhata was nobly represented in later times by the learned and energetic Rajah Jai Sing, with his five observatories and colossal instruments Worthy successors to the famous Rajput astronomer have been found in the Directors of the Madras and Trivandrum observatories, and a Memoir on scientific operations in India would be very incomplete without a notice of the labours of the astronomers

The section on the Physical Geography of India is intended to give a comprehensive view of the attempts to deduce generalizations from the numerous classes of observations that have been collected by the surveyors, whether geodesists, geologists, antiquaries, or meteorologists, and it also contains some additional references to original sources of information, including a sketch of the labours of botanists and forest conservators The subject is one which could not be done justice to within the limits of even a large volume, and a mere sketch, such as is contained in this section, can only be of use in supplying references, and possibly in furnishing a few suggestions and incentives to further inquiry, for physical geography is the comprehensive science which utilizes and makes fruitful the observations accumulated by many classes of inquirers If the triangulations of the geodesists are the skeletons which the topographical surveyor supplies with flesh and blood, it is the physical geographer who clothes these naked bodies with every description of graceful adornment, and gives them beauty and completeness

The Memoir concludes with some account of the system by which these difficult and expensive operations in India have been reduced to shape, and made serviceable, both to science and to the general public The work of compilers and map makers forms a necessary supplement to the more arduous labours in the field The Spanish Council of the Indies established an efficient Department for the utilization of the work of explorers, of which I have given some account, but Hakluyt was the ancestor of our Geographical Department at the India Office, which also inherits the traditions of Rennell, of Dalrymple, and of Horsburgh These are great names, and conscientious efforts to emulate their services cannot fail to ensure satisfactory results

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January 1871

# PREFACE

## TO THE SECOND EDITION

THE result of the publication of the first edition of the Memoir on the Indian Surveys was very satisfactory. It was a part of my plan that the Memoir should be supplemented by Annual Abstracts on the same model, each abstract being a Memoir for one year. The Abstract was to consist of connected narratives for the year of the various operations which are the subjects of the Memoir, accompanied by references to all books, selections, articles, despatches, proceedings, or other papers containing fuller information on the different points. At the end of seven years the contents of the Annual Abstracts were to be embodied in the second edition of the Memoir.

Accordingly these Abstracts of the Surveys were published in 1871, 1872, 1873, 1874, 1875, and 1876. In 1877 the time came for the appearance of the second edition of the Memoir. Out of the 750 copies of the first edition over 700 had been disposed of, and the earlier Abstracts were out of print. In the new edition of the Memoir it has been found advisable to increase the number of sections. An additional sub section has become necessary for the Marine Survey Department, and separate sections are added for the route surveys beyond the frontier of British India by native explorers, for the Revenue Surveys, for Tidal Observations, for the Statistical Survey of India, and for a discussion of the orthography of Indian proper names. An index has also been added. In all other respects the arrangement of the two editions is identical. All who have been concerned in furthering the operations of the various Indian Surveys must look back with feelings of deep satisfaction to the amount and character of the work that has been achieved in the interval between the publication of the two editions of this Memoir.

In the Preface to the first edition it was pointed out that nothing had been done to continue the work of the Indian Marine Surveys, and a hope was expressed that before long the section on Marine

Surveys would be useful as a means of reference. That hope has been fully realized. Owing to the representations of the Geographical Department the marine surveys have been resumed under the able management of Captain Taylor, an efficient system has been organized, and most useful work is being done. The operations of the Great Trigonometrical Survey under Colonel Walker have advanced with rapid strides towards completion. The Revenue and Topographical Surveys have never been more active, and Colonel Thuillier has brought the various processes for the reproduction of maps, and the arrangements for the supply of geographical information, to a high state of perfection. The Geological Survey has, during the last seven years, made extraordinary progress, and it will not be long before the construction of a geological map of India will be possible. In archæology the survey of General Cunningham has added to the store of knowledge year by year. Mr Burgess has vigorously entered upon a parallel survey in Western India, while Mr Sewell has commenced similar operations in the Madras Presidency.

The Preface to the first edition pointed to the necessity for establishing a system of meteorological observing and reporting on a really satisfactory basis. The importance of this matter was also brought to notice, again and again, in the Annual Abstracts. Now an efficient Meteorological Department is constituted under Mr H. F. Blanford, a uniform system of registration has been established throughout India, and it is possible to combine all the results in one general review. In the first Preface notice was called to the neglect of tidal observations, and to the urgency of taking them at selected points round the coasts of India. Measures have now been adopted to secure this end, and Captain Baird, an able and accomplished officer, has been entrusted with the superintendence of tidal observations.

Similar advances have been made in the work treated of in the other sections of the Memoir, and in every branch the useful aid furnished by the Geographical Department has been acknowledged. That aid has taken the form of incessant efforts to give publicity to work done, and to the aims and objects of labourers in India, of prompt attention to all requirements in this country, and of cordial co-operation on every opportunity.

The concluding section of the Memoir treats of the work achieved by the Geographical Department of the India Office itself during the ten years of its existence There is still, I sincerely trust, a long and active career before it, and in watching the continued usefulness of an important branch of official work, which I had the honour to originate, all my labour and anxiety during the last ten years will be fully rewarded

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*of the India Office*

January 1878

# ANALYTICAL TABLE OF CONTENTS

*Sections*

I.—Indian Marine Surveys.

## IV.—First Period of the Topographical Surveys, 1800–23

V.—SECOND PERIOD OF THE TRIGONOMETRICAL SURVEYS, 1823–43



VI.—SECOND PERIOD OF THE TOPOGRAPHICAL SURVEYS, 1823–43

IX.—FOURTH PERIOD OF THE TRIGONOMETRICAL SURVEYS, 1862–77

X.—ROUTE SURVEYS BEYOND THE FRONTIER OF BRITISH INDIA BY NATIVE EXPLORERS



XI.—FOURTH PERIOD OF THE TOPOGRAPHICAL SURVEYS, 1861–77

XII —The Revenue Surveys of India



XIII —Supply of Instruments for the Indian Survey

## XIV.—THE GEOLOGICAL SURVEY OF INDIA

## XV — The Archæological Survey of India

## XVI.—Meteorological Observations

## XVII.—Tidal Observations

## XVIII.—Astronomical Observations in India

## XIX.—Physical Geography of India

### XX.—The Statistical Survey of India



### XXI.—Orthography of Indian Proper Names

Postscript



Appendix

# I.

# INDIAN MARINE SURVEYS.

## 1

## EARLY VOYAGES AND THE BOMBAY MARINE A D 1601—1830

THE Surveys of India began along the coasts, and the sailors preceded the shore going surveyors by nearly 200 years A sketch of the great services of the Indian Navy, therefore, will fitly precede an account of the operations of the surveyors on land Before India could be measured, it was necessary to get there and the history of Indian surveying takes us back to the day when James Lancaster's fleet of four ships and a victualler got under weigh from Torbay on the 2nd of May 1601 The East India Company set forth one or more voyages every year during the next twenty years, and the Company's sea captains observed for latitude and variation with the greatest diligence, keeping careful journals which must have been full of valuable information for the construction of charts

Lancaster and Middleton, the commanders of the first two East India fleets, only visited the Eastern Islands, and came home with ladings of pepper and cheerful hearts It was Captain Keeling, the leader of the third voyage in 1607, who first went to Surat, landed Mr Finch to form a factory, and sent Captain Hawkins, his second in command, to persuade the great Mogul, at Agra, to order his officers to deal justly and favourably with the English Then followed Sharpey's unlucky voyage and shipwreck on the shoals of Cambay, the remarkable voyage of Saris to Japan, and the establishment of factories on the Malabar coast by other captains, down to 1621

The observations of these bold and talented seamen bore good fruit in the shape of "plotts" (charts) and sailing directions, which were condensed into "Rules for our East India Navigations," by the famous Mr John Davis of Limehouse, who made five voyages himself[1]

Richard Hakluyt, Archdeacon of Westminster, was the historiographer of the East Indies, receiving the appointment from Sir

[1] "Harris's Voyages," i, p 224

Thomas Smith, the first Chairman of East India Directors, in 1601 Hakluyt had the custody of all the journals of East India voyages, and made excellent use both of them and of the information he gleaned from "noted seamen of Wapping,"[1] with whom he constantly conversed For he freely communicated his knowledge by giving lectures to the students at Oxford, and "was the first that "produced and showed both the olde and imperfectly composed "and the new lately reformed mappes, globes, spheres, and other "instruments of his arte, for demonstration in the common "schooles, to the singular pleasure and great contentment of his "auditory"

While Hakluyt thus made the maps and journals from the Indies useful to the public, Edward Wright, the excellent mathematician and engineer who accompanied the Earl of Cumberland on his voyage to the Azores, was compiling and systematizing the logs and charts He was the first person appointed by the Company to perfect their charts, in 1616, on a salary of 50*l* a year,[2] and was thus the John Walker of the seventeenth century

Hakluyt died in 1616, and the journals of the East Indian voyages, no doubt with the consent of the Directors, were handed over to the Rev Samuel Purchas, the quaintest and most entertaining of old writers, but one who was much too fond of taking liberties with his materials "Purchas his Pilgrimes" was published in 1625, and included the journals of the first twenty voyages set forth by the East India Company, but in a sadly abridged and mutilated form Several of the originals have disappeared, and only one was ever published separately Sir Thomas Smith, the Chairman, who was the first to allow the journals to be lent, died on the 4th of September 1625, the year the "Pilgrimes" were published, and Purchas himself died in 1626 The deaths of lender and borrower, occurring nearly at the same time, possibly account for the loss of some of the earliest journals of the Company's voyages[3]

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[1] "Fuller's Worthies," p 39

[2] "Calendar of State Papers, East Indies," p 284

[3] "The voyage of Sir Henry Middleton to Bantam and the Maluco Islands, printed for Walter Burre, 1606" A new edition of this voyage was edited and annotated by Bolton Corney, Esq, and printed for the Hakluyt Society in 1855 The Hakluyt Society has also resolved to print the voyages of Sir James Lancaster, to be edited by the present writer, together with a calendar of the logs and journals of the other East India voyages down to the year 1707, which are still preserved in the India Office This volume will be completed in 1878

The rest are still preserved at the India Office, and are numbered in two series, the first, extending from 1606 to 1708, and the second, containing the logs of the East India Company's ships, from 1708 to 1832 The journals of Lancaster, Middleton, and Saris are missing A copy of the latter (being the eighth voyage of the East India Company) was purchased some years ago, from Mr Kerslake, a bookseller at Bristol, and is now in the Topographical Depôt of the War Office The oldest logs, at the India Office, are those of Captain Keeling in 1606, and Captain Sharpey in 1608 Among the other journals, of the first series, there is a curious treatise on map making in Thomas Love's log kept on board the "Peppercorn" in 1610, Downton's memorial of his second voyage in 1613, the journal of the junk "Sea Adventure," on her voyage from Firando to Siam, kept by Captain Adams, Sayer's journal kept from Firando to Cochin China, the journal kept in 1621 during a cruize off Manilla on board a ship in the combined English and Dutch fleets which sailed from Firando, and journals of other voyages to Aden, Surat, the Persian Gulf, and the Malabar and Coromandel coasts One only of the Arctic voyages set forth by the East India Company has been preserved It is that of Captain Knight who sailed in 1606, and, landing on some frozen shore, was never heard of again. The discovery of the manuscript of Captain Knight's journal goes some way to exonerate old Purchas, and to show that he did return the journals he borrowed, for Knight is one of his "Pilgrimes" But though many of the logs have fortunately escaped destruction, a thick darkness closes over the subject of marine surveying, and continues far into the eighteenth century For all log books dating farther back than 1855 have been burnt at Calcutta, and in 1860 tons of precious records in the India Office shared the fate of the Alexandrian Library Among them, the Minutes and Reports of the Committee of Shipping, containing a rich mine of information relating to all that concerned the marine branch of the Company's affairs, as well as the Indian Navy logs that had been sent home, were consigned to a fate worse than that of warming a true believer's bath

Thus there is little light to be thrown upon marine affairs in the East Indies, and on the observations and surveys of the gallant seamen belonging to the Company's service for many years, but during those years the Bombay Marine was being developed into a service which was destined to produce a noble succession of surveyors From very early times armed vessels were employed at Bombay to protect the Company's ships from the pirates that swarmed along the coast In 1742, on a reduced establishment, we find a commodore of the Bombay Marine with three 20-gun ships, and several armed gallivats and grabs under his command [1] In 1755 Commodore James, with a small force of the Bombay Marine, took the castle of Suwarnadurg,[2] and in the same year Admiral Watson, in taking Gheria, the stronghold of Angria, with five ships of the British navy and 2,000 soldiers under Clive, had besides nearly a dozen armed vessels of the Bombay Marine

Here then was the material for training surveyors, but it was not until the days of Rennell and Dalrymple that real encouragement began to be bestowed upon marine surveying, and that its great importance was at last appreciated

Captain John Ritchie was Hydrographical Surveyor to the East India Company from about 1770 to 1785, and surveyed the coasts of the Bay of Bengal and the outlets of the Ganges His work formed part of the material for Rennell's map of Hindustan Many of his charts were engraved by Dalrymple, the Company's hydrographer, and a manuscript volume of his remarks is preserved in the Geographical Department of the India Office [3] But his latitudes and longitudes were taken afloat, and his soundings were barely more than sufficient to show the track of his vessel A

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[1] "Anderson's Western India" "Rise of the army and navy at Bombay " Bombay Quarterly Review,' v, p 265

[2] Suwarnadurg, (*suwarna* golden, and *durgam* foot )

[3] "Remarks upon the coast and bay of Bengal, the outlets of the Ganges and interjacent rivers, according to the surveys of John Ritchie, hydrographer to the United India Company'

*Contents*

1 Entrance to the Hooghly, and remarks on its pilotage
2 Rivers eastward to the Megna, Coast Islands
3 Chittagong and Islands
4 Tempests to which the head of the bay is subject
5 Coast of Arracan
6 Coast of Ava to C Negrais
7 Andaman Islands
8 Nicobar Islands

Dalrymple engraved Ritchie's chart of the Coromandel and Orissa coasts (1771), and others

Captain Lacam also surveyed the coast at the mouth of the Hughli in 1770.

Captain Huddart is mentioned by Major Rennell in his Memoir on the map of Hindustan, as having taken a series of observations for latitude and longitude along the Malabar coast between 1780 and 1790.

Captain John McCluer, in the ships "Endeavour" and "Panther," surveyed the whole west coast of India from Diu Head to Cape Comorin. The resulting chart was drawn by Lieut. Wedgborough, and many of McCluer's smaller plans were engraved by Dalrymple. McCluer made one of the earliest plans of Bombay harbour, assisted by Lieutenant Court, which was afterwards corrected by Dominicetti, and Wedgborough made a chart of the Laccadive Islands. McCluer was also the first to construct a chart of the Persian Gulf of any accuracy, and was far in advance of his time in his ideas of surveying.

The close of Captain McCluer's career was remarkable. In July 1783 the East India Company's packet "Antelope" sailed from Macao. She was commanded by Captain Henry Wilson, and two lads from Christ's Hospital were on board as midshipmen, named John Wedgborough and Robert White. On August 10th the "Antelope" ran on a rock near one of the Pelew Islands and became a wreck. The natives treated the shipwrecked crew with great hospitality, they built a small vessel, and when they sailed in her for Macao, in the following November, Captain Wilson took with him a son of the King of the Pelew Islands, named Prince Lee Boo, who was taken to England, and died of small-pox at Rotherhithe on December 27th, 1784.[1] Captain McCluer was ordered to proceed to the Pelew Islands to report the death of Prince Lee Boo, with the "Panther" and "Endeavour," taking Wedgborough and White with him as Lieutenants. The "Panther" sailed from Bombay on August 24th, 1790, and reached the Pelew Islands on January 18th 1791, when the sad news was conveyed to the father of Lee Boo. In February the "Panther" left the Pelew Islands, McCluer having been ordered to survey the north coast of New Guinea. He was

[1] See an account of the Pelew Islands, composed from the journals and communications of Captain Henry Wilson, who, in August 1783, was there shipwrecked in the "Antelope," by George Keate, F.R.S. (London 1788), 4to pp. 378.

There is an abridgment of this Account in the "Child's Own Book" (11th edition, 1865, p. 343.)

engaged on this work from July to December 1791, discovering the great inlet at the western extremity, which was named McCluer Bay The "Panther" then proceeded to Bencoolen, and afterwards returned to the Pelew Islands While there Captain McCluer addressed a letter, dated February 2nd, 1793, to Lieut Wedgborough resigning the command of the "Panther,' asking for arms and ammunition, which were given to him, and announcing his intention of remaining on the islands This having been arranged the "Panther," under command of Wedgborough, returned to Bombay on August 17th, 1793 McCluer married natives and lived contentedly for 15 months, when he got anxious for news, and went in an open boat to Macao There he bought a vessel in order to return to the Pelew Islands for his family, at the same time writing to the Chairman of Directors with an application to be reinstated in the service He returned to the islands, took his family on board, and then went to Bencoolen He sailed from thence and was never heard of again But three of his wives had been sent to Bombay in another vessel and arrived safely In 1797 they were sent back to the Pelew Islands, at the Company's expense [1]

Between 1777 and 1795 Lieutenant Archibald Blair was very actively engaged in making surveys of parts of the Andaman Islands, the Katiwár coast, Salsette, and other patches here and there [2]

In 1788 Captain Michael Topping submitted a journal kept on board the E I C ship "Walpole," in a voyage to Madras, with a chart of the Bay of Bengal In 1790 he was sent to make a survey of Korangi and the mouth of the Godávari river, a service which he performed most creditably, submitting a chart and a valuable memoir as its results He was then employed during 1792 in taking observations for determining the course of the currents in the bay of Bengal, and he afterwards took a series of levels of the river Kistna from the sea to Bezwara, with a view to the construction of irrigation works These services led to his

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[1] See "Supplement to the account of the Pelew Islands, compiled from the journals of the 'Panther' and 'Endeavour, two vessels sent by the H E I C to those Islands in 1790," by the Rev John Pearce Hochin (London 1803) This supplement is bound up with the later editions of Keate s Pelew Islands

[2] For an account of Blair's Survey of the Andamans, see "Selections from the Records of the Government of India" (Home No 24) Port Blair was named after him

appointment as chief surveyor at Madras in 1794, when he drew up a general plan for the improvement of the geography and navigation of India. The bay of Korangi was surveyed again in 1805–6 by Lieutenant Warren, who also made a plan of the roadstead of Vizagapatam.[1]

The expedition to the coast of Egypt led to an examination of the Red Sea in 1799–1800, and Sir Home Popham, who commanded the fleet, drew up some sailing directions for its navigation. But even then it was not entirely unknown. On Lord Valentia's chart the tracks are given of the cruizer "Swallow" in 1776, "Venus" in 1787, and in 1795 Lieutenant Court had taken the "Panther" up as far as Suez. A chart of the Red Sea was drawn by Lieut. Robert White in 1796, for which he received much praise and his promotion. In 1803 Lord Valentia was travelling in India, and while at Calcutta he declared to Lord Wellesley, the Governor General, that he felt it to be a national disgrace that the western coast of the Red Sea should be a perfect blank on our charts, and his lordship volunteered to embark on board one of the cruizers of the Bombay Marine and investigate that shore, with a view to prosecuting further inquiries into the state of Abyssinia. The great Viceroy concurred, and Captain Keys of the cruizer "Antelope" was ordered to take Lord Valentia on board at Mangalur, and place himself under his lordship's orders. The "Antelope" sailed for Aden on March 13th, 1804, with Captain Keys as Commander, Lieutenants Hall and Maxfield, Midshipman Hurst, Lord Valentia in the anomalous position of commanding the commander, and Mr. Salt as private secretary. The arrangement did not answer. At Mokha Captain Keys began to show a disinclination for the work, at Dhalac he accused Lord Valentia of wanting to get the credit of discoveries made by his officers, and at Masâwwa they came to an open quarrel, and only communicated with each other in writing. They returned to Bombay in September, and Captain Keys was put under arrest.

Yet neither Lord Wellesley nor Lord Valentia were disheartened. Two other vessels were ordered to be fitted out for a second expedition under the same arrangement, which this time answered admirably. Captain Court, who had a high character both as a

[1] A manuscript memoir of Lieut. Warren's Survey is preserved in the Geographical Department of the India Office. Captain Topping's Memoir on Coringa (Korangi), with notes by Lieut. Warren and Captain Biden, was published by the Madras Government in 1855.—*Selections*, No. XIX.

seaman and a man of science, took command of the "Panther," with Lord Valentia and Mr Salt on board, and two midshipmen named Hurst and Crawford, while Lieutenant Maxfield had the tender "Assaye," a small schooner. They sailed from Bombay on December 4th, 1804, surveyed part of the Dhalac Islands, the great bay to which Captain Court gave the name of Annesley, the island which he called Valentia, and the coast for some distance to the north of Masáwwa. In July 1805 Lord Valentia landed his secretary, Mr Salt, at Arkiko, accompanied by Captain Rudland of the Bombay army, a Mr Carter, and an adventurous blue jacket named Pearce, to go on a mission to the ruler of Tigré at Antâlo, his lordship visiting Mocha and other places in the meanwhile. The embassy was a success; but as for geography, Mr Carter observed for latitude several times at Antalo, and his result was nearly 40 miles out. In November 1805 the whole party sailed from Masáwwa, and reached Suez in the end of January 1806. Lord Valentia had agreed perfectly with Court and Maxfield, and had got some useful work done. They parted with regret, and the crew of the "Panther" gave his lordship three cheers when he went over the side. The results of the surveys of Captain Court and his officers are given in a chart of the Red Sea in two sheets, in Lord Valentia's travels.[1] Lieutenant Maxfield also made a chart of Masáwwa, and part of the Abyssinian coast, assisted by young Crawford and Hurst, for which he received Rs 600 from the Government as a recognition of his zeal, and his youngsters were granted Rs 200 each.

The hydrography of the Indian seas at the opening of the present century was deemed of sufficient importance to warrant the appointment of a Marine Surveyor General at Calcutta, and Captain Court was selected for the post, which he held until 1823. During this period, from 1806 to 1820, Captain Daniel Ross was engaged, with the assistance of Lieutenant Maughan[2] and others, in surveying the coast of China.[3] In 1818-19 he surveyed the straits of Malacca,

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[1] "Voyages and travels to India, Ceylon, the Red Sea, Abyssinia, and Egypt, in 1802–6, by George Viscount Valentia, 3 vols (London, 1809).

[2] In 1804 Lieutenant Maughan had made a survey of the Gulf of Kach, for which he received Rs 1,000 from the Government, "as an encouragement to others to emulate his praiseworthy conduct."

[3] "Directions intended to accompany the chart of the South Coast of China, by Daniel Ross and Philip Maughan, Lieuts of the Bombay Marine." Printed by order of the Directors of the East India Company (London, 1808.)

near Singapore He also made surveys of a portion of the Gulf of Pechili and of the Canton province, as well as of some of the Eastern Islands His charts were published as they were completed, and the whole were incorporated into a general chart by Captain Horsburgh Admiral Collinson, when surveying in China, had opportunities of testing several of the charts drawn from surveys by officers of the Bombay Marine, and he bears testimony to the accuracy of their work It surprised him to find how much further advanced the Bombay officers were than the marine surveyors of that period in England The surveys of the Canton river, and of the coast 100 miles on each side, by Daniel Ross, were found by Admiral Collinson to be remarkably correct Captain Court also had two vessels surveying the Bay of Bengal under Lieutenant Maxfield, and caused searches to be made for various shoals Captain Knox surveyed a portion of the sea-face of the Sundarbans in 1803–4, and Captain Maxfield's chart of the coast from Ságar point to Lighthouse point at the mouth of the Hugli, from a survey executed in 1816, was in use until it was superseded by Captain Lloyd's work in 1841 Admiral Sir Henry Blackwood having reported that H M S "Leander" had been safely at anchor inside the Armagon shoal, north of Madras, for four days during the monsoon, Captain Maxfield was sent to investigate the capabilities of the place, which has since been called Blackwood's Harbour He went there in 1822 on board the "Henry Meriton," accompanied by Captain de Haviland, but the conclusion come to at the time was that its distance from Madras was an inconvenience which outweighed any advantages it might have as an anchorage[1] In 1823, however, the Madras Government hired a schooner called the "Mary Anne" to ride out the monsoon in Blackwood's Harbour, as an experiment

In 1821 a partial survey of the Gulf of Kach was executed by Lieut Middleton

While Captain Court was Marine Surveyor General at Calcutta, the name of James Horsburgh became indissolubly connected with the Marine Surveys of India Beginning life as a cabin boy, this bold and diligent Scotch sailor soon rose to the command of a vessel in the Eastern seas, and his innate love of surveying had excellent opportunities for development After many years he returned to England, and the publication of a set of his charts, engraved by

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[1] Chart of Palikat and Armagon shoals, by Captain Maxfield

Walker, at once placed him in the first rank of hydrographers Mr Dalrymple, who was hydrographer to the East India Company, died in 1807, and the post remained vacant for three years During that interval Captain Horsburgh published the first edition of his East Indian Directory,[1] for which the Court of Directors granted him a hundred guineas, and on November 10th, 1810, he was appointed to examine the journals of the Company's ships, and became hydrographer From that time all charts passed under his scrutiny, and were published with the benefit of his superintendence until the time of his death in 1836 [2]

On the death of Captain Court in 1823, he was succeeded at Calcutta by Daniel Ross "The Father of the Indian Surveys" as he was called He was indeed the first who introduced a really scientific method During the Burmese War from 1823 to 1826 the useful operations under his superintendence were interrupted, but he had the "Research" (300 tons) and "Investigator" (450 tons) at work in the Mergui Archipelago, and in 1827 Captain Crawford, the midshipman whose zeal, when with Lord Valentia, had been rewarded by a grant of Rs 200, surveyed part of the coast of Arakan in a hired brig John Crawfurd, in his embassy to Ava, speaks in the highest terms of Captain Crawford's surveying work The "Research" was given up to Captain Dillon to go in search of La Perouse, but the little "Freak" was substituted, and surveys were made along the Martaban coast In 1828 Moresby surveyed some of the Laccadive Islands

In 1828 there was a fit of ruinous economy The "Freak" was sold, the "Investigator" was declared to be unseaworthy on account

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[1] The first edition appeared in 1808, the second in 1817 In 1874 Commander A D Taylor published "The Indian Directory founded upon the work of the late Captain James Horsburgh, F R S" (Allen, 1874) See page 43

[2] Captain Horsburgh s copy of the "Minutes of the Committee of Shipping' is preserved in the Geographical Department of the India Office The first entry is that recording his appointment on Nov 10th, 1810, the last is on June 20th, 1837, the year after his death

Fourteen charts, actually compiled by Horsburgh himself, were published by the East India Company, viz —

1 North Atlantic Ocean
2 South Atlantic Ocean
3 Part of the Indian Ocean
4 East Peninsula of India
5 West Coast of Sumatra
6 Straits of Rhio and Durian
7 Straits of Banca and Gaspar
8 Carimata Passage
9 Straits of Sunda
10 China Sea (2 sheets)
11 Canton River
12 East coast of China
13 Eastern Passages to China (3 sheets)
14 Tracks through Pitt Passage and Dampier Strait (1793)

of the ravages of white ants, and Lord William Bentinck ordered the surveying establishment to be broken up

But stout old Daniel Ross was urgent and importunate in advocating a resumption of the good work and in 1830 he again had two brigs, the "Flora" and "Sophia," in the Mergui Archipelago, under his assistant, Lieutenant Lloyd while he himself examined the coast of Arakan [1] Captain Ross did his work with great care and regard for scientific accuracy, and it was all on a trigonometrical basis He measured bases on shore by running a ten foot rod along a cord stretched tight between the extreme points, and kept in position by stakes, the direction being verified by a telescope When work on shore was impracticable, recourse was had to measurement by sound The vessels were anchored when the weather was calm, and the time was taken between the flash and report of a gun, on the assumption that sound travels 1,140 feet per second All angles were taken with a sextant, and the triangulation was verified by frequent astronomical observations In Ross's time the Government of India used to strike off a few copies of his charts at Calcutta by lithography, and send the originals to the India House for engraving and publication [2]

Captain Daniel Ross resigned his appointment in November 1833, and was succeeded by his able assistant Lloyd He retired to Bombay, where he was Master Attendant, and President of the Geographical Society from 1839 until just before his death [3]

In 1820 the survey of the Persian Gulf was commenced [4] under Captain Guy of the "Discovery" (268 tons), with Captain Brucks as his assistant, in the brig "Psyche" Guy retired, after having examined the Arabian side up to the head of the Gulf [5] His successor, Captain Brucks, was a good sailor, though unfortunately not

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[1] Captain D Ross's MS "Sailing Directions for the Mergui Archipelago" are preserved in the Geographical Department of the India Office

[2] "Progress of Maritime Surveys" "Journal of the Asiatic Society of Bengal," i, p 327

[3] The following is a return of the cost of the Bengal Surveys from 1821 to 1824 —

1821–22 Annual expense of survey vessels "Nearchus," "Minto," "Sophia," and "Henry Meriton," Rs 1,19,055

1823–24 Annual expense of survey vessels "Research" and "Investigator," Rs 59,379

1833–34 Annual expense of survey vessels "Flora" and "Sophia," Rs 25,055

[4] The Persian Gulf Survey was commenced by Captain Maughan at Cape Masandim, but he had done very little when Guy succeeded him

[5] The memoir of Captain Guy's portion of this survey, drawn up at his request by Lieutenant Houghton, is preserved in the Geographical Department of the India Office in MS

a scientific surveyor, but he had under him Lieutenants Haines, Kempthorne, Cogan, Pinching, Etheisey, Whitelock, and Lynch, all men of scientific and literary attainments, while the charts were constructed with great taste and ability by Lieutenant Houghton. This officer was afterwards draughtsman to the Indian Navy at Bombay.

It must not be forgotten that surveying was but a small part of the work of the Indian Navy. The influence of England in the Persian Gulf was exercised to suppress piracy and extend commerce, to maintain the *status quo* of the chiefs, to exclude foreign influence, and to root out the slave trade. The English may look upon their connexion with the Persian Gulf with almost unmixed satisfaction. They have hunted down the atrocious hordes of pirates, and have enabled unarmed merchantmen to pass up and down in safety. The successful invasion of Persia in 1856 is amongst the more recent operations of the Indian Navy. The naval head-quarters in the Persian Gulf were at Bassadore (Basîdû), in the Island of el-Kishm, where there was a hospital on shore, a bázár, five or six private houses, a billiard room, and a fives court.[1]

The survey occupied ten years, from 1820 to 1830, and Lieutenant Haines also examined the Mekran coast. The results are given in 14 charts. We also have, as results of the old Persian Gulf Survey, a "Memoir descriptive of the Navigation of the Persian Gulf, being sailing directions by Captain Brucks himself,[2] notes made by Lieutenant Kempthorne on the identification of places touched at by Nearchus, which would have gladdened old Dr. Vincent's heart, on the ancient commerce of the gulf, and on a visit to the ruins of Tahiri, which he successfully identified with the missing old Muhammadan city of Siráf,[3] and three papers by Lieutenant Whitelock, one being a description of the islands at the entrance of the gulf, another an account of the Arabs on the pirate coast, and the third a narrative of a journey in 'Oman.[4]

Captain Brucks was an old sailor who had been at sea ever since he was 11 years of age, and he had completed 16 years' service in the Bombay Marine. He endeavoured to give his work a trigonometrical basis, and always observed for latitude and longitude on shore,

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[1] "Report on Bassadore, with a plan of the roads," by Midshipman Hewett. "Bombay Selections,' No. 24, p. 47.

[2] "Bombay Selections,' No. 24, pp. 527–634.

[3] "R. G. S. Journal," v. p. 263. "Bombay G. S. Journal," i. p. 294, and xiii. p. 125.

[4] "R. G. S. Journal," viii. p. 170. "Bombay G. S. Journal," i. p. 294.

with an artificial horizon, because the refraction was so great as to make it useless to observe with the natural horizon. But in fact only a portion of the survey was trigonometrical, and the bases were measured from ship to ship by sound. The other portion was merely a running survey, verified to some extent by astronomical observations. There was also some confusion in the longitudes. One half of the survey is referred to the meridian of Bassadore, which was fixed by chronometric measurement from Bombay; but, in those days, Bombay was 7 miles too far to the east. The other half of the survey was calculated from Bushire, the longitude of which had been correctly fixed by Mr. Rich, a former Political Resident, of high scientific attainments.[1] Thus the work does not come up to the standard of excellence subsequently reached by the officers of the Indian Navy, and most of it has since required revision.

At the same time this old survey of the Persian Gulf reflects credit on those who executed it, when the imperfection of their instruments and the difficulties they had to overcome are taken into consideration, as well as the fearful climate, the hostilities of Arab tribes, and the great amount of work done. Guy and Brucks were both invalided, besides junior officers. Captain Brucks returned to England in 1842. He died in 1850. He was for years employed in preparing a history of the Indian Navy, but the papers collected by him on this subject have never been published.[2]

After returning from the Persian Gulf, Lieutenants Cogan and Peters made a survey of Bombay harbour and of the coast as far as Bankote in 1832, which was published on a chart of two sheets.[3]

In 1832 the Bombay Marine was converted into the Indian Navy, by the wish and command of King William IV., and an admirable system of surveying was inaugurated under the auspices of its first Commander-in-Chief, Sir Charles Malcolm.

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1 The manuscript geographical and archæological memoranda and maps of Mr. Rich were presented to the Geographical Department of the India Office by Mr. Claude Erskine, in 1877.

2 See 'Bombay Times,' March 16, 1850.

3 The oldest English plan of the harbour of Bombay is in Fryer's work, published in 1698. Next there is one by Mr. Nicholson, master of H.M.S. "Elizabeth," published in 1787: it is stated to be an index to a large one in eight sheets. Then followed that by McCluer and Court, corrected by Dominicetti, and then the survey by Cogan and Peters. (See page 33.) Dalrymple published a plan of Mahim and the north end of Bombay Island by Lieut. Edward Harvey, from a survey in 1777.

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## THE INDIAN NAVY

### A.D. 1832—1862

WHEN Sir John Malcolm came out as Governor of Bombay in 1827, his brother Sir Charles was appointed Commander-in-Chief of the Bombay Marine, which was henceforth to be called the Indian Navy.[1] The change dated from 1832. Sir Charles Malcolm instituted several extensive and important surveys, and the Indian Navy, which came into existence under his auspices, saw its most palmy days during his administration. He was the first Commander-in-Chief of that distinguished service. He was also the founder of the Bombay Geographical Society, an enlightened patron of science and literature, and a warm friend to the officers who served under him.[2] The first important act of his administration was the formation of the Red Sea Survey.

In 1829 the Indian Government resolved to prepare to open the route by Egypt for steam vessels, and coal was sent from Bombay to Suez in a collier, escorted by the ten-gun brig "Thetis," as a protection from pirates that then swarmed in the Red Sea. The old tub was lost on the reefs north of the Jaffatine Islands, and on the return of the "Thetis" to Bombay a regular survey was resolved upon.

At that time all knowledge of the Red Sea was derived from the chart of 1796 by Lieutenant White, from some sailing directions drawn up by Sir Home Popham during the expedition of 1800, and from Captain Court's charts of part of the western coast, when with Lord Valentia.[3]

Captain Moresby, an excellent seaman and surveyor, was appointed to the "Palinurus" to survey the northern half from Suez to Jiddah, while Captain Elwon, in the "Benares," took up the southern half from Jiddah to Bab el-Mandeb. The officers were picked men; there

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[1] Sir Charles Malcolm, one of three distinguished brothers, was born in September 1782, and entering the navy served in his brother Pulteney's ship at the cutting out of vessels at Manilla, in 1798. His promotion was rapid, and he saw much service throughout the war. He was knighted by Lord Wellesley at Dublin in 1826, and became a Rear-Admiral in 1837.

[2] The Bombay Geographical Society was instituted on April 9th, 1831, and Sir Charles Malcolm was its first President, from its foundation until he left India in 1838, when he was succeeded by Captain D. Ross.

[3] See page 7.

were Carless, the future surveyor of the mouths of the Indus, James Young, Pinching, Powell, Barker, the Abyssinian traveller, Christopher, the pioneer of the Indus, who fell gloriously at Multan, Wellsted, the accomplished author, and Felix Jones, then a very young officer, but whose skill as a draughtsman was already appreciated No expense was spared in fitting out the expedition, and all the surveying appliances of the day were provided, besides ample supplies of well found boats and tenders The latter were native craft with Arab crews The sea was then practically unknown, and great dangers and privations were inseparable from such a service

The first base was measured by a chain at Suez by Captain Moresby in 1830, and the survey was steadily continued, without other interruptions than were necessary to refit the ships and crews, to its completion in 1834, by a system of triangulation down either shore The work was verified by frequent bases, by almost daily azimuths, by latitudes by the sun and stars observed on shore with artificial horizons, and by chronometric differences [1]

The original charts were drawn on a scale of an inch to a mile, but in places where the complicated nature of the channels required greater nicety, scales as high as ten inches were employed

The original drawings were mostly by Felix Jones

The noble resolution of all the officers was that the Red Sea Survey should be as perfect as labour and skill could make it, and it has served well to guide thousands of steamers up and down one of the most important and, at the same time, one of the most intricate routes in the world

The charts were compiled at Bombay from the original drawings by Lieut Carless, and sent home to be engraved The northern part of the Red Sea, by Captain Moresby, was published in two sheets in 1833, and the southern, by Captain Elwon, also in two sheets, in 1834 Two sheets of harbours in the Red Sea, and the sailing directions by Captains Moresby and Elwon, were published in 1841 In 1848 Captain Barker, I N, made a re survey of the anchorage at Suez,[2] and Suez Bay, as well as the Straits of Jubal, have recently been again examined by Captain Mansell, R N In the contemplated partial revision of the survey, called for by the opening of the Suez Canal and the great increase of traffic, the original

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1 "Letter from Captain Felix Jones to the Hydrographer of the Admiralty, July 13th, 1870"

2 Captain Barker's chart of Suez Bay was accompanied by a memoir

drawings on larger scales would have been of the greatest possible value, but it is feared that they have been carelessly thrown aside and lost

The literature of the Red Sea Survey is chiefly from the pens of Lieuts Carless and Wellsted In the second volume of his "Travels in Arabia,"[1] Wellsted gives a most interesting account of the proceedings of the survey in the gulfs of Suez and Akaba, and along the coast of Arabia, and he also wrote several detached papers bearing on the work on which he was engaged in the Red Sea, while Carless furnished a valuable memoir on the gulf of Akaba[2]

A survey of the coral islands which cross the track of Indian trade had long been considered of the greatest importance to navigation, and Captain Horsburgh strongly urged its necessity[3] As soon, therefore, as Captain Moresby had completed his work in the Red Sea, he was ordered to proceed in the surveying ship "Benares," with the "Royal Tiger," commanded by his assistant surveyor, Lieut Powell, and a large decked boat called the "Maldiva," to survey the Maldive Islands The surveying staff was composed of Lieuts Robinson, James Young, Barker, Macdonald, Riddle,[4] Christopher, Michael Lynch, and Felix Jones The latter officer drew the original charts, and their execution was so beautiful that they were brought home for the Queen's inspection The Maldive Islands were almost unknown, and in order to acquire a knowledge of the language, customs, and resources of the inhabitants, Lieuts Young[5] and Christopher were landed in June 1834,

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1 "Travels in Arabia," by Lieut J R Wellsted (2 vols ), 1838

2 "Notes on Bruce's charts of the coast of the Red Sea, compared with the positions of the recent survey," by Lieut Wellsted —*R G S Journal*, v p 286

"Observations on the coast of Arabia between Ras Mohammed and Jiddah," by Lieut Wellsted —*R G S Journal*, vi p 51

"Memoir on the Gulf of Akabah, from notes during the survey by Moresby in 1833," by Lieut Carless, I N —*Bombay G S Journal*, vol i

Lieut Wellsted died in 1843 He also published a work entitled "The City of the Caliphs," 2 vols , and wrote an elaborate memoir on the Island of Socotra, which he visited and explored in 1837, in the *R G S Journal*, v pp 129–229, with a map See also *Journal of the Asiatic Society of Bengal*, iv p 138

3 Captain Horsburgh had written a paper in 1832 on the "Navigable Channels separating the atolls of the Maldive Islands —*R G S Journal*, ii p 72

4 Mr Riddle died from the effects of the climate of the Maldives

5 This distinguished officer was lost in a hurricane on the Malabar coast in April 1847, when in command of the "Cleopatra" See a paper on the subject of this hurricane by Captain Carless in the *Bombay G S Journal*, viii p 93 James Young was engaged at the time of his death in diligently collecting materials for wind and current charts

and resided for some time at Malé, the principal island The results of their observations are recorded in a very interesting memoir [1] It was found that the Maldivans were a civilized, commercial, and seafaring people, who constructed their own quadrants, and translated our nautical tables into their language [2] Having completed the Maldive Survey, Captain Moresby proceeded to the Chagos Archipelago in February 1837, and afterwards surveyed part of the Saya da Malha bank, about five degrees S E of the Seychelles He completed this important work, and returned to Bombay in September 1838 [3]

Mr Darwin, in the preparation of his work on the structure and distribution of coral reefs,[4] received much assistance from Captain Moresby One section of his chapter on Atolls is devoted to the Maldive Archipelago and the great Chagos Bank, and mainly consists of information communicated to him by Captain Moresby, which enabled him to give accurate and very interesting descriptions of these coral formations

The Gulf of Manaar and Palk Strait, with the Pamban Channel and Ceylon coast, were taken up, after the completion of the Maldive Survey, by Lieuts Powell and Ethersey, assisted by Lieuts Grieve and Christopher, with Felix Jones again as draughtsman They surveyed the Pamban Pass, the west side of Palk Strait, Adam's Bridge, the west coast of Ceylon from Galle to Colombo, and a small portion of the Tinnevelli coast After their recall in April 1838, the work was continued by Captain Franklin, R N,

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1 "Memoir on the Inhabitants of the Maldive Islands," by Lieut James Young and Lieut Christopher—*Bombay G S Journal*, i p 54 "Vocabulary of the Maldivan language," compiled by Lieutenant Christopher, I N—*Journal of the Royal Asiatic Society*, vi p 42

2 See a very interesting account of the nautical instruments used by the Maldive navigators, by James Prinsep, in the *Journal of the Asiatic Society of Bengal*, v p 784

3 The charts resulting from these surveys are—

1 Maldive Islands, by Captain Moresby and Lieut Powell 3 sheets 1835
2 Maldive Islands (reduced)
3 Chagos Archipelago, by Moresby and Powell 1836
4 Principal groups in the Chagos Archipelago, by Moresby and Powell 1837

Captain Moresby drew up sailing directions for the Maldive Islands and Chagos Archipelago "Nautical directions for the Maldive Islands and the Chagos Archipelago," by Commander Robert Moresby, I N, 1839 Printed by order of the Court of Directors (London, 1840) See a Summary of "Moresby's Report on the Maldives" in the *Bombay G S Journal*, i p 102

4 "The Structure and Distribution of Coral Reefs," by Charles Darwin, F R S First edition 1842 Second edition, revised 1874

afterwards the Madras Master Attendant[1] This officer executed his survey in a small country craft of 60 tons, between 1840 and 1845 He completed the coast from Cape Comorin to Point Calimere on the Indian side, and made a plan of Tutikorin harbour, and of the pearl banks[2] Dalrymple had published a plan of Tutikorin by Van Keulen, in 1782

While Moresby went to the Maldives on board the "Benares" the old "Palinurus" was fitted out for the survey of the south coast of Arabia, which was commenced in October 1833 Captain Haines received the command, and his officers were Lieutenants Sanders, Cruttenden, Grieve, Rennie, and Dr Hulton The survey was intended to cover 500 miles of coast, but it was discontinued in May 1837, and Captain Haines was appointed Commissioner for the arrangement of affairs at Aden with orders to obtain satisfaction from the Sultan, for the plunder of a Madras vessel that had been wrecked on the coast He arrived there in command of H E I C S "Coote" (18 guns), and Aden was occupied by the English on January 16th, 1839 Captain Haines was the first Political Resident of Aden, and held that post for 12 years Now that so many years have passed away since the end of his melancholy career, regret may be expressed at the sad and cruel fate of this zealous but unfortunate officer[3] He completed the survey of a large portion of the south coast of Arabia, and in October 1837 Lieut Carless was despatched to survey the coast of Africa about Cape Gardafui, work which was satisfactorily accomplished

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[1] The resulting charts are—

1 Coast of Madura, by Powell, Ethersey, and Franklin (1838)
2 Western side of Palk Strait, by Powell and Ethersey (1838)
3 Pamban Pass, by Powell, and Ethersey (1837)
4 Islands of Ramasward and Manar, by Powell and Ethersey
5 W coast of Ceylon Franklin, Powell, and Ethersey 4 sheets
6 Palk Strait and Gulf of Manar Powell, Ethersey, and Franklin 2 sheets (1838 and 1845)
7 Harbour of Tutikorin Franklin (1842)
8 Coast of Tinnevelli Franklin (1842)

Lieut Christopher wrote an account of Adam's Bridge and Rameswaram, with a plan of the temple —*Bombay G S Journal*, vol vii

[2] Captain Franklin s sailing directions were published by the Madras Government "Instructions for navigating the Gulf of Manar and Palk's Bay" (1851)

His chart of the Pearl banks was lithographed, and there are copies in the Geographical Department of the India Office (See *General Catalogue*)

[3] Correspondence relating to Aden, Parliamentary Paper, 1839

These surveys are utilized by the publication of ten charts,[1] and are also described in several very interesting memoirs Captain Haines himself has given a graphic account of the Hadhramaut and Yemen coasts in two elaborate papers,[2] and his assistant and successor, Captain Sanders, has supplemented them by a further paper,[3] while Lieut Cruttenden has given us a journal of his excursion into Dafar[4] Dr Hulton, the surgeon of the "Palinurus," furnished a very interesting history of the Kuria Muria Islands,[5] and Lieut Cruttenden has published a still more valuable account of his visit to Sana'â, the capital of Yemen, while the "Palinurus" was surveying Mokha roads in 1836[6] Sana'â had not been seen by any European since the time of Niebuhr in 1762,[7] which gives additional importance to Lieut Cruttenden's account of the town, and of the coffee-yielding highlands which he traversed to reach it Dr Hulton, who was Cruttenden's fellow traveller, was taken ill on the road, and died soon after returning to Mokha Commander Albany Grieve succeeded Captain Sanders, and completed the Arabian coast survey in 1849 He wrote sailing directions and

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[1] 1 Entrance to the Red Sea, by Haines (1835)
2 S E coast of Arabia Haines 3 sheets (1836)
3 Several bays near Cape Aden Haines (1836)
4 N E coast of Arabia Sanders and Grieve (1849)
5 Gulf of Aden Haines, Barker, and Grieve (1847)
6 Kuria Muria Islands Haines (1837)
7 Island of Socotra Haines (1834)
8 Islands west of Socotra Grieve (1848)
9 N E coast of Africa Carless 2 sheets (1838)
10 Gulf of Masira Grieve 2 sheets (1847)

[2] "Memoirs to accompany the chart of the south coast of Arabia, by Captain Haines,' Parts I and II —*R G S Journal*, ix p 125, and xv p 104

Two copies of the original manuscript of the first part of Captain Haines's Memoir, with pen and ink sketches and copies of Himaritic inscriptions at Sana'a, by Lieut Cruttenden, are preserved in the Geographical Department of the India Office

[3] "Short Memoir of the Proceedings of East India Company's brig 'Palinurus' during the examination of the Arabian coast"—*R G S Journal*, xvi p 169

[4] "Journal of an excursion into Dafar," by Midshipman Cruttenden —*Bombay G S Journal*, vol i The MS of Cruttenden's Journal, dated "Palinurus," March 16th, 1836, is preserved in the Geographical Department of the India Office

[5] "Account of the Curia Muria Isles," by the late Dr Hulton —*R G S Journal*, xi p 156, *Bombay G S Journal*, vol iii

[6] "Excursion to Sána, the capital of Yemen,' by Lieut Cruttenden —*Bombay G S Journal*, vol ii, and *R G S Journal*, viii p 267

[7] The Rev Mr Stern, who afterwards suffered a long captivity in Abyssinia, was at Sana'â in 1856 He went there to visit the Jews, travelling from el Hudaidah in the dress of an Arab See an article on Yemen in the *Geographical Magazine* for January 1874, p 398

notes about the coast, which were incorporated in the "Gulf of Aden Pilot," drawn up by Commander Ward and published by the Admiralty in 1863

In 1833, Lieut Whitelock, a veteran of the Persian Gulf, commenced a rough survey of the west coast of Katiwár, and had completed it as far as Diu, including the island of Bait, at the time of his death in 1836 In the following year Lieut Ethersey zealously took up the work where Whitelock left off, and surveyed the coast round the head of the Gulf of Cambay, and down the east side to Surat, as well as the N Konkan coast from St John's to Bassein He performed this work in a miserable native *pattamar* called the "Bhowany," with the water washing up to his ankles under the cabin table[1] During this service Ethersey laid down the dangerous shoals off Surat called the Malacca banks, on which Captain Sharpey was wrecked in 1607, attentively observed the bore or rushing tide at the head of the Gulf of Cambay for two successive seasons, and explored the fossiliferous tertiary formations on the island of Perim Besides his charts, the results of his survey are recorded in two valuable memoirs[2]

We now come to the important work of the officers of the Indian Navy in the River Indus When Colonel Pottinger went to Sind in 1833, he was accompanied by Lieut Del Hoste, who prepared a topographical memoir with sketch maps, and Alexander Burnes was also exploring the Indus in those days[3] The work of Lieut John Wood[4] in the Indus commenced in about the year 1835, in

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[1] The charts representing this work of Whitelock and Ethersey are—

1 Coast of Katiwar from Diu to Dwarka Whitelock 1833
2 Katiwár from Diu to Perim Isle 2 sheets Ethersey 1836
3 Diu Harbour Whitelock 1833
4 Gulf of Cambay Ethersey 1845

[2] "On the bore or rushing tide in the Gulf of Cambay '—*R G S Journal*, viii p 196
"Notes on Perim Island, in the Gulf of Cambay —*Bombay G S Journal*, vol ii
"The Bore in the Gulf of Cambay "—*Bombay Selections*, No 25

[3] In the Geographical Department of the India Office there is a MS "Route book of the Mission to Sind in 1833, with Sketch maps,' by Lieuts Patterson and Del Hoste (There is a memoir by Lieut Del Hoste on Sind in the *Bombay G S Journal*, i p 22 )

Also MS map of the Indus and Punjáb rivers from the sea to Lahore, by A Burnes, with a paper regarding the construction of the map

[4] John Wood was born in 1812, educated at Perth Academy, and joined the Bombay Marine when very young He retired in 1842, and, after visiting many of the colonies, he finally became managing Superintendent of the Indus Flotilla, and lived for many years in Sind He was of an extremely retiring disposition, but his great worth as a

command of the first steam vessel that floated on the river, when he examined its course from the sea to Haidarabad, and remained in the country to observe its periodical rise and fall. In 1836 Lieut. Wood accompanied Alexander Burnes in his mission to Kabul, and afterwards performed one of the most remarkable journeys that has ever been undertaken in Central Asia. Wood made a survey of the Indus from its mouth to Attock. At Kalabagh, the point where the mighty stream escapes from the Salt Range, he found it impossible to stem the current. Undaunted by the difficulty, Wood landed and went by forced marches to Attock, thence descending the river and completing his survey amidst the falls and rapids. After reaching Kabul he crossed the mountains to Kunduz, and was eventually the first European, except Marco Polo, who ever reached the "Bam-i Dunya" or roof of the world. Thus in 1838 Wood discovered the source of the Oxus, and for this splendid achievement he received the Gold Medal of the Royal Geographical Society in 1842.[1] Afterwards Commander Grounds and Lieut. Stroyan surveyed the rivers in the Punjáb, and were so employed for two or three years. Their plans were recently discovered in a box at Bombay, with other valuable originals, by Commander A. D. Taylor.

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valuable public servant was fully recognized, and his loss was much felt in Western India. Captain Wood died in London on November 13th, 1871. (See *R. G. S. Journal*, xlii. p. clvii.)

1 "Memoranda on the River Indus," by Lieut. John Wood.—*Bombay G. S. Journal*, vol. i.

"Report on the source of the Oxus, by Wood."—*R. G. S. Journal*, x. p. 520.

"Personal Narrative of a Journey to the Source of the River Oxus, by the Route of the Indus, Kabool, and Badakshan," by Lieut. John Wood. (1845.) A second edition, with an essay on the geography of the valley of the Oxus, by Colonel H. Yule, C.B., was published by Mr. Murray in 1872.

"Selections from the Records of the Bombay Government," No. 17.

There are several manuscript maps by Lieut. Wood in the Geographical Department of the India Office. A series of sheets of the Indus and a chart of the Indus from Mittun to Attock in 1838, four sheets, on a scale of two inches to the mile, not coloured.

The original MS. maps, showing the routes of Lieut. Wood in Central Asia, are also preserved in the Geographical Department of the India Office. They consist of a map of the upper valley of the Oxus from Kunduz to its source, showing the new ground explored by Lieut. Wood, 1837–38; a survey of routes from Peshawur to Bamian, with sketches and sections of the Khaibar and Hindu Kush passes; the route of Burnes's mission to Kabul, in the sheets, and the whole of Burnes's route from Kabul to Bokhara, and thence through Persia to Bushire, in nine sheets, drawn by Lieut. Wood. There are also a set of route surveys in Turkistan (seven sheets), and a reconnoitring survey of the Khawk pass, the most easterley from Kabul to Balkh in Turkistan.

At about the same time Lieut Wyburd of the Indian Navy penetrated into Central Asia, and his fate still remains a mystery

Meanwhile Lieut Carless, in the "Palinurus," had carefully surveyed Karáchi, and the whole coast from the eastern mouth of the Indus to Sunmiyáni, in 1837 and 1838[1] The Indus mouths were again surveyed, in 1846, by Captain Selby, assisted by Midshipmen Taylor and Stroyan, in the "Tapti" brig He drew maps shewing the great swatch way in which, in a regular line of 9 to 10 fathoms, there is a sudden dip of 40 to 68 fathoms, and so to 120 He concluded this to be the vast bed of the Indus before it had brought down the mountains of soil which now divide its stream into so many channels These maps have never seen the light Subsequently the operations of the Punjáb campaigns led to the formation of an Indus Flotilla, under the command of Captain Powell, to ascertain the capabilities for navigation both of the Indus and of its Punjáb tributaries In 1847 Lieut Christopher, with this view, went up the Sutlej and the Chenab in the steam tender "Meanee," with an iron flat laden with merchandise in tow, and made full reports of his observations[2] Lieut Christopher joined the force before Multan under Herbert Edwardes in 1848, and was killed during the siege In 1848 and 1849 the whole coasts of Sind and Kach, including the entrance to the gulf of Kach, and part of the lower Delta of the Indus, were surveyed on a large scale by Grieve and Ward In 1852-53 the Katiwár coast from Bait to Purbunda was surveyed by Constable and Stiffe, and thence completed to Diu Head in 1853 54 by Grieve and Constable An elaborate survey of Karáchi Harbour was made by Captain Grieve in 1853 54,[3] assisted by Lieuts Constable, W H Barker,

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1 "Memoir to accompany the Survey of the Delta of the Indus, in 1837," by Lieut Carless —*R G S Journal*, viii p 328 "Bombay Selections," No 17 In the Geographical Department of the India Office there are three copies of a MS map of the Indus, from Haidarabad to the sea by Lieut Carless The extension of the Indus Delta to seaward is progressing at a prodigious rate, it was partially re-examined by Lieut Stiffe in 1867, and will require periodical re-examination

2 "Report of an experimental voyage up the Indus and Sutlej," by Lieut Christopher —*Bombay G S Journal*, viii p 144

"Journal of an ascent of the River Chenab," by Lieut Christopher —*Bombay G S Journal*, viii p 236

3 In two sheets on a scale of eight inches to the mile When Mr Walker drew up his report on Karáchi Harbour he acknowledged his indebtedness to the excellent chart by Captain Grieve This meritorious officer co-operated with Mr Parkes in his examination of the harbour until his sudden death on Jan 17th, 1858 Mr Parkes took Grieve's chart as the general basis of his survey of Karachi Harbour

and Stiffe Grieve had finished the Sind, Kach, and Katiwár coasts, as well as his survey of Karáchi, just before his untimely death He was one of the ablest surveyors in the Indian Navy

Sir Charles Malcolm presided over the Indian Navy from 1827 to 1838 In the latter year Sir Charles was succeeded by Captain Robert Oliver, R N, who had to recall all the surveys in consequence of the breaking out of war, and from 1839 to 1844 surveying operations were almost entirely suspended Even when, after the latter date, a few surveys were sanctioned, they were confined to the narrowest limits, the officers were miserably found both as regards vessels and instruments, their allowances were cut down, and the acquisition of all knowledge beyond bearings and soundings was coldly discountenanced

But officers who had been trained by Moresby and Haines, and whose zeal had been encouraged by Sir Charles Malcolm during so many years of progress, could not so easily be turned from their useful careers They worked on, in spite of official discouragement In 1823 an observatory had been formed at Colaba, the sea-girt spit of land south of Bombay, and Mr Curnin received the appointment of Company's Astronomer, but the instruments supplied to him were so bad that he refused to make use of them Other instruments were sent out in 1835, and remained unpacked for five years The transit instrument was put up at last, in 1840, and since September 1841 a regular register of magnetic and meteorological observations, commenced by Mr Orlebar, has been kept Time is also observed for rating ships' chronometers In Sir Robert Oliver's time, the chart office of the Indian Navy was one little corner of the sail loft in the dockyard at Bombay, where numbers of valuable documents were eaten by white ants and cockroaches The office of the draughtsman of the Indian Navy was afterwards removed to the observatory at Colaba, by Sir Robert Oliver, and here the chronometers of the Indian Navy and Merchant vessels were rated, and the charts were compiled, drawn, and occasionally lithographed Captain Montriou succeeded Lieutenant Houghton in this office, which he held from 1847 to 1852, and drew up the information called for in the Parliamentary Paper printed in 1852 He was succeeded by Lieut Fergusson, who held the appointment until the end came in 1862 The establishment consisted of the draughtsman, and two natives for copying, and its whole cost was under 500*l* a year

In 1844 a few surveys were again permitted, but in such a niggardly spirit that an officer making geological or other scientific investigations apart from sounding with the lead was obliged to pay his own boat hire! Captain Sanders[1] was sent in the "Palinurus" to continue the portions of the Arabian coast left unfinished by Captain Haines, assisted by Lieutenants Fell, Constable, Ward, and Whish, and accompanied also by that accomplished naturalist and geologist Dr H J Carter The work was completed by Lieutenant Grieve in 1845, who also, assisted by Lieutenant Ward, carefully surveyed the islands lying to the west of Socotra [2] The second survey of the Arabian coast enabled Dr Carter to make and record those valuable geographical and geological observations, which have since, from time to time been published [3]

Sir Robert Oliver, the second Commander-in-Chief of the Indian Navy, died at Bombay, and, after a short interval, was succeeded in 1849 by Captain Lushington, who set several useful surveys on foot, and did his best to restore the service to the state of efficiency it had attained in the days of Sir Charles Malcolm

From 1844 to 1847 Captain Montriou, assisted by Midshipmen Taylor, Whish, Nixon, Lamb, and Dickson, surveyed the anchorages of Vijayadrug, Ratnagiri, and others south of Bombay in the "Tapti"

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[1] Captain Sanders died at sea, near Malta, on his way home in 1848

[2] The sailing directions for the Arabian coast and Socotra have been drawn up by Commr Ward "The Gulf of Aden Pilot," compiled by Comm C Y Ward, H M I N (Published by the Admiralty in 1863)

[3] In 1846 Dr Carter published an account of the ruins of "El Bellad," formerly a town on the shore, in the province of Dafar, on the south east coast of Arabia, in the *R G S Journal*, xvi p 187, and with additions in the *Bombay G S Journal*, vii p 225, with a plate In 1847 his notes on the Gurrah Tribe of the south east coast of Arabia appeared in the *Journal of the Bombay branch of the Asiatic Society*, ii p 195 with a plate Also notes on the Mahrah Tribe of the south east coast of Arabia, with a vocabulary of their language, and further notes on the Gurrah, iii p 339, and a description of the frankincense tree of Arabia (*Boswellia papyrifera*), ii p 380 His "Memoir on the Geology of the South east Coast of Arabia" is in the same journal for 1852, iv p 21, and the second edition, which is the best, will be found in the "Geological Papers on Western India" (1858), p 551

Dr Carter's admirable geographical description of the south east coast of Arabia, together with an essay on the comparative geography of that coast, was published in the number of the *Journal of the Bombay branch of the Asiatic Society* for January 1851 It has since been reprinted separately

He also wrote a paper on the igneous rocks of Maskat and its neighbourhood, and on the limestone formation at their circumference, in the *Journal of the Bombay branch of the Asiatic Society*, No xiii (1850) brig, but was frequently called away to assist in quelling the Sawant-Wari insurrection. Captain Selby, in the "Palinurus," with Lieuts. Ward, Sweny, May, and Bewsher, having the "Nerbudda" cutter commanded by Midshipman Charles Foster, as a tender, trigonometrically surveyed the coast of India from Cape Comorin to Beypur. The northernmost Laccadive Islands next the Sesostris and Padua banks were carefully examined in the "Tapti" by Selby, assisted by Taylor, in 1848. Selby constructed a map of a constant circular current prevailing between the Malabar coast and the Laccadives, which was not published, and the want of it caused the loss of one of the P. and O. steamers.[1] In the memoir which accompanied his drawings, Captain Selby described the remarkable mud bank at Alepy, and entered at some length on the effects of the fearful cyclone of 1848 in the Laccadive group.

Captain Lushington seems to have systematized and put fresh vigour into this somewhat desultory work. During 1850–52 Lieutenants Rennie and Constable, on board the "Euphrates" brig, filled in some of the gaps left by Ethersey on the North Konkan coast, while Lieutenant A. D. Taylor, assisted by Lieutenant Whish, with Barker, Stiffe, and Macaulay, surveyed the Gulf of Kach and coast of Katiwár on board one little *pattimar* and the "Maldiva" cutter. Lieutenant Taylor's survey was plotted on four sheets, on the scale of one inch to a mile, then reduced to one sheet by Whish and Stiffe. Their admirable chart is densely covered with soundings, and Taylor pointed out in his memoir the merits of the anchorages to the eastward of Bait Harbour. Indeed one important result of his labours was to establish the existence of good harbours suitable for the export of Gujrát cotton, which are two days to windward of Bombay.[2] The value of the splendid survey of Bait was practically tested in 1859, just after the Indian Mutiny, when the harbour was crowded with vessels for the attack on the fort occupied by the recalcitrant Waghers.

Captain Selby was engaged from 1848 to 1850 in making a very important chronometric survey of the Bombay bank of soundings, on board the "Tapti" brig, assisted by Whish, Sweny, Macaulay,

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[1] MS. letter from Captain Selby to Sir Henry Leeke, dated October 13th, 1855.

[2] "General description and sailing directions for the coast of Katiwár." (Bombay, 1855.) See also the important paper by Captain Taylor "On the Harbours of India," read at the meeting of the British Association at Liverpool, 1870. See also his "Report on the Harbours of India" (August 1870) in the papers on East India Marine Surveys, presented to Parliament in 1871.

and Foster At a distance of 100 to 150 miles from the shore there is a vast step or precipice some 2,000 feet deep, and the lead is all at once brought from 50 to 300 fathoms and no bottom But within this ridge, the bank, from Diu on the north to Ratnagiri on the south, has a gradual and well defined slope, so that by the unaided lead, and without seeing a heavenly body for days, the navigator may track his way safely and surely to his port [1] Captain Selby also surveyed the entire approach to Bombay harbour from about 17° 30 N to 19° 30 N , and connected the North Canara with the Gujrát coast, including the tail of the Malacca banks

The labours of officers of the Indian Navy have been the chief means of bringing the Somali coast of Africa to our knowledge

In 1838 Captain Carless had made a beautiful survey of the African coast from Ras Hafun to Ras Gulwaini, assisted by Lieutenants Grieve and Selby The results of Captain Carless's labours would probably have been lost had not the steam frigate "Memnon," under the command of Captain Powell, been wrecked on that coast on the 10th of August 1843 She was supplied with a little outline chart, the result of Captain Owen's running survey of 1823–26 The question was asked whether Owen's was the best chart in existence, and it then came out that Carless had made an elaborate survey and drawn charts of the coast some years before the wreck of the "Memnon " His chart was *then*, when the mischief had been done, ordered to be engraved. Lieutenant Barker examined the coast S W of the straits of Bab el-Mandeb and the Gulf of Tajura in 1840, and two years afterwards he accompanied the embassy of Major Sir W C Harris to the Abyssinian King of Shoa, as astronomer Lieutenant Christopher was Barker's assistant on the African coast, and near the mouth of the Juba he discovered the Haines river, which flows for many miles parallel to the coast, and terminates in a deep lake about 50 miles N E of the mouth of the Juba Lieut Grieve, in 1848, surveyed the Somali coast between Berbera and Ras Gulwaini, and the islands between Socotra and Cape Gardafui, thus completing the Gulf of Aden , and also compiled a fine chart of the whole, as far as Socotra He was a very accomplished draughtsman, and rapid surveyor The Somali coast was also visited and reported upon by Lieutenant Cruttenden in 1848, who was then Assistant Political Agent at Aden , and Lieut Stroyan

1 "Bombay G S Journal," xii p xx

was killed when serving on this coast, with the expedition of Burton and Speke These officers have recorded the results of their observations in several papers Lieutenant Christopher kept a journal, and noted down his inquiries into the resources of N E Africa,[1] Lieutenant Barker wrote on the same subject,[2] and Lieutenant Cruttenden published two memoirs on Eastern Africa and on the tribes of the Somali coast [3]

On the Bengal side, when Daniel Ross retired, his second in command, Captain Lloyd, succeeded as Marine Surveyor General, with James Young, Fell, Rennie, and Montriou as his assistants Lloyd had been in the survey department under Daniel Ross since 1823 In 1833 he had one brig, with which he conducted a survey of the inland navigation of Arakan, but, after the first season, his operations were put a stop to by severe illness, contracted by much exposure in that unhealthy climate On his restoration to health, he, in 1835, surveyed the river Hughli from Sagar Island to Calcutta, carefully connecting his work with the base line measured by Colonel Everest on the Barrackpur road In 1840 he completed the survey of the sea face of the Sundarbans from Chittagong to Hijili, the results of which he submitted to Government in the form of carefully drawn charts and a most valuable and interesting memoir He compares the state of the coast at the dates of different surveys, and his remarks, in showing the changes that are taking place, prove the urgent necessity for periodical revisions of the surveys He also describes the remarkable phenomenon at the head of the Bay of Bengal, similar to that reported by Captain Selby off the mouths of the Indus, called the "swatch of no ground" It is a deep chasm, open to seaward and very steep on the north-west face, with no soundings at 250 fathoms [4] Captain Lloyd also surveyed the Chittagong river, and made additions to Ross's survey of the Mergui Archipelago, a short account of which he published at

[1] "Bombay G S Journal," vol vi "R G S Journal," xiv p 76 There is a MS extract from the Journal of Lieut Christopher (H C Brig "Tigris") on the N E coast of Africa, May 8th, 1843, kept in the Geographical Department of the India Office

[2] "R G S Journal," xviii p 130

[3] "Bombay G S Journal," viii p 177, and "R G S Journal," xviii p 136

See also a paper by Lieut Fraser, I N, relative to the River Juba —*Bombay G S Journal*, xvi p 78

[4] "The nautical remarks to accompany a survey of the sea face of the Sunderbunds," by Captain Lloyd, dated February 1841, are preserved in the Geographical Department of the India Office, in manuscript

the time Ross had laid down the outer islands between 1827 and 1830, and Captain Lloyd filled up the inner portions, and delineated the coast line.[1] The coast of the island of Cheduba was surveyed for the Indian Government by Captain Halstead, R.N., in 1840.[2]

On the retirement of Captain Lloyd in 1840 the Marine Surveyor Generalship at Calcutta was abolished, but Captain Fell was employed from 1841 to 1848 on board the brig "Krishna" in finishing detached surveys on the Coromandel coast, along the Pegu and Martaban shores, and on the north coast of Sumatra.[3] In 1851 he was engaged in compiling a chart, in three sheets, of the whole survey of the Coromandel coast from Palikat to Bimlipatam.

Captain Ward succeeded Fell in the command of the "Krishna." Between 1851 and 1859 he laid down the Mutlah river, the Preparis north channel, the Bassein and Rangoon rivers, the Malacca strait,[4] and Penang. Captain Ward also made surveys of the Sittang river and of the main branch of the Irawadi, but nothing has been heard of them since he sent in the drawings to the Government. Finally Lieutenant Heathcote was engaged upon the surveys of the Bay of Bengal from 1856 to 1862. In the former year he made a survey of the western entrance of the Hugli, from Kaokali to the Pilot Station at the Sand Heads. It was undertaken because the Gaspar channel, that commonly used, was becoming dangerous owing to accumulations of sand, and threatening to obstruct the traffic to Calcutta. This survey, which required very great exactness, was performed in the surveying vessels "Krishna" and "Spy," and the chart was drawn on a large scale, showing the depth of water to feet. It was accompanied by a report upon all the channels of the Hugli, comparing their present form with that which they showed upon the last surveys, and showing the amount of accumulation that had taken place in the intervals. The work was connected with the stations of the Great Trigonometrical Survey. Since Captain Lloyd's time there has always been

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1 "Journal of the Asiatic Society of Bengal," vii., pt. ii. p. 1027.

2 In H.M.B. "Childers." See Admiral Halstead's interesting "Report on the Island of Cheduba."—*J. A. S. B.*, vol. x., pt. i., p. 349.

3 There are printed sailing directions by Captain Fell for the coast of Pegu and Gulf of Martaban, dated March 4th, 1852, and MS. sailing directions for the north coast of Sumatra from Achin Head to Diamond Point, in the Geographical Department of the India Office.

4 Sailing directions for the Malacca Strait, by Captain Ward, are published in the last edition of "Horsburgh's Directory."

a river surveyor for the Hugli, with a small flotilla consisting of one brig, one schooner, one anchor or buoy vessel (the "Grappler") and four row boats Steam power is not yet used in this service, and the loss of time is great The surveyor has had to work on under great difficulties, and without qualified assistants

In 1855, Captains Rennie and Heathcote were appointed to accompany Sir Arthur Phayre's Mission to the Coast of Ava, with instructions to make such a survey of the Irawadi above the British possessions, as opportunities offered The circumstances were favourable for astronomical observations of all kinds The geographical positions of places and points were fixed, and a sketch survey of the rivers was forwarded to Calcutta, and afterwards lithographed for use in navigation A section of the Irawadi at a point a little above Ava was obtained, and the volume of its discharge at that point calculated [1] In 1861, Captain Heathcote was employed by the Admiralty to compile a chart of the bay of Bengal, and in 1857 he had made some additions and corrections on the Arakan coast He also made a chart of the currents of the S W Monsoon in the bay of Bengal, intended as an accompaniment to Taylor's chart of the Arabian sea for the same season The currents were worked out from a great number of the logs of the old Indiamen [2]

Lieutenant Sweny completed the Coromandel coast from point Calimere to Palikat in 1860

The survey of the rivers Euphrates and Tigris, and of that region of Mesopotamia, which, for its historical associations, its capabilities, and the importance of its geographical position, surpasses almost any other country in the world, is mainly the work of the Indian Navy [3] During upwards of 26 years the accomplished and persevering officers who executed the Mesopotamian Survey continued to work in the face of great difficulties and dangers, and for this alone the Indian Navy takes rank among the foremost contributors to geographical knowledge

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[1] For an account of the manner in which this running survey of the Irawadi was performed, see the *Journal of the Royal United Service Institution*, appended to a paper by Admiral Collinson on the "Survey of Rivers"

[2] The chart was sent to the India Office, and is printed, together with the Memoir which accompanied it, in the *R G S Journal for* 1862

[3] In 1826–30 Lieutenant Ormsby, leaving the Indian Navy, had devoted three years to exploring Mesopotamia His adventures are described by Wellsted in his "Travels to the City of the Caliphs" (2 vols, London, 1840)

After the time of Colonel Chesney, his second in command, who was nearly lost in the ill fated "Tigris," had charge of the survey in Mesopotamia This was Henry Blosse Lynch, an excellent scientific observer and daring explorer, who had commenced his career in the Persian Gulf Survey In 1837 Captain Lynch, C B, traversed the whole course of the Tigris from its source in Armenia to Baghdad, fixing the chief positions by astronomical observations, and others by cross bearings He then connected Nineveh, Baghdad, Babylon, and Ctesiphon by triangulation, and, when he completed the Tigris map in 1839,[1] his mind was full of interest in his work, and he exclaimed that the field of operations, instead of diminishing, appeared to extend

In October 1841 Lynch commenced the survey of the Euphrates by measuring a base on the level plain between Balis and Giaber He had the steamers "Nitocris," "Nimrod," and "Assyria," and was assisted by Lieuts Felix Jones, Campbell, Selby, and Grounds After ascending the river, it was connected with the Mediterranean by chronometric measurements [2] Captain Lynch retired from the survey in 1843, and his assistant, Felix Jones, succeeded him

Felix Jones had already seen service in the Red Sea Survey, in the Maldives, in Ceylon,[3] and in the Manar Gulf, and he had reported upon the harbour of Grane or el-Kuweit in 1839, since which time he had been serving under Captain Lynch in the Euphrates He was stationed at Baghdad, in command of the "Nitocris" steamer, and had other duties besides surveying, but every year he succeeding in completing some interesting and valuable surveys,

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[1] The map is on a scale of 12 inches to a degree

See "Note on a part of the River Tigris between Baghdad and Samarrah"—*R G S Journal*, ix p 471

"Note accompanying a survey of the Tigris from Ctesiphon to Mosul'—*R G S Journal*, ix p 441 Captain Lynch was ably assisted in this survey by his brother Michael Lynch, whose constitution did not equal his zeal, as he died from the effects of hard work and exhaustion at Diabekir This officer had suffered before from the climate of the Maldives

[2] "Memoir of the River Euphrates, in three parts, to accompany the map"—*Bombay G S Journal*, vi p 169

"Memoir of the country between Baghdad and the Hamreed hills," by Lieut Grounds—*Bombay G S Journal*, vol vi

[3] While employed here he visited and fixed Adam's Peak and the Horton Plains, descending by the Caltura River, of which he made a survey, in company with Major General Adams, who fell at Inkerman They pushed their way over the higher ranges by the Elephant paths, there being then no constructed roads

although for a great part of the time he was almost single handed In such a region it was impossible to go in any direction without meeting with work well worth the doing, and Felix Jones made the best use of his opportunities The country, infested by wild tribes of Arabs, was frequently dangerous, and it was necessary to seize upon any chance that offered for exploring and surveying

In 1844 Captain F Jones accompanied Sir Henry Rawlinson on a journey to collect information respecting the boundary between Persia and Turkey The results were a memoir and map of a country but little known In 1846 he made an ascent of the Tigris, from Baghdad to Samarrah, on board the "Nitocris"[1] In 1848 he undertook a journey to determine the course of the ancient Néhrwán Canal, and to survey the once fertile region which it irrigated,—now a desolate and almost impassable waste His interesting memoir on the Néhrwán Canal, accompanied by a map, gives the history of the work from the days of its construction in the time of the Sassanian dynasty, and minutely describes its vast brickwork dams and sluices In April and September 1850 Captain Jones surveyed the old bed of the Tigris, discovered the site of the ancient Opis, and made researches in the vicinity of the Median wall and Physcus of Xenophon In 1852 he made a trigonometrical survey of the country between the Tigris and the Upper Zab, including the ruins of Nineveh, fixing positions by meridian altitudes of the sun and stars, with chronometric differences for longitude The results of this work are recorded in the beautiful maps of "Assyrian Vestiges," in four sheets, and in a valuable memoir During 1853 Captain Felix Jones, assisted by young Collingwood, then a mid shipman, completed a map of Baghdad on a large scale, with a memoir on the province full of statistical information,[2] and in 1854 he sent home his maps of Babylonia They consisted of three sheets with a detailed memoir, and included the country from Museyb, north of Hillah, down to the N W end of the sea of Nejf Unfortunately these maps were lost in the India House[3]

1 "R G S Journal," xviii p 1

2 The memoirs and maps by Captain Felix Jones will be found in the "Bombay Selections, No xliii (New Series) Most of the memoirs were reprinted in the "Transactions of the Bombay Geographical Society"

3 In the survey of Nineveh and Babylon he was much indebted to Dr J M Hyslop of the Bombay Army, for valuable aid in the field operations, and to Mr T K Lynch, now Consul General for Persia in London, who entered *con amore* into the work from a love of research alone.

In 1846 Captain Felix Jones compiled a general map of Mesopotamia, from Scanderoon on the Mediterranean to el-Básrah, which was based on the surveys by Chesney, Lynch, and himself Captain Jones retired from the Mesopotamian Survey, to take up the post of Political Resident at Bushire in the Persian Gulf, in 1855 He possessed all the knowledge and tact which were necessary for an officer in his position For the work of the Mesopotamian Survey several acquirements were essential in addition to those of a surveyor, such as an acquaintance with the language and ancient history of the country, tact and judgment in dealing with wild Arab tribes, and capacity for enduring fatigue and privations All these were possessed by Felix Jones in an eminent degree In 1857, while he was Political Resident at Bushire, the Persian war broke out This he had foreseen and provided for by furnishing to the Government of India an elaborate plan for invasion, containing itineraries through Persia, and guides for the Commissariat Departments of the Army and Navy This paper obtained for him great commendation under Earl Canning's own hand [1] Assisted by Captain Malcolm Green, he made a survey of the Shattu 'l 'Arab, including the Karûn, which enabled Sir James Outram to attack Muhâmmerah

Captain Selby took charge of the Survey of Mesopotamia in 1855 He had previously done very important service in the spring of 1842, by ascending the Persian Rivers Karûn and Dizful in the E I C steamer "Assyria," thus demonstrating their navigability [2] He had with him in the Mesopotamian Survey Lieuts Collingwood and Bewsher as assistants These officers made a trigonometrical survey of the region west of the Euphrates, including the sea of Nejf, which is fed by that river, and embracing the classic sites of Meshed 'Ali, Birs Nimrûd, Kerbela, Kufa, and Babylon, and the portion of Mesopotamia from Samarrah on the Euphrates to a point about 10 miles above Baghdad on the Tigris The former portion was completed and sent home in 1861, with an elaborate memoir by Captain Selby But both maps and memoir were lost, through some unaccountable carelessness The original maps and field books have, however, been procured from Baghdad, and the maps have been redrawn by Lieutenant Collingwood, and engraved Lieutenant Collingwood also sur-

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[1] "Indian Records, Political and Secret"
[2] "R G S Journal," vol xiv p 219

veyed and drew maps of the Shattu-'l-'Arab from el Basrah to Makil, and of the course of the old Hindiyeh Canal, near Meshed Husain. This valuable work has recently been rescued from destruction at Bombay, by Captain A. D. Taylor. Captain Selby and Lieutenant Collingwood, while tracing the old bed of the Euphrates with great care, and surveying the Bahr el Nejf, were exposed to much harassing work among the marshes. They also sent in accurate plans of the irruptions from the Tigris, and showed that, before long, if no efficient steps were taken to check the evil, that river would be as unnavigable as the Euphrates now is.

The latter portion of the survey from above Baghdad to Tel Ibrahim, and from Tel Ibrahim to Simarrah on the Euphrates, was commenced in October 1862. In the end of that year Captain Selby retired, and Lieutenant Bewsher, who then took charge of the work that had thus been begun, completed it in 1865. The maps (seven in number) have been engraved in two sheets, and Bewsher's memoir[1] contains an interesting account of the ancient canals which can still be traced, and some details respecting the humbler modern system of irrigation. The ability and learning shown in this memoir are proofs that Lieutenant Bewsher would have been a worthy successor of the earlier surveyors, but he died of diseases contracted during the service, and the Government abruptly put a stop to the survey, leaving it incomplete, and with much work still to be done.

The survey of the west coast of India, south of Bombay, with the exception of some roadsteads and detached bits of coast laid down by Montriou, and the portion from Beypur to Cape Comorin by Selby, had not been revised since the old charts were drawn by McCluer in the last century. This most important work was entrusted to Lieutenant A. Dundas Taylor, who received the command of an old *pattimar*, the "Pownah," afterwards exchanged for the "Bheema." He was assisted by Lieutenant Sweny, and Mates May, Bewsher, Williams, and Lewis, and commenced work in 1853. The whole of Taylor's work is admirably executed on a trigonometrical basis, with bases measured on shore, and is included in six sheets of the

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[1] "On the part of Mesopotamia contained between Sheriat el Beytha, on the Tigris, and Tel Ibrahim." By Lieut. Bewsher, I.N.—*R. G. S. Journal*, xxxvii. p. 160.

coasts of South Konkan, Canara, and Malabar [1] It occupied six years, from 1853 to 1859 He also surveyed the harbour at Karwar, the anchorages at Beypur and Cochin, and the Bay of Korangi[2] on the east coast in 1857 There is no man living who is so intimately acquainted with the anchorages on the Indian coast from the mouths of the Indus to those of the Godavari, or who so completely understands their capabilities for improvement After his return to England he drew up a volume of sailing directions for the west coast of India [3] Lieutenant Williams afterwards completed the coast from Boria to Bombay These coast surveys were ably supplemented with deep sea soundings by Lieutenant Foster in the cutter "Nerbudda"

In 1859 Lieutenant Whish examined and reported upon the harbour in Bahrein Island and on a channel called the Khaur-el-Bab,[4] and in the following year he made a complete survey of Bombay harbour on several sheets on a large scale, which has since been reduced and published by the Admiralty

In 1860–61, under instructions from the Government of India, Mr William Marshall, senior midshipman of H M gunboat "Clyde" of the Indian Navy, then stationed at the Andaman Islands, made a trigonometrical survey of Port Blair, which has since been published by the Admiralty He also made rough surveys of Port Meadow, Middle Straits, and part of Great Coco Island, all of which were lithographed in India The natives of these islands being very savage, the surveys were executed in boats fully manned and armed, and before taking observations on shore it was generally necessary to station outposts in the jungle to prevent surprises Mr Marshall also discovered, by several chronometric measurements taken between Bombay, Madras, and Calcutta, that the Andaman Islands were placed eleven miles too

1 John Edye, Esq , who was master shipwright at Trincomalee in 1832–38, wrote a valuable paper on the sea ports of the Malabar coast, with remarks on the poon spars, coir fibre, and a list of timber in the forests, and another describing the native craft in use on that coast *See* "Journal of the Royal Asiatic Society,' i , p 1, and ii , p 324

2 Korangi (Coringa Bay), it will be remembered, was surveyed by Michael Topping in 1790, and Lieut Warren in 1805 *See* p 7 There is also a chart by Lieut Fell, 1846 and Dalrymple engraved a plan of Coringa roads by Wm Stevens, dated 1773

3 "West coast of Hindostan Pilot, including the Gulf of Manar, the Maldivh and the Lakadivh Islands,' compiled by Com A D Taylor, H M I N (Published by the Admiralty in 1866 )

4 "Memoir on Bahrein,' by Lieut Whish, I N—*Bombay G S Journal*, xvi p 40

far to the westward on the charts, and that the Great Coco Island was placed six miles too far to the westward of Port Blair

One of the last and not the least important work of the officers of the Indian Navy has been a careful revision of the old survey of the Persian Gulf in 1857–60, by Captain Constable, assisted by Lieutenant Stiffe

Captain Constable had for many years taken a deep interest in the maritime geography of the Persian Gulf, and had gradually collected a large mass of material with a view to preparing a sailing directory, with a description of the shores and islands A vast number of omissions and inaccuracies had been discovered in the old survey from time to time, and there was a weight of evidence to show that the knowledge of the gulf was very imperfect One remarkable instance of the unreliable character of the old charts was furnished by Commodore Carless in 1848, when entering the gulf on board the "Elphinstone" He found that a shoal marked on the chart as three miles from the Persian coast, really extended seven or eight miles to seaward Numerous other discoveries of the same character had been reported There is no published chart of the Shattu 'l Arab from el-Básrah to the sea,[1] and no marine survey of the Island of Karak[2] In 1846 Captain Carless[3] went to the gulf with eight chronometers and proved that the longitude of Bassadore was nearly correct with reference to Bombay but that Bushire was eight miles too far west[4]

It was abundantly clear that there existed a pressing necessity for a revision of the Persian Gulf Survey, and Lieutenants Constable and Stiffe were commissioned to execute it in 1857 They had the brig "Euphrates" from 1857 to 1858, and the schooner "Marie" from 1858 to 1860 Their revision of the old survey consisted in carefully determining certain positions round the gulf by observed latitudes (the altitudes all being taken with artificial horizons) and longitudes by chronometer, with as much triangulation in the vicinity of the fixed positions as time would admit of They com

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1 Lieut Collingwood made one, and so, I believe, did Capt Felix Jones, but both have been lost

2 Dalrymple published a plan of this island from a French MS in 1787, and Ensign Anderson (afterwards murdered at Multan) made a trigonometrical survey on a scale of $6\frac{3}{8}$ inches to a mile in 1839, on which every ravine and fissure is accurately laid down, but there is no marine survey of its shores

3 This officer died in 1848

4 "Memoir relative to the hydrography of the Persian Gulf," by Lieut Constable, I N —*Bombay G S Journal*, xii p 98

piled a general chart of the Persian Gulf in two sheets in 1860, which is thus a correct skeleton of the islands and principal points round the gulf, with some detail of the coast line round the fixed positions triangulated, and the remainder adopted from the old charts [1]

Lieutenant Stiffe now holds the post of engineer and electrician of the Persian Gulf Cable He is one of the most able, scientific, and accomplished of those surveyors who made the Indian Navy famous, and though his immediate duties are now unconnected with surveying, he has never missed an opportunity of improving, correcting, or adding to the charts

The subject of winds and currents in the Indian seas, to which Major Rennell devoted so much attention, has been carefully studied since his time Lieutenant A D Taylor compiled a chart of the Arabian Sea with great care, showing the winds and currents during the S W monsoon, by a comparison of upwards of a hundred logs of vessels of the Indian Navy [2] and Lieutenant Heathcote made a similar wind and current chart of the Bay of Bengal Lieutenant Fergusson, the draughtsman of the Indian Navy, also prepared three sets of charts, each set containing a chart for every month in the year, showing the winds and currents of the Red Sea, Persian Gulf, and Indian and China seas [3]

Henry Piddington, of Calcutta,[4] was, however, the great contributor to the study of the law of storms His attention was first turned to the subject by the reviews of Colonel Reid's work, and he tells us that it was, to him, a subject connected with many associations of his early life, and more especially with one instance in which to

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[1] "Persian Gulf Pilot, including the Gulf of 'Omân, compiled by Capt C G Constable and Lieut A W Stiffe, I N Published by the Admiralty (London 1864) Captain Constable's chart of the Persian Gulf was published by the Admiralty, and the hydrographer, the late Admiral Washington, sent it to the Great International Exhibition of 1862 as a good specimen of English chart drawing

Dr Carter reported on the geological specimens brought from the Persian Gulf by Constable and Stiffe, in the "Journal of the Asiatic Society of Bengal,' No 97, N S, p 41

[2] Sent home with a letter dated January 16, 1852, in which Captain Lushington called attention to Lieut Taylor's zeal, assiduity, and ability The chart was published in 1853, with a memoir

[3] Published in 1856

[4] Captain Piddington was Foreign Secretary to the Agricultural Society of India, Sub Secretary to the Asiatic Society of Bengal, Curator of the Museum of Economic Geology, and President of the Marine Court of Enquiry at Calcutta

the veering of a hurricane alone he owed his safety from shipwreck, after cutting away the mainmast of the vessel he then commanded His first memoirs on cyclones or circular storms were published in 1839 In the following year he received extracts from numerous logs preserved at the India House, furnishing records of hurricanes from 1780 to 1841,[1] and he thus accumulated proofs that these great storms are circular, that they turn from right to left, north of the equator, and that they are progressive He also made out the tracks on which they move, and their rates Mr Piddington continued to publish accounts of all important cyclones that occurred in the eastern seas from 1839 to 1851 This involved immense labour and research, the untiring and persevering collection of materials, and no small ability and judgment in their arrangement Each memoir was accompanied by a chart showing the course of the storm Mr Piddington was zealously assisted in his labours by Captain Christopher Biden, the Master Attendant at Madras [2]

The impetus thus given by the zeal of Captain Piddington to the study of the law of storms was communicated to the western side of India The great hurricane of April 1847, in which the "Cleopatra" was lost, was carefully observed, and remarks upon it were published by Captain Carless, of the Indian Navy,[3] and by Dr Thom, of the 83rd foot [4] Dr Buist afterwards collected accounts of hurricanes on the west coast from 1647 to 1847, and wrote a careful memoir on the subject of cyclones,[5] to which he added another reviewing the course of storms from 1854 to 1859,[6] and Lieut Fergusson published an account of the cyclone of November 1862 [7]

At Madras, Mr Franklin, the Master Attendant, published an account of the storms of October 20th and November 25th, 1846,

[1] "Journal of the Asiatic Society of Bengal," vol 11, pt ii p 605

[2] Captain Piddington published 23 memoirs on cyclones, in volumes 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, and 23 of the "Journal of the Asiatic Society of Bengal" He also published "A Horn Book of the law of Storms" Calcutta (Second edition) 1845 The sixth edition of Piddington's "Sailor's Horn Book of the Law of Storms," was published in London, by Williams and Norgate, in 1876

[3] "Journal of the Bombay Geographical Society," viii p 1

[4] "Journal of the Bombay Geographical Society," viii p 93

[5] "Journal of the Bombay G S," vol xii p xxv

[6] "Journal of the Bombay G S," vol xv p 19

[7] "Journal of the Bombay G S," vol xvi p 127

with diagrams,[1] and Lieutenants Mullins and Hemery of the Engineers described the cyclone at Nellor and Cuddapah on November 2nd, 1857[2] The full report on the Calcutta cyclone of October 5th, 1864, was drawn up by Colonel Gastrell and Mr H F Blanford, with maps and diagrams At the end there is a list of recorded storms in the Bay of Bengal from 1737 to 1865, chiefly from Piddington's Memoirs

In 1864 Colonel Fraser, who erected the lighthouses on the coast of British Burmah, made a proposition that monthly returns of wrecks should be furnished, with a view, first, to show the positions of wrecks on a chart, second, to show the general causes of losses at sea, and, third, to give a table of loss of life, cargo, and ships, with the value In accordance with this idea, the first wreck chart of India for 1864-65 was produced in 1865[3] Another was published at the Surveyor General's office for 1866, and a wreck chart of the approaches to Bombay harbour has been prepared with reference to the urgency of its being adequately lighted It shows the wrecks from 1826 to 1866, and was compiled by the Master Attendant Nor must the chart by Colonel Fraser, showing the lighthouses on the Burmese coast, with printed directions, be omitted in an enumeration of valuable publications for the use and guidance of navigators

In 1862 the Indian Navy ceased to exist, and all the surveys were abruptly stopped and left incomplete In his anniversary address to the Geographical Society for that year Sir Roderick Murchison said,[4] "The war services of the Indian Navy, as well as the " beneficial and enduring results of its repression of piracy and the " slave trade, are well known These services have been varied, " honourable, and useful, but in the eyes of geographers the wide " spread and lasting utility of the excellent surveys made by officers " of the Indian Navy hold an equally prominent place "

Before the Indian Navy had become a thing of the past, there was a destruction of the materials for its history Previous to 1860 there were many and most valuable records of that service in the India Office, but in that year nearly all were reduced to pulp The

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1 "Madras Journal of Literature and Science,' xii p 146
Ibid, iii, N S, pp 65 and 70
3 See page 47
4 'R G S Journal," vol xxxiii p cliii

charts, with the copper plates, original drawings, and sailing directions, were transferred to the Admiralty in 1861

The official records of the Bombay Marine and Indian Navy have been almost entirely destroyed Its history can now only be traced in the fragmentary memoirs, papers, and reports which have already been quoted and indicated by references Some statistical details will be found in a Parliamentary Paper called for by Mr Joseph Hume, and printed in August 1851 [1] It is much to be desired that before the generation of Indian marine surveyors passes away, one of their number would gather together the recollections of his colleagues, and with the aid of such fragments as have survived the general destruction, give to the world a history of the work done by the Indian Navy in war and during peace The history of its war services, containing such episodes as the gallant capture of the "Médée" by Henry Meriton,[2] Commodore Dance's action with Linois, and many deeds of daring in Persia, Burma, and China, combined with the splendid services of its surveyors, would form a very noble record [3]

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[1] "Statement of the nature and locality of the maritime surveys undertaken by the East India Company since 1820, and other papers connected with the subject"

[2] See *Brenton*, iii p 341, and *James*, iii, *p* 65 Captain Meriton was Master Attendant at Bombay in 1820

[3] In the "Foreign Quarterly Review" for July, 1845, (lxx p 454), there is an article on the surveys of the Indian Navy A work entitled "The land of the Sun" (1870) has been published by Lieut C R Low, late of the Indian Navy, giving an account of his services in the Red Sea and Persian Gulf, with notices of Aden, Perim, the Somali coast, the Andamans, and the ports in the Persian Gulf, &c Lieut Low has also written a history of the Indian Navy, which came out in numbers in "Colburn's United Service Magazine," from October 1876 to December 1877, and is about to be published separately

## 3
## THE MARINE SURVEY DEPARTMENT
## (1873—77)

IN March 1861 the marine surveys on the coast of India were practically abandoned The Secretary of State proposed to the Admiralty that in future the surveys should be conducted in vessels selected by the Bombay Government and paid by the Government of India, but that the hydrographer of the Admiralty should suggest what surveys ought to be taken up, and that the resulting charts and memoirs should be published under the authority and at the expense of the Admiralty all correspondence between the hydrographer and the surveyors passing through the India Office Admiral Washington, who was then hydrographer, pointed out the great practical inconveniences of such mixed responsibility, and expressed his inability to foresee how such an arrangement could work The India Office, however, insisted upon the arrangement that was originally proposed, and the discussion dropped But in August 1861 the Government of India was informed that the surveys then incomplete were to be finished by the Indian Navy, and that all future surveys and charts would proceed from the Royal Navy at Imperial expense It does not appear that the latter part of this alleged arrangement had ever been proposed to the Admiralty Admiral Washington submitted a list of the surveys that should be completed by the Indian Navy, and some of them have since been published by the Admiralty

From the date of the alleged arrangement in 1861, until the establishment of the Marine Survey Department in 1873, Indian marine surveys have been little attended to

The stock of charts and copper plates was handed over to the Admiralty,[1] but many original drawings and memoirs were lost, both at Bombay and in England They were the results of expensive surveys, and their loss is synonymous with the waste of many thousands of pounds It represents the cost of the surveys of which they were the results, as well as that of the future surveys which their loss has made necessary

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[1] The number of manuscript charts and plans was 264, of which 210 were obsolete

It is not clear what the arrangement with the Admiralty for securing the execution of necessary marine surveys really was, as there is nothing to show that the Admiralty ever heard of or agreed to the arrangement of which the Government of India were informed, in the Despatch, No 55 (Marine), 28th November 1862, para 14, namely, that in future "the surveys of the Indian Seas "would be conducted by the Royal Navy, at the expense of the "Imperial Government" But as the arrangement, whatever its exact nature may have been, entirely failed to secure the objects for which it was made, and as no survey of any part of the Indian coasts was undertaken by the Lords of the Admiralty after the abolition of the late Indian Navy it was represented by the Geographical Department of the India Office, in 1871, that some steps had become absolutely necessary The execution of marine surveys in the Indian seas, the periodical revision of old work, and the production of correct charts, are essential for the safety of the rapidly increasing ocean and coasting trade of India

There are sufficient reasons for the arrangement that was intended to have been made in 1862 having proved abortive The duties of the hydrographer of the Admiralty extend over the whole world, and the exigencies of the service seldom enable the Board to furnish him with the vessels and officers which he would consider necessary to execute needful surveys in the various seas and harbours The Indian seas would, at the best, only receive a proportional share of his attention, and it might be many years before he would consider that their requirements were more urgent than those of other parts of the world, with reference to the very limited means at his disposal It must also be remembered that the hydrographer has no special or local sources of information, through which he can learn the requirements of the Indian seas, as regards the revision and completion of surveys Vessels of the Royal Navy merely make ports, and probably never visit more than half a dozen out of the 300 ports which are frequented by the coasting vessels

But, from the point of view of the Government of India, the safe navigation of their coasts and of the surrounding seas is a question of the greatest importance, and the necessary surveys cannot be left unprovided for without the certainty of a vast amount of loss and misery, and without incurring a responsibility of the gravest kind Great dependencies are necessarily responsible for the due provision of means for approaching their coasts, in which respect accurate charts are even more essential than lighthouses Local Governments cannot afford to depend upon the share of attention that the Admiralty can enable the hydrographer to give to their coasts, in common with those of other seas and oceans throughout the world The Australian Colonies have found it necessary to employ surveying services of their own, and the fact that all surveys of Indian seas ceased for twelve years points to a similar necessity in India

The great ocean and coasting trade of India renders the provision of accurate charts on adequate scales a very important part of the duty of the Government, and although the present charts may be considered fairly to meet the requirements of general navigation, there was a good deal of work left incomplete in 1862, while several surveys will always require periodical revision

These considerations were sufficient to show the urgent need of some effective measure for securing the due execution and revision of marine surveys, and for the publication of accurate charts on adequate scales Only two courses were possible One had been tried, and had failed absolutely The whole responsibility was handed over to the Admiralty, and during the interval of twelve years that had since elapsed not a single survey had been undertaken in the Indian seas The other course was for the Government of India to organize a system for the survey of its own coasts, and to resume a responsibility which should never have been abandoned, and it was this course that the Geographical Department of the India Office earnestly advocated On March 30th, 1871, the question thus raised was referred to the Government of India

But it was three years before the matter was taken up in earnest, and it was then found that the need for some measure being adopted was most urgent Not a year passed without adding fearful proofs of the defective state of the charts Many charts, once accurate, had become obsolete, simply because no authority existed to record the changes effected by nature and by man from time to time It was impossible to exaggerate the hopeless state of confusion into which everything connected with marine surveys had drifted All traces of elaborate and expensive surveys had disappeared, important islands were still shown many miles out in longitude In Calcutta no correct list of the lights of the Bay of Bengal existed, and the wreck chart, the one document that professed to show all the lights, omitted four of them The Government of India could not fail to be impressed with the case as brought before them in the reports prepared in the Geographical Department of the India Office[1], and in a dispatch dated June 30th, 1873, it was requested that Captain A. D. Taylor of the Indian Navy might be deputed to Calcutta to assist in devising suitable means for restoring to efficiency the Indian Marine Survey Department, which had ceased to exist since 1861.

Captain Taylor arrived at Calcutta on the 22nd of December 1873, but before referring to the results of his investigations there, it will be well to enumerate the few pieces of marine surveying work that had been done between the date of the organization of the Geographical Department of the India Office in 1867 and the end of 1873.

In February 1871 Captain Robinson, the superintendent of Marine at Bombay, represented that a port on the Mekrán coast called Khor Rapsh should be surveyed, and that afterwards the Bahrein reef channels in the Persian Gulf should be taken up, including the approaches to el Katif and Deman, the north-east approach to Bahrein, and the unsurveyed bay south of Bahrein. Mr. Girdlestone, of the Topographical Survey, but formerly in the Indian Navy, was lent to perform this work in an old sailing schooner of 180 tons called the "Constance," with no good boats, no steam launch, and an insufficient staff of officers. She was away from March 8th to June 20th, 1871, yet the actual work only occupied four weeks. In a steamer, a surveyor could have done it all and returned to Bombay in five weeks, being a saving to Government of 650*l.* in pay and provisions. The inefficient equipment of a surveying vessel is, therefore, as wasteful as it is deplorable in other respects. Mr. Girdlestone completed a chart of the large inlet of Khor Rapsh, on the Makrán coast between Jashak and Chahbár, and ascertained differences of longitude by telegraph, between the Bombay Observatory and pillars which were erected at Gwadar, Chahbar, and Jashak.

In the autumn of 1871 the "Constance," under Mr. M. Chapman, took a series of soundings in the Gulf of 'Omân from Ras Jáshak to Ras as Shajar. Mr. Chapman, assisted by Mr. Thompson, then pro-

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[1] Also presented to Parliament. "Copy of Dispatch from the Secretary of State for India to the Governor General, of the 30th day of March 1871 (No. 7 Geographical) and its enclosures, on the subject of Marine Surveys in India." (India office, 22nd May 1871.) Asked for by Mr. Frederick Walpole. Ordered to be printed 7th July 1871.

ceeded to Bahrein and commenced the survey of the reefs, but in May 1872 nearly all the crew of the "Constance" were attacked with fever, and she returned to Bombay Mr Chapman had, however, completed a fair chart of Bahrein harbour and a portion of its adjacent reefs Being beyond the limits of British India this work will, for the future, fall to the province of the Admiralty In 1873 Lieutenant Stiffe of the Indian Navy compiled a new chart of the Makran coast, which has acquired some importance owing to the establishment of telegraphs along it since 1862 It is a revision of the old chart of Brucks and Haines in 1829, the longitudes being referred to that of the Madras Observatory, and the scale being the same as that of the Persian Gulf chart This chart has been engraved, and Lieutenant Stiffe has also drawn up detailed sailing directions for the Makrán coast

During the Orissa famine, the want of charts of that part of the coast was very seriously felt, and in 1869–70 the schooner "Gemini" was employed in surveying some of the creeks and harbours of Orissa, under command of Mr H A Harris, who had had 15 years experience in river surveying, having been assistant surveyor on the Hugli Nine charts were the results of this survey In 1869 a new survey of the Chittagong coast was completed, being a revision of that executed by Captain Lloyd

Before he left England for Calcutta, in the autumn of 1873, Captain Taylor completed the new edition of the first part of "Horsburgh's East India Directory"[1] This well-known work had already gone through eight editions since its original publication in 1809, under different editors, who added considerably to its bulk, without curtailing the original matter Captain Taylor's edition is, in reality, almost a new work He has adopted the system of brief paragraphs, dropped the marginal references, given abbreviations well understood by seamen, and introduced block printing of important names and words to catch the eye The opening of the Suez Canal necessitated a notice respecting the navigation of the Mediterranean, and Captain Taylor of course gives terse and succinct, but sufficiently complete directions for the Red Sea His introduction treats of the trade winds, monsoons, currents, land and sea breezes, storms, and cyclones, variation and deviation of the compass, and tides

During the winter of 1873–74 Captain Taylor prepared an exhaustive report at Calcutta, in which he reviews each chart and

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[1] See page 10 (*and note*)

plan, points out their deficiencies, and estimates their intrinsic and relative value, so that a most complete knowledge was thus acquired of the then existing requirements His proposal was that there should be a Superintendent of Marine Surveys with an office staff and a certain number of qualified surveyors, and he enters fully into all the details of present and prospective requirements After carefully considering this Report, the Government of India accepted the responsibility of completing and maintaining the surveys of the Indian coast line from the Pakchan estuary at the southern extremity of Tenasserim, to Sunmiyáni Bay on the western limit of Sind Beyond those limits all surveys must be undertaken by vessels and surveyors of Her Majesty's Navy, at the expense of the Imperial Government They also resolved to organise a small surveying flotilla

The whole annual cost of the Department was not to exceed 20,000*l*, and Commander A Dundas Taylor, than whom no man living has a more thorough knowledge of the subject, both from long experience and natural aptitude for the work, was appointed to be the first Superintendent of Marine Surveys

Thus, after a dreary period of 12 years, during which the surveys of the Indian coasts and the safety of the great mercantile fleet which frequents them, were entirely neglected, the Marine Survey Department was restored to efficiency The office of Marine Surveyor General was abolished on Captain Lloyd's retirement in 1840, after which time the work was carried on at hap hazard, with no efficient superintendence, and in 1862 it ceased altogether Its restoration to efficiency is an important measure which will be the means of preventing much loss, and of securing the safety of one of the largest mercantile fleets in the world, so far as accurate charts and reliable sailing directions can effect that object

Previous to the commencement of operations in India, Commander Taylor visited England in 1874, for the purpose of conferring with the Hydrographer at the Admiralty, more particularly respecting the selection of suitable officers of the Royal Navy as surveyors The Lords Commissioners of the Admiralty nominated six surveyors from the Royal Navy for service on the Indian coasts There were, however, still important duties connected with the preparation of charts and the projection thereon of the land surveys unprovided for, and these required qualifications and training of a special order To discharge these duties Mr R C Carrington of the Hydrographic Office, who had been highly recommended by Admiral Richards, was appointed, his post being that of Chief Civil Assistant to the Superintendent of Marine Surveys at Calcutta, with the title of Superintendent of the drawing branch The Admiralty placed at the disposal of Captain Taylor all those original charts and records in their custody which were the property of the Indian Government, and that officer selected those which he considered requisite to take back to India These originals, together with a goodly number of others that were found at Bombay doomed to destruction because frayed, insect-eaten, and dust stained, but fortunately rescued just in time, are now safely deposited in presses at Calcutta, and a catalogue of them has been printed

The catalogue of all the original and other documents deposited in the Marine Survey Office, Calcutta, has been compiled by Mr Carrington It comprises lists of the general and physical charts of India, and the coasts to the west, as well as of each section of the coasts of India from Karáchi to Tenasserim, and of the Andaman Islands, Ceylon, the Eastern Archipelago, and China Captain Taylor also prepared a useful review of all the Admiralty charts of British Indian coasts, showing in what respects they are incomplete and untrustworthy, and what surveys are required to render them adequate guides for navigation He cheerfully admitted, however, that the Admiralty charts are the best obtainable, and suggested that some of the wrecks and accidents were due to the fact that most merchant ships obtained for their use inferior copies of the Admiralty charts not corrected up to date Captain Taylor also made notes of the survey operations necessary between the Pakchan river and Karáchi Pending the extension of the Great Trigonometrical Survey throughout the length of the territory of British Burma, Captain Taylor did not recommend any minute maritime survey of the coasts, but supplementary soundings chiefly at the entrances of ports, where steamers now call or wish to call for commercial objects

The requisite surveys in the order of their importance were those of the Cattack coast from Point Palmyras to the south west for a distance of 270 miles, the Great Megna Flats or shoal water off the mouths of the Brahmaputra and Ganges (the latter river being one of those which bring down alluvial deposits that render periodical examination an absolute necessity), the Cocos, Andamans, and Nicobar Islands, the entrance of the Sittang River, the Gulf of Cambay, the Chittagong Coast from Fenny River to the Nauf River, the coast of Burma from Nauf River to the Pakchan, with further examination of the Mergui Archipelago as far southward as the Seyer Islands, or perhaps to Junk Salanga. Korangi or Coconada Bay required re-examination, owing to the silt brought down by the Godavari, which had had the effect of throwing the anchorage some two miles further northward. Future littoral changes were to be expected at the mouths of all large Indian rivers, the Indus, Narbada, Tapti, Kistna, Godavari, Mahanadi, Ganges, Brahmaputra, Arakan, Irawadi, and the Salwin, and also at the bars of minor rivers, notably Mangalur, Cochin, Negapatam, Narsapur, Chittagong, Rangoon, and Tavoy.

The first chart compiled under the orders of the new Marine Survey Department was received in England, and put into the engraver's hands in 1874. It is a chart of the West Coast of India from Sunmiyáni Bay, north of Karachi, to Pigeon Island, in latitude 14° south. It was compiled by Mr Carrington from the surveys of Ethersey, Grieve, Selby, Constable, Taylor, Ward, Whish, Stiffe, and Williams, 1835 to 1862, on the scale of three inches to a degree of longitude. Captain Taylor has issued three more charts uniform with the above, embracing the whole of British India.

By a resolution of the Government of India, dated October 25th, 1875, the duties of the Marine Survey Department were defined.

Systematic surveys of the coasts of India are to be carried on with suitable vessels efficiently equipped and manned. These surveys are to be connected with the shore surveys, and closed in on points already fixed by the Great Trigonometrical Survey. The original surveys of ports, harbours, and river entrances will be photozincographed, and issued for local navigation and engineering purposes, and from them charts of the coast will be compiled on a medium scale for the purposes of general navigation. Copies of all original surveys will be forwarded to the Admiralty Hydrographer for publication, and all corrections of surveys and other information, such as notices of changes in the places of buoys, lights, &c., will also be transmitted at once to the same office. A catalogue of all the charts of the Department will be kept, besides a sufficient stock of Admiralty charts, and copies of these will be furnished to the Local Governments and public officers on demand. The Superintendent of Marine Surveys is also charged with the duty of compiling an annual chart of wrecks,[1] an annual

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[1] See p. 37. The annual Indian Wreck and Casualty Statement and Chart will be drawn up by Marine Survey Department, from 1876.

list of lights,[1] with descriptions of them and their positions, and sailing directions for the Indian coasts.[2] He will report on the lighting and marking of the sea approaches to all great Indian ports and rivers, suggest improvements in harbour conservancy by means of buoys, beacons, and lights, and in the navigation of rivers throughout India. Any extracts from log books of vessels belonging to the Bengal and Bombay Marine, or to H. M.'s Squadron, which bear upon any discoveries, dangers, or errors in the charts of the Indian Seas will be communicated to the Department of Marine Surveys, which, like all the other branches of the Survey, is affiliated to the Department of Revenue, Agriculture, and Commerce.

The agency by which these duties are to be discharged consists of a Superintendent (Commander A. D. Taylor, late I. N.), two Deputy Superintendents, and nine Assistant Superintendents, three executive officers, one Medical Officer and Naturalist, and a Superintendent of the Drawing Branch. Six of the surveying officers belong to the Royal Navy, their services having been lent to the Indian Government by the Admiralty. The whole cost of the Department does not exceed two lakhs of rupees or 20,000*l.* per annum.[3]

The first general report on the operations of the Marine Survey of India was issued by the Superintendent, Commander Taylor, in the latter part of December 1876.[4] It commences with a retrospect of the preliminary steps from 1871 to 1873, which led to the deputation of Commander Taylor to India in the latter year. It

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1 The annual list of lighthouses and light vessels in British India, including the Red Sea and Coast of Arabia, with a map, is prepared by Mr. R. C. Carrington, Superintendent of the Drawing Branch.

2 The Hydrographic Notices are published from time to time, with a warning that the new information contained in them should be carefully considered, noted in the sailing directions, and compared with the chart, when a ship is navigating the locality to which it refers.

3 The Department consists of the following officers:—Commander A. D. Taylor, I.N., Superintendent; Staff Commander J. H. Ellis, R.N., Deputy Superintendent, 1st Grade; R. C. Carrington, Esquire, Superintendent of the Drawing Branch; Navigating Lieutenant F. W. Jarrad, Deputy Superintendent, 2nd Grade; Navigating Lieutenant G. C. Hammond, R.N., Assistant Superintendent, 1st Grade; Navigating Lieutenant E. W. Petley, R.N., and Mr. M. Chapman, Assistant Superintendents, 2nd Grade; Mr. P. J. Falle, Lieutenant W. H. Coombes, R.N., and Navigating Lieutenant J. C. Pascoe, R.N., Assistant Superintendents, 3rd Grade; and Dr. J. Armstrong, B.A., Surgeon and Naturalist.

4 "General Report on the operations of the Marine Surveys of India from the commencement in 1874, to the end of the official year 1875–76," by Commander A. Dundas Taylor (late I.N.) F.R.G.S., Superintendent of Marine Surveys. (Calcutta, 1876.)

touches upon the proposals of the Government of India for securing efficient surveys and charts, the measures taken in England to obtain qualified surveyors, and the final departure of Commander Taylor and the officers selected for service under him in December 1874.

The vessels chosen for the Marine Survey operations were at that date as follows:—

The "Clyde" (steamer) and the "Constance" (schooner) had been fitted at Bombay for surveying purposes, and the "Guide" (brig) and the "Lady Lawrence" (schooner) had been selected by the Kidderpur dockyard authorities for the same service. The last mentioned vessel, however, could not carry a steam cutter, and was unsuitable for chart work, so was retransferred to the Marine Department. The "Clyde" eventually proved to be almost useless under sail, and the "Guide" to be so affected by dry rot as to be unseaworthy and not worth repairing. These disappointments have caused much delay, and have necessitated the provision of a new steamer, which is eventually to be constructed in England.

Notwithstanding the lack of vessels, the Department has been able to accomplish much valuable work. Mr. Chapman, late I.N., in the "Constance," made a plan of Kolachul Harbour and surveyed the Enciam Rocks in Travancor, charting 6 miles of coast and 5½ square miles of water. He then rounded Cape Comorin, passed through the Pamban Pass, obtained additional soundings in Palk Strait, and verified those on the published charts, and then proceeded to Coconada, where he commenced the survey of the Bay, till relieved by Lieut. Hammond and Sub Lieut. Petley. This survey was completed on the 24th August. It comprised 79 square miles of water and 42 miles of coast, charted on a scale of 2 inches = 1 nautical mile. The survey has since been republished by the Hydrographer to the Admiralty.

On the 8th April the "Guide," under the command of Navigating Lieut. J. E. Coghlan, proceeded down the River Hugli, and surveyed the dangerous James and Mary Shoals, Luff Point to Anchoring Creek, including the entrance to the Rupnarain River, on the scale of 10 inches to the nautical mile (this being subsequently reduced for publication by photozincography to 6 inches to the mile). The chart is a valuable one for record, and Captain Taylor remarks that if the whole of the river from Chandernagar were annually surveyed in the same way, a comparison of the results would be invaluable in carrying out engineering works for the improvement of the conservancy of the river.

Staff Commander Ellis, R.N., in the "Clyde," had in February connected, by meridian distance, Pigeon Island with one of the Laccadive group, in his voyage from Bombay to Calcutta. He was also enabled to make an examination of the channel into Mutapetta Bay (Port Lorne), the soundings near which differed considerably from Captain Powell's survey in 1837. The dredging and blasting operations in Pamban Pass are still continued. A depth of 11 feet 9 inches had then (March, 1875) been attained, and it was confidently expected that the Pass would soon be available for vessels of 14 feet draught.

Survey operations along the Burma coast were commenced in November 1875 by Lieut. Jarrad in the "Clyde" examining the approaches to the Rangoon River, accompanied by Navigating Sub Lieutenant George. The erection and maintenance of a tide pole was a matter of great difficulty, owing to native boats fouling it, and the great strength of the tidal streams. Captain Taylor considers the establishment of a self-registering tidal gauge there very desirable. This important survey was completed on the 8th March, and comprised $37\frac{1}{2}$ miles of coast, trigonometrically laid down, and 216 square miles of water examined. In consequence of a discrepancy in longitude discovered in the compilation of the sheet, including the coast of Tenasserim and Singapore and Penang, the meridian distance between Elephant Point Obelisk, which has been determined by the Great Trigonometrical Survey, and Amherst, was astronomically measured. The result proved that the position of Amherst on Admiralty Chart, No. 823, is $4\frac{1}{2}$ miles too far west. Commander Taylor intends to have observations made next season at Diamond Island, off Cape Negrais, and Amherst, for the same purpose, and there would then be three principal points in the Gulf of Martaban fixed astronomically. These measurements of meridian distances are of great importance, as the whole of the eastern side of the Bay of Bengal has been very incorrectly laid down on the Admiralty Charts, an error of from five to eight miles sometimes existing.

After obtaining some prolific dredging between Diamond Island and Akyab, the "Clyde" commenced the survey of that port on the 21st March 1876. Much time was spent in clearing the hill tops of jungle, owing to the independent character of the Burmese, and the difficulty, through want of an interpreter, of communicating with them On the night of the 30th of March, Navigating Sub Lieut C George, R N, was suddenly seized with cholera, which had been rife for some time among the native population, and though every thing possible was done to arrest the progress of the disease, this promising young officer died at noon on the 1st April Lieut George was a son of Staff Commander C George, R N, Map Curator to the Royal Geographical Society Like his father, young George was trained to the surveying branch of the naval service, and joined the Indian Marine Survey Department in November 1877, as Assistant Superintendent His loss is seriously felt by the Department, in which he did most excellent service, and where he had won the warm friendship of all his brother officers He was a painstaking and intelligent young surveyor, and a great favourite His career was brief, but it was one to which his bereaved father can look back with pride, as that of a promising officer, who did his duty thoroughly and well Owing to the threatening prevalence of the disease, Commander Taylor, who was on his way down the coast of Burma on a visit of inspection, ordered Lieut Jarrad to leave Akyab The "Clyde" accordingly proceeded northwards, and tested the correctness of the coast between Cheduba and Kyouk Phyou, as shown on Admiralty Chart, No 821 Lieut Jarrad reports it to be roughly laid down and out of bearing when referred to Cheduba Island The published plan of Kyouk Phyou proved to be so incorrect that arrangements were made for the survey of the Port to be continued during the ensuing season

The "Constance," under the command of Lieut Hammond, left Calcutta in December 1875 for the purpose of making a plan of the anchorage of False Point on the Orissa coast In spite of many mishaps with the steam cutter, the survey was completed by the 9th of March The anchorage was charted on the 6-inch scale, the coast for 5 miles to the south and 10 miles to the north was surveyed on the 3 inch scale, and the soundings extend to from 5 to 8 miles off shore Lieut Hammond then proceeded to the northern portion of the shoal off Dhámra River, where he measured a base, and proceeded to sound the shoals Unfortunately, work was completely stopped by a heavy gale, and a great number of the crew falling sick compelled Lieut Hammond to return to Calcutta, whence he proceeded to England on medical certificate

During the months of April and May 1876, Commander Taylor made a tour along the eastern coast of the Bay of Bengal, and inspected the ports of British Burma He visited first Akyab and Moulmain, and then proceeded to Amherst This port has never been properly surveyed The late Mr Pearson, of the Bengal Marine, examined the Moulmain River in 1865, but no steps were taken to have the Admiralty Chart corrected by the survey Commander Taylor is of opinion that no large port of British India requires so much to be properly surveyed and mapped, and has accordingly arranged for Lieut Jarrad to commence next season's work at Amherst The Admiralty Chart of Tavoy proved to be dangerously erroneous, and the British India Steam Navigation Company's steamer "Mahratta," when navigating by it, struck on a rock in Tavoy River Subsequently, Captain Taylor discovered a copy of the survey of Tavoy, executed by Lieut R Moresby, of the Bombay Marine, in 1824, and published by Horsburgh in 1827, which is far superior to that issued by the Admiralty Captain Taylor proposes to issue amended charts of Tavoy, Mergui, Pakchan, &c After visiting Mergui he turned his attention to the passage from Mergui to Pakchan, which urgently needs sailing directions,—none of which at present exist He proposes to issue these in the form of hydrographic notices, explanatory of the normal trading route between Moulmain and Pakchan, touching at Tavoy and Mergui, with some useful remarks on the extended voyage along the Siam coast to Penang Below Pakchan, Commander Taylor has made a sketch showing the soundings in the entrances to Kopah, which has great tin mines like most of the ports along the Siam coast, but no trace of such a fine river as depicted on the Admiralty Chart A new chart of Kopah is now in preparation Of Salanga (Junk Seylon) a pretty good survey was obtained from Captain Richelieu, commanding the Siamese Royal gunboat "Coronation" This officer was trained in the British Royal Navy, is a good observer, and most intelligent in surveying the coast and islands The actual survey of this island differs immensely from the published one, and the corrected charts will be a great boon to the British India Steam Navigation Company and the coasting trade The new Survey of Salang was published at Calcutta, by the Marine Survey Department, in February 1877

The Superintendent of Marine Surveys has been consulted by Government on a variety of marine questions of great importance

Among these may be mentioned that of the re-organization of the River Hugli Survey, on which an exhaustive report has been submitted by him. Commander Taylor is of opinion that an elaborate scientific survey of the whole tidal basin of the Hugli River, at least from Chandernagar to the Sand Heads, is required, as well as an accurate series of levels from Calcutta to below Diamond Harbour.

During the year under review a valuable list of lighthouses and light vessels in British India, including the Red Sea and coast of Arabia, has been issued by the Marine Survey Department. The list is in the form of a hand book, giving in tabular order the lights, with their names, latitude and longitude, colour, radius of illumination, height, and other particulars. This little book will be a most useful aid to navigation. It has been compiled by Mr. R. C. Carrington.

The programme of work to be undertaken by the Marine Survey Department during the season of 1876–77 is as follows:—The "Clyde" was to leave Calcutta in November, call at Diamond Island (Bassein River), and connect the same astronomically with Rangoon and Amherst Pagoda, and then to proceed to survey the approaches and entrance to Moulmain River, on a 2½ inch scale. After that the "Clyde" is to examine the entrance to the Sandoway River, and then to complete the survey of Akyab Port,—a task which will probably occupy two months.

Commander Taylor proposes himself to visit first the Mergui Archipelago, in which trip he is to be accompanied by Dr. Armstrong, (the opportunities for research in natural history and geology being very promising in these islands), and then to inspect all the ports on the Coromandel Coast, with a view to satisfying himself regarding their requirements as far as regards lighting, buoying, &c. This programme has received the sanction of the Government of India.

## II.

## MAJOR RENNELL AND THE ROUTE SURVEYS, 1763–1800

THE land survey and mapping of British India have advanced with the acquisitions of territory, they were commenced when the first battles were fought, and the first provinces gained Rennell, the father of Indian geography, served under Clive, the conqueror of Plassy

At that time all existing knowledge of India, derived from routes of solitary travellers and rough charts of the coasts, had just been collected and utilized by the great French geographer D'Anville [1] His map of India appeared five years before the date of the battle of Plassy, and eight years afterwards Rennell was at work in the newly acquired territory of Bengal and Bahar, laying the foundations for the construction of a map which was destined to succeed the admirable work of D'Anville

James Rennell, the son of a captain in the artillery, was born at Chudleigh in Devonshire in 1742 He entered the navy, and distinguished himself as a midshipman at the siege of Pondicherry, but soon afterwards took service in the army under Clive, rose to the rank of major, and was eventually, but when still quite a young man, appointed Surveyor General of Bengal

Major Rennell's labours in the field extended over a period from about 1763 to 1782, when he finally left India In Section II of his memoir he describes this survey as covering an area about 900 miles long by 360 to 240 wide, from the eastern confines of Bengal to Agra, and from the feet of the Himalayas to Calpi The distances appear to have been chained, and observations were taken for latitude and longitude at certain stations The measured distances are said to have accorded minutely with observations for latitude, and closely with those for longitude

Rennell's maps of the rivers Ganges and Brahmaputra, reduced from the original surveys by himself, are preserved in the Geographical Department of the India Office They are on a scale of two miles to an inch A portion of the original surveys in

[1] The English edition of his map by Herbert, with a memoir, appeared in 1754

15 sheets, on a scale of 500 yards to the inch, is also preserved These are not only interesting memorials of the great geographer who executed them, but, looking to the changes which have since taken place in the rivers, are still useful in the study of the causes which operate to effect these changes For instance, Rennell's Surveys were turned to good account by Mr Fergusson, in his thoughtful and well considered paper on the recent changes in the delta of the Ganges [1] The maps of the districts of Bengal and Bahar are of course entirely superseded by those of the Revenue Survey, and now have only an historical interest They are on a scale of five miles to an inch (that of Chittagong being rather larger), and were compiled, by Major Rennell, from 500 original surveys made by himself and nine assistants These maps were published in 1781 as the "Bengal Atlas" [2]

Major Rennell returned to England in 1782, the very year of D'Anville's death, and thus as it were received his mantle, and commenced that useful career of nearly 50 years' duration, which has won him a place in the first rank of geographers The story of his labours in England belongs to another section of this memoir

Colonel John Call, who had made some route surveys of the southern part of the peninsula,[3] succeeded Major Rennell as Surveyor General of India on October 2nd, 1777, and the following years saw much good and zealous geographical work done by the disciples of Rennell Colonel Pearse was engaged in making astronomical observations at Calcutta from about 1774 to 1782, and in the latter year he undertook a journey to Madras, for the purpose of fixing positions, and laying down the intermediate coast line, for a distance of 700 miles He observed for latitude by stars' meridian altitudes, for longitude by immersion of Jupiter's satellites, and measured the distance with a perambulator This work

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1 "On recent changes in the delta of the Ganges," by James Fergusson, F R S — *Quarterly Geological Journal*, xix p 321 (1863)

2 The originals are now in the Geographical Department of the India Office They were taken home by some official, and treated by him as private property, till they were accidentally discovered in the collection of a lady of rank, and purchased for 100*l* by their lawful owners, the Court of Directors —*Bombay Quarterly Review* iii p 140

3 In the "Philosophical Transactions" for 1772, vol 62 p 353, there is a letter from John Call to the Astronomer Royal, Nevil Maskelyne, on the signs of the Zodiac he had observed on the ceiling of a choultry near Cape Comorin

occupied two years, from 1782 to 1784, and Colonel Pearse was ably assisted by young Colebrooke, the future Surveyor General, who latterly took all the observations During this period intelligent surveyors accompanied every army in the field, and good route maps were thus obtained In 1783, Colonel Kelly is reported to have made a most valuable collection of routes and maps of the Carnatic during a long course of service, some of which had proved valuable guides to General Sir Eyre Coote Captain Pringle also made maps, and measured 2,000 miles of road, in the Carnatic, during the war with Hyder Ali

Thus materials were rapidly accumulating, and Colonel Call, the Surveyor General, undertook the compilation of an Atlas of India in 20 sheets, to be collected afterwards into one general map on a smaller scale In 1787 it was nearly completed, and the Bengal Government ordered that a fair copy of it, on a scale of four inches to a degree, should be made, and hung up in the Council Room at Calcutta for constant reference Colonel Call went home in 1788, but died soon after he landed in England, and his map, which must have entailed an enormous amount of labour and expense, appears to have been lost

In 1787, when Colonel Call was compiling his map of India, he found so many contradictions and absurdities in the various surveys, that he requested Mr Reuben Burrow, an experienced marine surveyor and an accomplished mathematician,[1] to consider the subject, and draw up a plan for determining astronomically the positions of the principal places in Bengal Eventually Burrow received orders from Major Wood, Colonel Call's successor, to determine the latitude and longitude of Murshidabad, Rajmahal, Monghir, Patna, Dacca, Goalpara, and Chittagong But there was great difficulty in procuring the necessary instruments It sounds strange in these days, that the equipment of this Government

[1] Reuben Burrow contributed several mathematical papers to the "Asiatic Researches" —

1 "Hints relative to friction in Mechanics," i p 171
2 "Method of calculating Moon s parallax," i p 3
3 "Remarks on the Artificial Horizon,' i p 327
4 "Demonstration of a Theorem concerning the Intersection of Curves," i p 330
5 "Corrections of the Lunar Method of finding the Longitude," i p 433
6 "A Proof that the Hindoos had the Binomial Theorem,' ii
7 "Method of Reducing Practical Tables," iii

expedition could only be secured by borrowing a sextant here, a watch there, and a quadrant in another quarter, from different officers at Calcutta who happened to possess them

In addition to the work sketched out for him, Reuben Burrow went up the Ganges as far as Hardwar, taking observations, and making careful notes of everything he saw [1] It is remarkable that Rennell should not allude to the survey by Reuben Burrow in his second edition of the memoir, published in 1792

Colonel Call was succeeded in the office of Surveyor General of India by Colonel Wood, who was strongly impressed with the importance of making the marches of troops subservient to the promotion of geographical knowledge He actively collected information and materials for correct maps wherever it was to be obtained In 1792 he received the surveys by Lieut Emmitt, of portions of the Deccan, made during the previous war, which are said to have been both reliable and elegant In 1793, Colonel Wood's assistant, Lieut Colebrooke, submitted a map of the part of Mysore traversed by the army under Lord Cornwallis, with a memoir, and received Rs 6,000 for his trouble In the same year Major Kyd surveyed the route from Seringapatam, through Coorg, to the west coast, and Dr Hunter, the surgeon to the Residency at Scindia's Court, sent in route surveys made on marches from Delhi and Agra to Gwalior and Ujain [2] A map of Calcutta and its environs was made by a Mr Upjohn in 1794, who secured liberal patronage from the Government, and in 1795 Lieut Hoare received instructions to make a survey of the River Jumna When Captain Symes went on a mission to the Court of Ava in 1795, he was accompanied by Dr Buchanan and Lieut Wood The latter officer surveyed the route, and afterwards submitted a map of the Irawadi from Rangoon to Amarapura, with a paper of astronomical observations Mr John Crawfurd, when he went over the same ground in 1826, bore witness that Wood's survey was still the best extant [3]

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[1] "Remarks made in the Ganges and Burrampooter Rivers in 1787, by Reuben Burrows," MS volume preserved in the Geographical Department of the India Office See also his tables of latitudes and longitudes determined from astronomical observations, in the "Asiatic Researches," iv p 325

[2] See also Dr Hunter's Astronomical Observations, taken during a journey from Upper Hindustan to Ujain, in the "Asiatic Researches," iv p 41

[3] Syme's Embassy is in "Pinkerton's Voyages," ix p 246, and was also published separately in 1800

On the Bombay side Captain Moncrieff surveyed the district of Canara in 1799, while Colonel Charles Reynolds made a careful route survey of Malwa and part of Badnur Colonel Reynolds was for years engaged in collecting materials for a great map of India, which was at last completed and sent home in 1798, but it was never published [1] Reynolds measured one long line of route with great care, checking it at each end by observations for latitude, and established it as a base to which all other diverging routes were referred, the intervals being filled in from native information But such work was of course very inaccurate, and the maps of that period were only of service while India was an unknown region, to be traversed by armies, and ceased to be tolerable when that vast country became a British imperial possession, requiring to be administered

At the commencement of the present century the great triangulation was begun, which was to furnish a permanent geological basis of the highest order of accuracy, for all future surveying operations in India The process of constructing maps from route surveys and astronomical observations has since been gradually discontinued in the provinces which are under the immediate control of the British Government, though it is still necessarily practised in geographical explorations beyond the frontier, and more particularly in the Trans Himalayan regions

Yet the labours of Rennell and his school were not only useful at the time, but also served as incitements to encourage their successors, and the names of those first pioneers of the Indian Surveys will ever be held in reverence by geographers It is particularly pleasant to note the liberal and hearty encouragement which was given to young surveyors by the Government in those days, by granting them a good round sum of money for their services whenever they submitted creditable results of their labours in the field This was done to show them that their hard and meritorious work was appreciated, and to excite a feeling of emulation and zeal

[1] Some rough sheets for this map are still preserved, but the great map of India by Reynolds itself, a work of considerable value and interest, appears to have been lost in the destruction of precious records which took place at the time of the abolition of the East India Company

# III.

# FIRST PERIOD OF THE TRIGONOMETRICAL SURVEYS 1800–23

## 1

## INTRODUCTORY

It was not until the end of the last century that a trigonometrical survey was generally allowed to be the only accurate basis for the mapping of a country. The observations for ascertaining the shape of the earth by measuring an arc of the meridian were commenced a few years after the death of Sir Isaac Newton, but not by his countrymen, and these observations were the forerunners of the great trigonometrical surveys. The famous French expedition of Condamine and Bouguer went to South America in 1735, and the admirable work of these savans, aided by the Spanish brothers Ulloa, consisted in the measurement of two bases connected by a series of triangles, one north and the other south of the equator on the meridian of Quito, the arc being 180 miles long. It is to be regretted that while France and Spain were thus combining in the interests of science, England was less nobly engaged in burning churches and cutting off supplies from the Peruvian coast.

The labours of Condamine were followed by the measurement of an arc in Lapland, of another in France, and finally the countrymen of Newton took up the work at which they should have been foremost.[1] The idea of a Trigonometrical Survey of Great Britain was first conceived by General Watson, after the Scottish rising of 1745. It was intended to extend over the disaffected parts of the

[1] The particulars of the measurements of various arcs are as follows:—

| Date | Observers | Country | Latitude of Middle of Arc | Arc measured | Length of Degree in feet | Length of Degree in Ordnance Tables * |
|---|---|---|---|---|---|---|
| 1738 | Maupertius re-examined by Svanberg | Lapland | 66 20 10 N | 1 37 19 | 365 78[illegible] | 365 876 |
| | Struve | Russia | 58 17 37 | 3 35 5 | 36[illegible] 368 | 365 414 |
| 180[illegible] | Roy and Kater | England | [illegible] | 3 57 13 | 364 971 | 365 097 |
| | Lacaille | France | 46 5[illegible] 2 | 8 20 0 | 364 872 | 364 730 |
| 1790 | Delambre and Mechain | France | 44 [illegible]1 2 | 12 22 13 | 364 535 | 364 599 |
| 1755 | Boscovich | Rome | 42 59 0 | 2 9 47 | 364 262 | 364 479 |
| | Mason and Dixon | United States | 39 12 0 „ | 1 28 45 | 363 786 | 364 235 |
| 1750 | Abbé Lacaille | Cape of Good Hope | 33 18 30 S | 1 13 17½ | 363 718 | 363 871 |
| 1835 | Everest | India | 16 8 22N | 15 57 40 | 363 044 | 363 041 |
| 1808 | Lambton | India | 12 32 21 | 1 34 56 | 363 013 | 362 929 |
| 1735 | Condamine and Bouguer * | Peru | 1 31 0 S | 3 7 3 | 36[illegible] 808 | 362 758 |

* Geodetical Tables based on the elements of the figure of the earth given in the Account of the Principal Triangulation (of the Ordnance Survey). London 1868. Quarto 13 pages.

Highlands, and the design was subsequently extended so as to include all Great Britain and Ireland The work was committed to General Roy in about 1784, when he measured his famous base on Hounslow Heath He died in 1790, and Colonel Mudge was engaged in the measurement of his arc from Dunnose to Clifton in Yorkshire, in 1802[1] Thanks to the genius and resolution of one man, to whom the early commencement of similar work in the east is due, British India was only a few years behind France and England in beginning a great trigonometrical survey, a stupendous work, which has occupied the lifetime of several noble and devoted surveyors, and which, when completed, will be among the most glorious monuments of British rule in the east

The man who originated the great Indian Survey was an infantry officer serving in the army of General Harris, in the war with Tippoo William Lambton was born in 1753 He was very reserved in all particulars respecting his origin or family, and it is not known where he was born or who were his parents But his name points to the county of Durham, and he certainly passed his boyhood at Darlington For many years he devoted a large portion of his pay to the support of one of his parents He obtained a commission in the 33rd Regiment, and his proficiency in surveying obtained for him the work of measuring land granted to settlers in America He was appointed barrack master in Nova Scotia, and applied himself for several years to the study of mathematics Lambton was entirely self educated In 1795 the Duke of York issued an order that all officers in civil employment were to be struck off the strength of their regiments Lambton, therefore, gave up his barrack mastership, and joined the 33rd at Calcutta, after an absence of 13 years from regimental duties He was well acquainted with the methods of observing and computing which were in use among the learned men who had recently been engaged in the measurement of arcs in Europe He rejoined the 33rd Regiment, then commanded by Sir Arthur Wellesley, at Calcutta, in 1797,[2] was brigade major during the Mysor campaign, and distinguished himself by leading the left column, after all his superior officers had been disabled, in the storming of Seringapatam

After the fall of Tippoo, Lord Wellesley took measures for exploring and collecting accurate information respecting the vast territory

[1] "Philosophical Transactions," 1803

[2] While at Calcutta, Lambton contributed two mathematical papers to the 'Asiatic Researches" —1 "Observations on the Theory of Walls," vi p 93
2 "On the effects of Machines when in motion," vi p 309

which had thus been thrown open to the English. Dr Buchanan was employed to report upon the agriculture and products of Mysore and Malabar. Colin Mackenzie proceeded with his admirable topographical surveys and memoirs; and it was then also that Major Lambton submitted his project for the measurement of an arc of the meridian, and for a trigonometrical survey across the peninsula.

The measurement of an arc in the peninsula of India was, in a purely scientific point of view, of the highest importance. By it the exact figure of the earth was to be ascertained, and it should be remembered that this was not, as has been asserted, an object of mere curiosity. It affects some of the tables used in navigation, especially all those of which the moon's parallax is an element, and is therefore an investigation of the greatest practical consequence to the whole civilized world. Moreover, the measured base line, the series of accurately measured triangles, and points fixed by numerous astronomical observations, all which are necessary for ascertaining the shape of the earth, were the basis from which, as a back bone, the triangulation was eventually to be extended over the whole of India. The primary triangles formed guides by which the topographical and revenue surveyors were enabled to fill in the details, and delineate all the main features of the country within fixed limits of errors.

Trigonometrical surveying is divided into three distinct branches. First, the selection of sites for base lines to form the ends of certain ranges of triangles; their setting out; and their measurement with the utmost attainable accuracy. The base line becomes the side of a triangle, the length of which is thus known, and by trigonometry the distance of other points, visible from its extremities, can be ascertained through angular observations with suitable instruments. Second, the construction of the range of triangles. This is done by ascertaining the position of selected points on the earth's surface by angles taken at first from the ends of a measured base, and then carried on from point to point in succession so as to form a network of positions fixed by this triangulation along a belt of country. The accuracy of the work is checked by the base line which terminates it. The primary triangulation is completed by a sufficient number of such belts across the area of the survey, both in the direction of latitude and longitude. Third, as a further check to the triangulation, astronomical observations for latitude and longitude are made at selected points.

The positions of a sufficient number of places spread over the area of survey are in this way fixed with the greatest accuracy; and they become the starting points from which the topographical surveyors proceed to fill in the detail, as well as checks upon their accuracy

But from the first, the staff of the Great Trigonometrical Survey was distinct from that of the Topographical and Revenue Surveys The nature of the work, the training, and the objects, were distinct, and even the time required for each, and the calls of the public service rendered it impracticable that they should be carried on together The trigonometrical surveyor was obliged to secure extreme accuracy, both in his terrestrial measurements and in his celestial observations The same stars had to be taken over and over again, and it was often necessary to wait for days until they were in the desired positions His mathematical attainments must be of the highest order, and he would have neither the time nor, as a rule, a special aptitude for the collection of topographical details for filling up the exact skeleton furnished by his scientific labours The two kinds of work are distinct, and require a different training in many respects, and a different turn of mind On the other hand, the topographical and revenue surveyors found the main landmarks on which their maps were to be based, already fixed and established to their hands Their work consisted of secondary triangulation, and filling in the details with the plane table It was their duty to examine and delineate all the natural features of the country, to mark boundaries, and collect information of all kinds While they would never be detained so long at one spot, as would often be the case with the trigonometrical surveyor, they would be longer in one district, filling in and completing the maps Thus, though their work was in some respects similar, and even may be said to dovetail at certain points, it was on the whole so distinct that it has generally been found most convenient to carry on the two surveys apart from each other

By the trigonometrical survey a network of primary triangles was formed with numerous fixed positions By the topographical and revenue surveys the details were filled in, and the data for the maps collected These points will be brought out more clearly as the narrative of the surveys proceeds The labours of each system will be recorded separately, in the successive periods The first period covers the work of Major Lambton, and will be divided into two sections, first that treating of the trigonometrical surveys of Lambton himself from 1800 to 1823, and secondly that under which the topographical surveys of Colin Mackenzie and his followers in the peninsula, and of other workers in the Bengal Presidency, must be recorded, covering the same period of time

(2)

## Colonel Lambton and the Measurement of an Arc of the Meridian

Major Lambton's proposal for a mathematical and geographical survey of the peninsula and the measurement of an arc of the meridian in connection therewith was supported by Sir Arthur Wellesley and approved by the Madras Government. It is a curious coincidence that two of the most energetic and influential supporters of Lambton's proposal, Mr. Petrie and Mr. Andrew Scott, should have been first cousins of the father of the future superintendent of the surveys, Sir Andrew Waugh. Lambton was himself appointed to conduct the measurement, but it was not until 1802 that he was furnished with the necessary instruments. Meanwhile he organized an efficient staff, and obtained the able assistance of Lieut. Warren of the 33rd,[1] and Lieut. Kater.[2]

Lambton's instruments were a theodolite, zenith sector, and steel chains. The three foot theodolite, by Cary, was captured on the passage to India by the French frigate "Piemontaise," and landed at Mauritius, but it was eventually forwarded to its destination by the chivalrous French Governor, De Caen, with a complimentary letter to the Governor of Madras. The zenith sector was one of 5 feet radius by Ramsden. The chain was one that had been sent as a present to the Emperor of China, with Lord Macartney's Embassy, and refused. It was handed over to Mr. Dinwiddie, the astronomer to the mission, apparently as part payment for his

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1 Author of the Kala Sankalita. This officer was descended from a noble French family, by the mother's side.

2 Kater, afterwards so well known for his pendulum and other scientific observations in England, was appointed an Assistant in the Survey in October 1803. He invented a very ingenious method of ascertaining the amount of moisture in the atmosphere, while serving under Lambton. He observed that the bearded seed of a species of grass called in Tamul *yerudoovaal pilloo* (*Andropogon contortum*, Lin.), possessed an extreme sensibility of moisture, and he constructed a hygrometer of this material. "Asiatic Researches, ix, p. 24 and 375."—Henry Kater was born at Bristol in 1777, and went out to India in 1794, as an Ensign in the 12th Regt. Ill health obliged him to return to England in 1806. He is most generally known in connection with his labours for the construction of standards of weights and measures. Captain Kater died in 1835.

services, and he brought it to Madras with the zenith sector.[1] Both were bought by the Government for Major Lambton's survey. The chain was 100 feet long, consisting of 40 steel links of $2\frac{1}{2}$ feet each. In May 1802 another steel chain arrived from England, manufactured by Ramsden, and having been set off from his bar at a temperature of 50°. This was never used in the field, but reserved as a standard with which the old chain was compared both before and after measurement. There was also a standard brass scale by Cary, 3 feet long, for use if the standard chain failed.

The fixed position or point of departure of the Trigonometrical Survey of India is the Madras Observatory, and its longitude was always a matter of some moment. Observations had been taken since 1787, but the building was erected in 1792. It contained a 20-inch transit, and a 12-inch altitude and azimuth instrument by Troughton. From 1796 there is a regular series of meteorological reports, and the astronomical results are recorded in huge folios printed at Madras.[2] Mr. Goldingham, who seems to have succeeded Michael Topping, was the Madras astronomer contemporary with Colonel Lambton. He made experiments with the pendulum at Madras, and on the equator near Bencoolen in Sumatra, other careful experiments for ascertaining the velocity of sound, and observed regularly for latitude by the transit of heavenly bodies over the meridian, and for longitude from eclipses of Jupiter's satellites and lunars. Since 1787 a regular series of observations of eclipses of Jupiter's satellites had been taken, and about 800 lunar distances. The means of the eclipses gave a longitude of 80° 18′ 30″ E., but the results from the lunars were 2′ 55″ more to the east. In 1815 Lieutenant Warren had charge of the observatory during Mr. Goldingham's absence in England, and reduced the longitude to 80° 17′ 21″ E. These figures were adopted by Colonel Lambton in the survey, but they were destined to further change.

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[1] According to another account, these instruments were bought from Dinwiddie at Calcutta, and sent down to Madras.

[2] "Astronomical Observations," by J. Goldingham, 4 vols. (folio) Madras, 1825–27.

"Madras Observatory Papers," by John Goldingham, Astronomer.—(Madras, 1827.)

"Results of Astronomical Observations made at the H. E. I. C. Observatory at Madras," by T. G. Taylor. 4 vols. Madras, 1831–37.

See also "Journal of the Asiatic Society at Bengal," ii. p. 380. The Meteorological Reports of the Madras Observatory will be found in the 'Madras Journal of Literature and Science.'

Mr Taylor succeeded Mr Goldingham as astronomer at Madras in 1831, and was supplied with a new set of instruments consisting of a five-foot transit instrument, a mural circle, and a five foot tele scope equatorially mounted He specially devoted his attention to the positions of 2881 fixed stars, to observations of planets passing the meridian, moon culminating stars, and occultations He reduced the longitude of Madras to 8~~3~~° 14′ 20″ E, by observations 80 between 1839 and 1847 [1]

It must be borne in mind that the astronomical observations of the surveyors were not taken only for the purpose of fixing points for geographical purposes The object of the astronomical observations was also to measure the angular, as distinguished from the linear, length of a degree Thus, supposing observations for latitude were taken at two points distant from each other exactly one degree or sixty minutes of a celestial arc, then by triangulation the distance of these points in yards, feet, inches, and decimal parts of an inch, might be ascertained by angular observations referred to a measured base line, or the distance itself might possibly be measured by the same method as a base line, or it might be traced or staked on the ground, measured, and corrected for irregularities of the surface by levelling operations By such means the length of a degree of latitude on the earth's surface would be ascertained if the two points were on the same meridian, or of a degree of longitude if they were on the equator or a parallel So also the actual form of the earth's circumference, and any departure of it from the regularity of the celestial arc can be obtained

The longitude of Madras is important, as that of the secondary meridian, or substitute for the prime meridian of Greenwich Observatory, from which observations for longitude in the Indian Survey are reckoned Every station and place in that Survey will be erroneous if the longitude of Madras is in error In other words,

[1] Mr Taylor was followed, at the Madras Observatory, by Captain Worster, Major Jacob, Major Tenant, and Mr Pogson According to Findlay, in the new edition of his Directory, the last result (80° 14′ 19 5″) was from observations by Major Jacob The observations of Worster and Jacob were also published, and extend from 1848 to 1852

Besides the publications of Goldingham, Taylor, and Jacob, see "Philosophical Transactions," vol cxii, p 408, "Memoirs of the Astronomical Society," xxxi p 83 (1861–63), and a short account of the observatories in India, in the "Times of India," for June 15th, 1850 the accuracy with which the entire map of India, as a whole, will be placed on the globe, will correspond precisely to the accuracy with which the geographical position of the Madras observatory has been determined At present three different authorities, commenced at different periods, are based on the three different results, accepted as accurate at the time of adoption The Indian Atlas adopts 80° 18′ 30″ E as the longitude of Madras, the Survey Department in India uses 80° 17′ 21″, while the Admiralty, on their charts, have 80° 14′ 19 5″ The point will be again investigated when the longitude is ascertained through the electric telegraph from Greenwich

The actual work of the Great Trigonometrical Survey of India was commenced on the 10th of April 1802, by the measurement of a base line near Madras The ground selected by Major Lambton for this operation was a flat plain near eight miles long, with St Thomas's mount near its northern, and Perumbauk hill near its southern end The chain was fitted into five coffers of wood, each 20 feet long, which were supported on tripods with elevating screws The base line was 7½ miles long, and the measurement was completed on the 22nd of May, when observations were taken to determine the angle of the base with the meridian

Major Lambton, by means of triangulations from this base line, then proceeded to measure an arc of the meridian, and the length of a degree at right angles with the meridian, in the neighbourhood of Madras These operations were conducted with great care, and the Major himself devoted 16 nights to the observation of the star Aldebaran at each of the stations at the extremities of the arc, while Lieutenant Warren filled in the topographical details of this part of the survey, from Cuddalor to Paudri, north of Madras

But these preliminary labours were only first trials in which the young surveyors were, as it were, trying their wings Sir George Everest says, in one of his letters to the Duke of Sussex, that they were afterwards rejected by Major Lambton himself, and never adverted to by him in his latter days, but as failures

From the Madras base line a series of triangles was carried up to the Mysor plateau, and a second base was measured near Bangalor in 1804, by Lieutenant Warren, as a datum for extending the triangles to the Malabar coast, and as a base of verification for the triangles brought from the Madras base[1] Lieutenant Warren also

[1] A base, which afterwards appears to have been rejected, was measured by Lambton himself at Bangalore between October 14th and December 20th, 1800

made some experiments to estimate the effects of terrestrial refraction[1] Lieutenant Kater was next despatched to select stations in the mountains of Coorg and Bednur, whence the flag staves on the western sea coast would be intersected A series of triangles, in two degrees of latitude, was then carried across the peninsula, the flag staves at Tellicherry, Cannanore, and on Mount Delly, being intersected from the summit of Todiandamol, the highest peak in Coorg, but no base line was measured on the Malabar coast

The distance across the peninsula, at this point, was found to be 360 miles, while the best maps had hitherto given it as 400 miles Thus 40 miles had to be taken off the width of the peninsula at one swoop, and the absolute necessity for a Trigonometrical Survey, owing to the hopeless inaccuracy of other methods, was thus demonstrated This work was completed in 1806

Having connected the two sides of the peninsula, Major Lambton devoted much of his future labours to the measurement of an arc of the meridian, and the series of triangles that was measured for this purpose is known as the "Great Arc Series" He first brought the series down from the Bangalor base line towards Cape Comorin, and a new base line was measured in Coimbatoor in 1806 But this was very far from representing the whole of his work, which included a network of primary and secondary triangles, almost covering the peninsula

In 1808 a base line was measured at Tanjore, and on this occasion Major Lambton dispensed with the tripods, and made the measurement on the ground, drawing out the chain by means of two small capstans In this flat country Major Lambton availed himself of the *goparams* or lofty towers of the pagodas, on which scaffoldings were erected, and thus the triangles were formed, connecting Tanjore with Nagor and Negapatam But, in hoisting the three foot Cary's theodolite to the summit of the Tanjore pagoda, a most serious accident occurred One of the guys carried away, and the instrument was dashed with great force against the wall of the pagoda, the blow falling upon the tangent screw and clamp, and quite distorting the limb Ordinary men would have been disheartened at such a mishap, but Lambton was endowed with indomitable resolution, and was full of resource He hurried back with the theodolite to Bangalor, where there was an establishment of ordnance arti-

1 "Asiatic Researches," ix p 1

ficers, and shut himself up in his tent, refusing admittance to all comers except a few of the workmen who assisted him. He then took the instrument entirely to pieces, cut out a circle of the exact size on a flat plank, and gradually drew the limb out so as to fit into the circumference by using wedges, screws, and pullies. In six weeks he had brought it back nearly to its original form, and the same instrument was used for all the subsequent observations up to 1830.

A base line at Tinnevelli was measured in 1809, and the primary triangles were extended thence to the sea shore at Punnae, eight miles north east of Cape Comorin. This terminal station is a square building with two doors and two arched windows, and a solid pillar in the centre, on the top of which is a large circular stone with a hole through it. It is a mile south east of the village of Punnae, and about 700 yards from the beach. Major Lambton devoted 28 days to fixing the latitude of the Punnae Station, during which time he took 236 astronomical observations. In addition to the "Great Arc Series," another series of triangulations was carried across the peninsula from Negapatam to Ponany and Calicut, and another round the coast from Rameswaram, through Travancor and Cochin, to Calicut.

The Arc Series was thus completed from Cape Comorin to Bangalor, and in 1811 Major Lambton and his staff turned their whole attention to its extension northwards, in the direction of the Himalayas. Major Lambton himself, ever hopeful and buoyant, calculated on personally completing it as far as Agra. A base was measured at Guti, with triangles connecting it with that near Bangalor, and others extending to the river Tungabhadra. The Guti base is also the foundation of a series of triangles connecting Masulipatam with Goa, and bases of verification were measured near Guntur, on the beach at Coomta, and at Cape Ramas. Thus an accurate basis of triangulation was formed from Cape Comorin to the Kistna river, enabling the Topographical Surveyors to proceed with the mapping of the country, and the heights of peaks and table lands were carefully measured.

Major Lambton then crossed the Tungabhadra and entered the territory of the Nizam, continuing the Great Arc Series to the neighbourhood of Bidar, where another base line was measured at a station called Dumargidda in 1815. Astronomical observations were taken with the zenith sector to determine the celestial arcs of

amplitude, and nothing remained to the completion of near 10 degrees of the meridional arc from Cape Comorin to Bidar. In concluding his fifth report, the enthusiastic surveyor thus writes:
"In 20 years devoted to this work I have scarcely experienced a "heavy hour. Such is the case when the human mind is absorbed "in pursuits that call its powers into action. A man so engaged, "his time passes on insensibly, and if his efforts are successful his "reward is great, and a retrospect of his labours will afford him an "endless gratification. If such should be my lot I shall close my "career with heartfelt satisfaction, and look back with unceasing "delight on the years I have passed in India."

Yet the difficulties in the field were not the only obstacles with which Lambton had to contend. He was called upon from time to time, to demonstrate the utility of his work; even Major Rennell came forward to maintain that route surveys on an astronomical basis were equally accurate and more economical, and Major Lambton's resources were crippled and starved by the Finance Committee at Madras.[1] Nor did he receive any encouragement from scientific bodies in Europe during the early years of his survey when such support was most needed, and would have been most welcome. Professor Playfair reviewed his work in the "Edinburgh Review" in 1813, and he received one letter from Nevil Maskelyne at a time when he was surrounded by difficulties, and when he was vainly endeavouring to impress the nature and utility of his operations on the local Government. He used to dwell on this letter from the Astronomer Royal as the event which had most cheered him under all his toils. But for many years he never received one word of encouragement, sympathy, or advice, either from the Government or from the Royal Society. Indeed it was a foreign nation that was the first to recognize the importance of his services. In 1817 Major Lambton was made a corresponding member of the French Institute, but it was not until the following year that the Royal Society tardily followed the example, and elected him a Fellow.

The Governor-General, "not unaware that with minds of a certain "order he might lay himself open to the idle imputation of vainly "seeking to partake the gale of public favour and applause which "the labours of Lieutenant Colonel Lambton have recently at-"tracted," at last recognized the great importance of the survey.

[1] "Calcutta Review," vol iv, p 80 (1845)

He transferred it to his immediate control on January 1st, 1818, and ordered it to be denominated for the future, "The Great Trigonometrical Survey of India" Captain Everest was appointed as Colonel Lambton's chief assistant, and Dr Voysey as medical attendant to the surveying parties, and geologist[1]

In the end of 1818 young Everest joined Colonel Lambton at Haidarabad The assistant describes his chief, at this time, as an old man with a bald head fringed with a few snow white hairs, about six feet high, erect, well formed, and muscular His complexion was fair and his eyes blue, but dimmed and weakened by time Yet when he aroused himself to adjust the great theodolite, they shone with the lustre, and his limbs moved with the vigour of full manhood "His high and ample forehead gave animation and "dignity to a countenance beaming with intellect and manly "beauty" But these moments of activity were like the last flickerings of an expiring lamp The old surveyor was gradually wasting away, and in June 1819 was the last occasion of his ever taking part in the work of triangulation

Central India was then in a most unsettled state, and instead of attempting to push forward the Great Arc Series, Lambton employed his parties in completing the triangulation between the rivers Kistna and Godavari In June 1819 Everest was despatched upon this duty, into a wild country, where each village had its mud fort defended by jinjals, and many districts were in rebellion against the Nizam's government He overcame the difficulties arising from the disturbed state of the country, but he and his party, working in a region teeming with malaria under a tropical sun, were at length prostrated by jungle fever, and in 1820 Everest himself went to the Cape of Good Hope for the recovery of his health

Meanwhile the indefatigable but now aged and broken chief of the survey once more began to push forward the Great Arc Series He measured a base line with the steel chain stretched on the ground by capstans, at Takalkhéra in the valley of Berar, in the winter of 1822, but the standard had got rusty, and was unreliable Old Colonel Lambton during this time was constantly at work with the zenith sector, exposed to a tropical sun, and unaided, for his assistants were all sick owing to the reckless exposure to which he had subjected them He himself took no rest at night, but con

[1] For a notice of Dr Voysey's work, see the section on the Geological Survey

tinued to work at the zenith distances of stars His constitution received its death blow, while his observations proved wild, and were confusedly registered "Men cannot last for ever," wrote his assistant, "and the Colonel's infirmities had evidently subdued all but "his spirit, at the time of his last effort"

On Everest's return from the Cape, he was detached, in October 1822, to bring up a series of triangles connecting Bombay with the Great Arc Series Colonel Lambton set out from Haidarabad to Nagpore, to make arrangements for continuing the Great Arc operations But he died on the road at Hinganghat, now one of the great Berar cotton marts, on the 20th of January, 1823, aged 70[1] His assistants and servants were affectionately attached to him and looked upon him as a father, and in 1822 he counted three generations of them in his camp His assistants, De Penning and Rossenrode, attended upon him in his last hours A tomb was erected over his remains at Hinganghat, by Mr Jenkins, the then Resident at Nagpore

Colonel Lambton, the first Superintendent of the Great Trigonometrical Survey, completed the triangulation of 165,342 square miles in the peninsula of India, at a cost of 83,537*l* In concluding his last report he says, "I sincerely hope that, after I relinquish "the work, somebody will be found possessing zeal, constitution, "and attainments wherewith to prosecute it, and it would indeed "be gratifying to me if I could but entertain a distant hope, that "a work which I began should at some future day be extended "over British India"

That hope was fulfilled in the appointment of George Everest as his successor

The labours of Colonel Lambton are recorded in the following manuscript volumes, deposited in the Geographical Department of the India Office

VOL I (Part 1)—Trigonometrical Operations, 1802—3, with a map

„ (Part 2)—Trigonometrical Operations, 1803—6, with a map

VOL II—Operations, 1807—11

VOL III— „ 1811—14 Dated at Haidarabad in 1818

VOL IV—Missing from the Geographical Department of the India Office

[1] The Government Gazette of the time gave his age at 75

Vol V —Operations to Jan 1823 Signed W Lambton, and counter-signed in 1832 by Everest

Vol VI —End of Lambton's Reports, with an Appendix by Everest, relating to his own operations under Lambton in 1822—23, and to Capt Garling's in 1816—17 Signed by Everest in 1832

Abstracts of these accounts will be found in vols 7, 8, 10, 12, and 13, of the "Asiatic Researches" The first three of these were reviewed in the 21st volume of the "Edinburgh Review" (1813) by Professor Playfair Colonel Lambton published an abstract containing the results of all his measurements from Punnae to Dumaigidda in the "Philosophical Transactions" of 1818 See also Everest's "Account of the Measurement of an Arc of the Meridian (1830)," and his series of letters to the Duke of Sussex (London, 1839), for some further interesting particulars respecting Colonel Lambton and his services[1] The operations of the survey under Colonel Lambton are also described in the "Account of the operations of the Great Trigonometrical Survey of India," vol i, by Colonel J T Walker, R E, F R S (Dehra Dún, 1870) There is a "Biographical Sketch of the late Colonel Lambton" in "Gleanings in Science," vol ii, p 27, (Calcutta, 1830,) and an article "On the Measurement of the Indian Meridional Arc," in the same work, vol iii, p 337 The whole of Colonel Lambton's operations are shown in a chart of eight sheets engraved by Mr Walker

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[1] Major Jervis published some extracts from Colonel Lambton's Notices of Malabar (Coimbatore ?) in the *Bombay Geographical Society's Journal*, vol iv (1840)

# IV —
# FIRST PERIOD OF THE TOPOGRAPHICAL SURVEYS
## 1800–23

HITHERTO the maps of Indian districts had been based on military route surveys The initiation of detailed topographical surveys, based on triangulation, is due to Colin Mackenzie, one of the most indefatigable surveyors and persevering collectors of information that ever served this country

Colonel Mackenzie commenced his exploring labours after the close of the war of ~~1837~~ In that and the following years he was 1782
at work in Coimbatore and Dindigul In 1790–94 he was engaged in surveying Nellor, Guntur, and the Ceded Districts, and his journal in manuscript is among the most interesting relics in the Geographical Department of the India Office[1] In 1799 he was appointed to conduct the topographical survey of Mysor

It was Mackenzie who suggested the establishment of the Madras Military Institution, which, under the able superintendence of Captain Troyer, trained most of the surveying officers who, under Mackenzie and others, carefully surveyed the peninsula of India

Mackenzie was engaged on the Mysor Survey during several years His system of triangulation was independent of Colonel Lambton's, and the two officers do not appear to have worked harmoniously Mackenzie measured five bases in the Mysor country, in convenient situations, each from three to five miles long, and connected them by triangles His results were a topographical

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1 "Remarks on a journey in the countries of Cummum, Purwathum, and Canoul, being a continuation of the survey of the frontier and passes between the Pennar and the Krishna in 1794," by Captain Colin Mackenzie This manuscript volume is in the form of a journal, with archæological and other notes, and sketches on the margins

The following manuscript maps, drawn by Colin Mackenzie at this period, are also preserved in the Geographical Department of the India Office —

1 Nizam s dominions and Mysore, showing acquisitions of territory, 1799
2 Military chart of the Carnatic, 1802
3 Roads from Bangalor, to Nellor, &c, 1793
4 Survey of passes leading from the Carnatic to Karnúl, 1792
5 Passes between the Pennar and the Kistna, 1794

Mackenzie's account of the Perwuttum Pagoda is published in the *Asiatic Researches*, v, p 303 survey comprising 40,000 square miles, a general and seven provincial maps, and a valuable memoir in seven folio volumes, containing, besides a narrative of the survey, much carefully digested statistical, historical, and antiquarian information Of these seven volumes, four have been found and restored to the Geographical Department of the India Office, after a long search The other three are missing ! !

In 1809 Mackenzie was removed from the Deccan Surveys, and became Surveyor General of Madras In 1811 he went with the expedition to Java, where he got through much work with his usual zeal and energy, and resumed his post at Madras on his return in 1815 He superintended the continuance of the survey of the Ceded Districts, commenced in 1809, until he was removed to Calcutta, and took up the appointment of Surveyor General of India

But his surveys were only a part, and, indeed, a small part of the stupendous labours of Colin Mackenzie He devoted himself to the study of Indian antiquities, and visited every place of any interest, from the Kistna to Cape Comorin, accompanied by a native staff of assistants, copying and collecting records He got together 3,000 sassanums or tenures inscribed on stone or copper, and the Mackenzie collection consists of 1,568 manuscripts in different Indian languages, 8,076 inscriptions, 2,630 drawings, 78 plans, 6,218 coins, and 106 images He sent some beautiful sculptured stone work from the Amravati tope to the India House before 1820, and published various papers on historical and topographical subjects [1] Among the results of his labours were the discovery of the existence of the Jain religion, and of other sects, and the descriptions of tumuli of early tribes

After Colonel Mackenzie's death, Horace Wilson volunteered to examine and report upon his manuscripts, and the result appeared in 1828 [2] Our knowledge of the literature and early history of Southern India is almost entirely due to the Mackenzie MSS

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[1] In Dalrymple's Oriental Repertory are papers by Mackenzie on routes in Nellore, and on the source of the Pennar In the "Asiatic Annual Register" for 1804 are his Life of Hyder Aly, and his Histories of the Bijayanagar and Anagundi Rajahs, and in vol ix of the "Asiatic Researches" he first brought to notice the religion and monuments of the Jains

[2] "Mackenzie Collection of Oriental Manuscripts," by H H Wilson, Secretary to the Asiatic Society 2 vols (Calcutta, 1828) A further series of Reports on the Mackenzie MSS was made to the Madras Government by Revd W Taylor They

In 1811 Lieutenant Garling, an élève of the Madras Military Institution, commenced the survey of the Portuguese territory of Goa A base was measured at Cape Ramas, and the survey was completed in 1812 Besides the maps, Lieutenant Garling wrote a memoir in four volumes, containing a general description of the Goa territory, and detailed accounts of the coast, anchorages, rivers, population, and villages, with tables, cultivation, towns, and roads and passes

As soon as the Goa Survey was completed, Lieutenant Garling, with Lieutenant Conner and three sub assistants, commenced work in Soanda and Bilgi, in North Canara, in 1813 The topographical survey of Soanda is founded on the base measured near Goa, whence a net of triangles was extended over the new country, and united with the stations of Lambton's Trigonometrical Survey The detail was taken up by plane tables on a scale of one inch to a mile, and all topographical objects that could be expressed on the scale were embraced in the survey The field work was completed in March 1815, and the descriptive memoir, in two volumes, contains an account of the general aspect of the region surveyed, with details respecting the cultivation, water supply, inhabitants, tenures, trade, routes, and history

Lieutenant Conner then proceeded to conduct a survey of the little mountainous principality of Coorg, exactly on the same plan as that of Soanda Colonel Lambton had carried his primary triangles through Coorg, so that Conner could use them as a basis on which to construct his secondary series He commenced work in 1815, and completed the survey in October 1817 The memoir, in one volume, intended to illustrate the map, contains details respecting the boundaries and extent of Coorg , a table of areas of the districts , accounts of the principal places , descriptions of the mountains, rivers, forests (with a catalogue of trees), animals, agriculture, implements of husbandry , a register of villages , and tables of triangles, and of bearings and distances [1]

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are printed in vols vii , viii , ix , of the *Madras Journal of Literature and Science* See a notice of Colin Mackenzie in the *Journal of the Royal Asiatic Society*, i , p 333, and *Madras Journal of Literature and Science*, ii , p 262

[1] Conner s memoir on Coorg was reprinted at Bangalore in 1870 "Memoir of the " Codugu Survey commonly written Koorg," by Lieutenant Connor, Surveyor (Bangalor Central Jail Press, 1870), 2 vols 8vo Part I, p 137, part II, p 119

Travancor and Cochin were surveyed by Lieutenants Ward and Conner between 1816 and 1821 Their memoir, in seven volumes, contains a journal, tables of triangulation, and descrip tions of the districts, villages, forests, productions, and passes Extracts from it, describing the hill tribes of Travancor, were published in the "Madras Journal of Literature and Science," vol i, pp 1 and 54

Malabar was surveyed by Lieutenants Ward and Conner between 1825 and 1829 Their memoir, in one volume, furnishes a special description of each taluk, including Wynaad, but Ward refers to the great work of Buchanan for fuller details [1]

Tinnevelli was surveyed by Assistant Surveyor Thomas Turnbull and others, between 1807 and 1813, and the memoir which accompanied the map is most valuable, but, unfortunately, it was left unfinished, owing to the death of its author Tinnevelli was a portion of the ancient Pandian kingdom, and the memoir describes inscriptions on granite walls, the temples and other religious monuments, the climate, population, products, and gives details respecting the boundaries, the resources of each taluk, and the roads This was the best account of the people in the extreme south of India that had appeared since the publication of the "Lettres Edifiantes" The Tinnevelli surveyors, however, could not be induced to penetrate into the forest covered mountains towards the Travancor frontier, from a not altogether erroneous idea that they were unhealthy, and there is still a large blank space on the atlas in that direction

The provinces of Dindigal and Madura were surveyed between 1815 and 1824 by Assistant Surveyors Thomas Turnbull and William Keyes, and afterwards by Lieutenant Ward Their memoirs are well written and most valuable, containing full details respecting those provinces, and an account of the wild and little known hill region bordering on Travancor The account of the

[1] The memoir on Malabar, by Captains Ward and Conner was communicated by Major Jervis to the Bombay Geographical Society, and published in their vol iv (May 1840) The map of Malabar was drawn on a scale of one inch to a mile, but there is only one sheet of it in the Geographical Department of the India Office A beautiful reduction of it was drawn in 1832 at Madras, on a scale of two inches to the mile, by C Ignatio, (draftsman), a complete copy of which is preserved in the Geo graphical Department The portion including Wynaad has been lithographed separately at Madras by Colonel Priestley

Palnai hills, from Lieutenant Ward's memoir, is published in the "Madras Journal of Literature and Science," vol vi, p 280

Ward and Keyes also surveyed the Coimbator district between 1821 and 1624, and a descriptive memoir accompanied their maps They were the discoverers and explorers of the Nilgiri hills, and Ward completed a map and memoir of that mountain knot in 1821 An isolated range of hills, with a remarkable peak, separated from the Nilgiris by the Bhowani river, was named after the founder of the Great Survey, and is known as Lambton's Peak Range

The Carnatic was topographically surveyed by the officers of the Military Institute, and Trichinapalli by Lieutenant Ward, whose memoir, in two volumes, contains registers of triangles, tables of bearings and distances, maps of roads on a scale of one mile to an inch, and accounts of the system of irrigation, trade, and agriculture

The eastern districts of Ellor, Rajmahendri, and Guntur were surveyed between 1815 and 1823 by Lieutenant Mountford and the officers of the Military Institute The memoir on the Ellor Survey is in three volumes That of Rajmahendri, in two volumes, by Captain Snell, contains tabulated routes with coloured maps For this survey a base was roughly measured on the boarders of the Colair Lake in May 1820, and connected by triangulation with two of Lambton's points near the Kistna The map was on a scale of one mile to an inch The survey of the Nizam's territory, commenced in Colonel Lambton's time, occupied upwards of 30 years

Thus full materials for a map of the whole peninsula of India south of the Kistna, based on Lambton's Great Trigonometrical Survey, were furnished The memoirs, with a few exceptions, are preserved in the Geographical Department of the India Office Those that are wanting are three volumes of the memoir of the Mysor Survey in seven volumes,[1] that of Madura, and that of the Nilgiris by Ward, which were lent many years ago to some one who never returned them These manuscripts appear to have been placed in the hands of Mr Montgomery Martin, for publication by

1 We have also a manuscript volume by Colin Mackenzie, entitled, 'Report on the State and Results of the Survey of Mysore, in a geographical, statistical, and historical view, up to July 1st, 1807, with a map explanatory"

the Court of Directors A small portion of the Coorg Memoir appeared in two parts in the "Colonial Magazine" during the year 1842, and the whole was reprinted at Bangalor in 1870 Extracts from the Travancor and Dindigal Memoirs were published in the Madras Journal of Literature and Science With these exceptions, and that of the Malabar Memoir in the "Bombay Geographical Society's Journal," the whole of these valuable and interesting memoirs remain in manuscript

While the topographical surveyors of Madras were thus energetically filling in and completing Colonel Lambton's work, their brethren in the north of India were not idle

That indefatigable geographer, Colonel Colebrooke, was Surveyor General at Calcutta from 1803 until his death in 1810 He had previously made a series of astronomical observations in the Carnatic in 1791, consisting of latitudes by meridan altitudes of stars, and longitudes by eclipses of Jupiter's satellites, and in the previous year he had made similar observations during a voyage to the Andaman and Nicobar Islands [1] He also made a survey of the Ganges, but only one of the original sheets has escaped destruction, and is now in the Geographical Department of the India Office [2] Colebrooke's attention was early called to what was, at that time, one of the most interesting problems in Indian geography,—the position of the source of the Ganges The only knowledge then attainable of the upper Himalayas and Tibet was derived from Chinese sources through the Jesuit missionaries It appears that a map of Tibet was put into the hands of Father Regis at Pekin, in 1711, and that he reported its defects to the Emperor Kang-hi, who resolved to procure one that was more accurate and reliable Two lamas, who had been instructed by the Jesuits at Pekin, were sent to prepare a map from Sining to Lhasa, and the source of the Ganges The results of their labours were given to the missionaries in 1717, by whom they were communicated to Du Halde, and published in Paris Much of this map was from oral information, but all that was derived from personal observation appears to have been well laid down Our knowledge of Tibet and of the course of the

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[1] "Asiatic Researches," iv, p 317, and p 321

[2] No 3, Mouth of the Cossimbazar to Colgong It is dated 1796 There are also three sheets of another incomplete set by Colebrooke, dated 1801

See "Narrative of the Mission of George Bogle to Tibet," edited by Clements R Markham, C B, F R S (Trubner, 1876) Introduction, p lxi

Sanpu was entirely derived from this source, until the journeys of Captain Montgomerie's pundits corrected the old lamas' work, within the last few years, while confirming its general accuracy The map published by Du Halde was re-examined by D'Anville, who moved the source of the Ganges further north, and Rennell, in his first map, copied D Anville almost exactly Afterwards, Anquetil du Perron obtained the results of some observations along the course of the Ganges from a Jesuit missionary named Tieffenthaler, who did not, however, carry his compass survey beyond Hardwar, the rest being laid down from native information [1] Rennell, in his second edition, adopted the position of the source of the Ganges from Tieffenthaler, which was based on no better authority than that of the lamas, namely, the report of natives

Thus this important geographical question was left in a state of doubt, and Colonel Colebrooke considered that, as Surveyor General, and for the honour of his country, it was his duty to attempt its solution

In 1800, Lieutenant Wood, the former surveyor of the Irawadi in 1795, had, "by order of General Sir James Craig, K B, commanding the Army in the Field," made an elaborate survey of the Ganges from Hardwar to Allahabad,[2] and in 1808, Colonel Colebrooke resolved to complete the examination of the sacred river from Hardwar to its source Captain Guthrie and Mr Daniell, the artist in 1789, and Colonel Hardwicke in 1796, had already penetrated as far as Srinagar, and the observations of these officers had enabled Rennell to correct the error of Tieffenthaler in placing Srinagar N N W instead of E N E of Hardwar But the source of the Ganges had not yet been reached

Such was the state of knowledge when Colonel Colebrooke obtained the sanction of the Government for his expedition But while he was preparing to set out, the Surveyor General was seized with a fatal illness, and the execution of the project devolved upon Captain Webb, who was accompanied by Lieutenants Raper and

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[1] There is a copy of this curious map of the Ganges, published by Anquetil, in the Geographical Department of the India Office, entitled, "Carte Général du cours du Gange et du Gogre, dressée sur les cartes du Tieffenthaler, Missionaire" Par M Anquetil du Perron Paris, 1794

[2] This survey is beautifully drawn and coloured on several sheets The MS is preserved in the Geographical Department of the India Office, and there is also a second set of sheets of Wood's Survey on a reduced scale But both are in a disgraceful state from long neglect

Hearsey They surveyed the course of the Ganges from Hardwar to near its source at Gangotri, and fixed the position of Srinagar, on the Aluknunda, and other points, between April and June 1808 [1]

In 1805, Colonel Crawford, while conducting a survey in Nepal, measured some of the peaks of the Himalayas, and was the first to announce their immense height, but the journal of his survey is unfortunately lost Mr Colebrooke, the Sanscrit scholar, and kinsman of the Surveyor General, took a great interest in the question of the height of the Himalayan peaks, hereafter to be finally settled by Andrew Waugh, and wrote a paper on the subject [2]

After the untimely death of Colonel Colebrooke, the office was held by Colonel Garstin from 1810 to 1814, and Colonel Charles Crawford succeeded him During this period many useful route surveys were made by officers who accompanied the armies in Oudh and Rohilcund, and in 1807, Dr Buchanan, who had so ably reported upon Mysor and Malabar, was nominated by Lord Hastings to make a statistical survey of Bengal, with an account of the condition of the people, their religion, agriculture, productions, &c He had efficient assistants and draftsmen, and his labours extended over seven years, from 1807 to 1814 [3]

In 1816, Colonel Colin Mackenzie, who had been working in the Madras Presidency for more than 30 years, became Surveyor General at Calcutta, where he reduced and compiled many useful maps, and set several surveys on foot He eventually died there of old age in 1821, and was temporarily succeeded by Colonel Hodgson

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1 The Manuscript of Webb's Survey of 1809, in 12 sheets, from Hardwar to Gangotri, is preserved in the Geographical Department of the India Office The narrative of his expedition was written by his companion, Lieutenant Raper, and published in the "Asiatic Researches," xi, p 446–63

2 "In the Asiatic Researches," vol xii For interesting particulars respecting early measurements of Himalayan peaks, see also "Murray's Discoveries in Asia," ii, p 382, "Baillie Fraser's Journal, p 323, "Buchanan Hamilton's Nepal," and the "Quarterly Review," No 34 The reviewer challenges the accuracy of the observations, and, like a true conservative, declares that the Andes will be found to be higher than the Himalayas

3 Dr Buchanan's Survey cost 30,000*l* His MSS were sent home in 1816, and in 1838 Mr Montgomery Martin got leave from the Court of Directors to publish extracts, which accordingly appeared in three thick volumes There are a series of manuscript maps of the Bengal Districts, drawn for Dr Buchanan, in the Geographical Department of the India Office, but they are merely compilations to illustrate his reports, and were engraved by Mr Walker in 1838 for Mr Montgomery Martin's book

After the termination of the Nepal War, Lord Hastings, in 1815, appointed Captain J A Hodgson and Lieutenant Herbert to survey the mountainous regions between the Sutlej and the Ganges, which are bounded on the north by Chinese Tibet A base was measured by Lieutenant Herbert with staves made of *deodara* wood, latitudes were fixed by stars' zenith distances, and longitudes by observations of Jupiter's satellites,[1] but, although the scientific basis of the survey is highly creditable to the officers employed, the interior filling in was scanty and inaccurate[2] Captain Webb was employed to continue the survey over the province of Kumaon, from 1815 to 1820, and in 1818 Hodgson and Herbert were engaged[3] in Gurhwal

Between 1815 and 1821, Captain James Franklin, a very accomplished officer, surveyed the whole of Bandalkhand, and produced a valuable map of that region, and a memoir on its geology A survey based on routes and cross routes was also made in 1821 by Captain Johnson, of Bhopal and Bairsiah, in Central India[4]

The Sundarbans were surveyed between 1812 and 1818 by two young brothers, Lieutenants Hugh and W E Morrieson They were much annoyed by tigers and alligators, and they relate how a

[1] The original manuscript map showing the base measured by Hodgson and Herbert near Saharanpur, and the triangulation founded on it, to ascertain the heights of peaks, is preserved in the Geographical Department of the India Office

[2] Interesting accounts of these operations will be found in the Asiatic Researches, vol xiii, p 297, and vol xiv, p 60 and p 187

The operations of Hodgson and Herbert were also published in a work entitled "Astronomical Observations in various parts of Hindustan, and a Survey of the sources of the Ganges and Jumna," by Capt J A Hodgson "with operations for "determining the heights of peaks in the Himalayas, by Captains Hodgson and Herbert, 1817" It contains an account of their measurement of a base, with drawings of the apparatus

There is a copy of this work in the Geographical Department of the India Office, bound in red morocco and gilt, with a manuscript title page

In 1829, Herbert commenced a periodical at Calcutta, called "Gleanings in Science," to which James Prinsep was a frequent contributor Herbert became Astronomer at the Lucknow Observatory in 1831, and Prinsep took his place as editor In 1832 the "Gleanings" were converted into the "Journal of the Asiatic Society of Bengal," and have been published monthly ever since Herbert died at Lucknow on September 24th, 1833

[3] The original "Journal of the Survey of Gurhwal," by Lieutenant J D Herbert, 8th Regiment N I, in 1818, is preserved in the Geographical Department of the India Office

[4] The field books of Captains Franklin and Johnson are preserved in the Geographical Department of the India Office

tiger sprang from a branch just over their theodolite while in the act of observing, and how the shaking of the ground near them made the instrument vibrate, owing to the tread of huge monsters in the jungle Hugh died of jungle fever at Jessor in 1818, and his brother was killed in an action with the Gorkhas [1]

A rough survey of Cattack was commenced in 1818 by Lieutenant Buxton, a survey of Bakarganj was instituted in 1819, and those of the Silhet frontier, and of Azimghur and Jaunpur were commenced in 1818 A line of country was also surveyed by Lieutenant Jackson, from Midnapur to Nagpur in 1818, with a view to ascertaining the practicability of making a road [2]

In the Bombay Presidency, during this period, Colonel Monier Williams made a careful survey by compass and perambulator of Gujrât, Kach, and Katiwar, between 1813 and 1820, and some maps were compiled from route surveys in the Deccan, but none were based on triangulation Captain Dangerfield was engaged on geographical work in Malwa, and between 1812 and 1816 Colonel Dickenson and Captain Tate surveyed the town and islands of Bombay and Salsette, and this map was accompanied by a statistical memoir [3]

[1] Their field books are preserved at Calcutta *See* "Calcutta Review," vol lxiii (1859)

[2] See a dispatch from Lord Hastings, dated February 15th, 1821

[3] The map of Bombay, by Dickenson and Tate, was lithographed for Major Jervis in 1843, on a scale of 1 inch to 1,200 yards, but it is very inaccurate

# V

# SECOND PERIOD OF THE TRIGONOMETRICAL SURVEYS

## 1823-43

### Sir George Everest, and the completion of the Measurement of an Arc of the Meridian

On the death of Colonel Lambton in 1823, his assistant George Everest was appointed to succeed him as Superintendent of the Great Trigonometrical Survey of India, and thus the hope of the veteran surveyor, expressed in his last Report, was fulfilled "A "man was found, after he relinquished the work, possessing zeal, "constitution, and attainments wherewith to prosecute it"

George Everest, son of Tristram Everest, Esq, of Gwernvale in Brecon, was born on July 4th, 1790 He began his education at Marlow, and completed it at Woolwich, where he passed a brilliant examination He sailed for Bengal as an Artillery Cadet in 1806, and executed a reconnaissance survey for Sir Stamford Raffles in Java in 1814-16,[1] when he became the friend of Mr John Crawfurd In 1817 he was employed in establishing a telegraph system from Calcutta to Benares, and joined the survey in 1818

He had been Colonel Lambton's chief assistant for upwards of five years At the time of his chief's death he was engaged on the Bombay longitudinal series On taking charge of the survey, he found the most northern work to be a base line measured at Takalkhéra in the valley of Berar, but the triangulation had not been extended so far Here Everest commenced work in November 1823

He was surrounded by many difficulties His colleague, Dr Voysey, died in December 1823, and Lambton's principal assistant, Mr De Penning, a half caste from Madras, became weary of the service, and retired in February 1824 The rest of Lambton's staff consisted of Madras men, who were unwilling to go so far from their homes, and there were no trained hands to take their places

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[1] The MS volume containing the original route survey of Java in 1814-16 is preserved in the Geographical Department of the India Office

Everest himself was attacked with a severe fever, and his limbs were paralyzed. Still he resolutely persevered, lest, if he broke down, the establishment should be scattered, and the trained men be lost, whom it would be impossible to replace. He was lowered into and hoisted out of his seat by two men, when he observed with the zenith sector.

He now had to take the meridional arc series across the Satpura hills,[1] which bound the valley of Berar to the north, about 15 miles north of the Takalkhéra base. He anticipated that the density and magnitude of these mountains would cause a considerable deflection of the plumb line, and made some careful observations with a view to deciding the point. He then carried the triangulation across the Satpura hills as far as the plain of Sironj, where a base line was measured with the old chain in November 1824. In January 1825 a series of observations was taken at Kalianpúr near Sironj, and then at last the Superintendent's health completely broke down. He was obliged to go to England on sick leave, but still retaining his appointment, in 1825.

During Colonel Everest's absence, a longitudinal series of triangles was extended from the Sironj base to Calcutta, over nearly 700 miles of difficult and little known country. This important work was entrusted to Mr. Joseph Olliver, who had been Everest's pupil from the time he first joined the survey in 1818, and whom he called his "right arm."

Colonel Everest was in England from 1825 to 1830, and his time was fully employed in studying the newest improvements and superintending the construction of instruments on the most approved principles. When he returned to India in 1830, he was provided with the best instruments that could then be produced. He had a large theodolite with an azimuth circle 36 inches in diameter, by Troughton, and two double vertical circles three feet in diameter, by Troughton and Simms. But the most important improvement introduced into the survey by Everest, at this time, was the measurement of the bases by compensation bars, instead of the old inaccurate method by chains.

One of the objections to the chain method was the impossibility of determining the temperature of its different parts while in actual

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[1] He calls them the Mahadeo hills.

use. Colonel Colby, of the Irish Survey, invented the method of measuring bases by compensation bars,[1] founded on the principle of eliminating the errors arising from changes of temperature by compensation or self correction. Advantage is taken of the unequal expansion of various metals to eliminate the effects of variations of temperature altogether. Two bars, one of brass and one of iron, each about 10 feet long, are firmly clamped together in the middle so that no motion can take place near the centre, and any expansion from change in temperature must be towards the extremities. At a temperature of 62° the two bars are precisely the same length. At each end of both bars an aperture is worked out to admit a conical pivot, and the two pivots, one in the brass the other in the iron bar, are adjusted to a flat iron tongue. When the temperature rises, the brass bar will be lengthened more than the iron one, and the tongues will incline inwards, and *vice versâ*. Consequently there is a point on the tongues at which theoretically the expansion of the bars is compensated by the inclination of the tongues. This point is marked with a dot on each tongue, and the distance between these dots is, as nearly as it can be made, ten feet. The bars are supported on brass rollers and enclosed in deal boxes, from which the tongues only project. Before going to India, Colonel Everest tried the compensation bars in Lord's cricket ground. Two iron standard bars were made of 10 feet each, called A and B, and two brass standard scales of six inches, also A and B, with which the compensating bars and microscopes were frequently compared. All the measurements were referred to these standards.[2]

Colonel Everest arrived at Calcutta in the autumn of 1830, with six sets of bars, and well supplied with the most improved instruments. He combined the appointments of Surveyor General and Superintendent of the Great Trigonometrical Survey in his own person. He found that Mr. Olliver had nearly completed the Calcutta longitudinal series, which originates at Kalianpúr, and terminates at

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1 It is said that a base 100 feet long in Ireland was measured six times with Colby's compensation bars, and that the extreme difference between the measurements did not exceed half the breadth of a sharp steel point on a plate of metal, observed with a microscope.

2 "Transactions of the Physical Class of the Asiatic Society of Bengal." 1839. This was an interesting lecture by Everest on the compensation bars, the substance of which will be found in the *Asiatic Researches*, xviii. p. 189.

Fort William, Calcutta On Everest's arrival he resolved to measure a base line of verification for this series, which is interesting as the first base line in India that was measured with the compensation bars Mr Taylor, the Astronomer at the Madras Observatory, was deputed to Calcutta to assist Colonel Everest at the measurement of this base It extends for 6½ miles along the road from Government House at Calcutta to Barrackpur The extremities are marked by two towers 75 feet high, which overtop the trees and houses [1] The measurement was commenced on November 23rd, 1831, finished on January 21st, 1832, and the triangulation of the Calcutta longitudinal series was completed on July 2nd, 1832 [2]

In 1832 Colonel Everest resumed the work connected with the meridional arc series, and in the commencement he had to encounter difficulties which could only have been surmounted by a combination of qualities which are rarely found united in one man His staff had to be trained to the work, and, in addition to his incessant labours in the field, he had to transact all the business connected with his office as Surveyor General

Hitherto the meridional arc series had been conducted over the elevated plateau of the Deccan, where numerous rocky heights offered excellent sites for stations But in extending the triangulation beyond the Sironj base, the surveyors entered upon a much more difficult country for their work Here the great plateau of Central India terminates with the high land round Gwalior, and the valley of the Chambal commences From this point the east flank of the meridional series is on flat land, while the western side rests on low hills as far as Delhi But from Delhi a wide plain, overgrown with groves of mango and tamarind, intermingled with lofty peepul and banian trees, and thickly scattered over with villages, extends for 104 miles to the foot of the Siwalik hills, the first outwork of the Himalayas At a distance of a few miles from the observer on the great Gangetic plain, the trees appear to form a continuous belt of foliage, while clouds of dust often obscure the view

[1] The following officers were engaged in measuring this base Lieutenants Western and Bridgman, Mr Taylor the Madras Astronomer, Messrs Logan, Olliver, Peyton, Torrick, Rossenrode, and Lieutenant Wilcox the Surveyor of Assam There is an account of the measurement in the *Journal of the Asiatic Society of Bengal*, i p 71 See also James Prinsep's "Determination of the Constant of Expansion of the Standard," i p 130

[2] The area surveyed was 33,442 square miles Total cost 13,074*l*

In entering upon this difficult country, Colonel Everest was supported by able and zealous young assistants In 1832, Andrew Waugh,[1] his future successor, and Renny joined the survey, and Olliver and Rossenrode had already been in training for some years

It is the practice of the survey, before commencing the main triangulation of a series, to execute an approximate series by which the stations for observing the angles of the main series are selected, and the positions of the triangles sketched out

Mr Olliver commenced the new work by exploring the tract north of the Chambal, while Mr Rossenrode was deputed to carry on an approximate series along the meridian of the great arc as far as the Chambal river It then became necessary to erect permanent towers for stations on the Gangetic plain, and in order to select their positions, Colonel Everest designed a mast 30 feet high, with a circular table, 40 inches in diameter at the top, round which a square scaffolding of large bamboo was built This was intended to observe from, and 13 other masts, 70 feet high, with cross bamboo staves having an ignited blue light at one end, and a sway rope at the other, were placed on the surrounding stations

On December 5th, 1833, Colonel Everest arrived at Muttra, the station for collecting bamboos for the masts and scaffolding The instrument used on the top of the observing mast was a Troughton and Simms 12-inch theodolite, constructed in 1830 The signals at the pinnacles of the other masts were blue lights, burnt by sets of four, at intervals of 10 minutes But, owing to the distance between the stations, the signals were scarcely ever visible to the naked eye, and it was necessary to lay the telescope in the proper direction, to be calculated beforehand by a series of minor triangles This system, invented by Colonel Everest, was called "*ray tracing*" By May 1834 all the 35 stations between the Chambal and the foot of the Sewalik hills had been selected Day and night, at all hours, from December to May, Everest was perpetually at work Colonel Lambton had used masts and flag staves as signals But, owing to the nature of the atmosphere, objects of this kind cannot be easily bisected in the day time during the healthy season, and are often invisible for days together So Lambton chose the rainy season when the atmosphere is very clear, for field observations The con-

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[1] Nominated July 2nd, 1832

sequence was a reckless waste of life and health, besides much suffering and discomfort But luminous objects were found to succeed best in the dry healthy season Everest therefore substituted the heliotrope[1] for day observations at short distances, and reverberatory lamps with argand burners,[2] or blue lights, for the night

The position of each station having thus been fixed, 17 permanent towers were erected They are square at the base, about 50 feet high, with walls five feet thick at the bottom and two at the top The roof or terrace is supported by two large stone beams on which rests a cylindrical well of masonry surmounted by a circular slab of sandstone At right angles to these stone beams, and 3½ feet above them, are rafters supporting the stage for the observer, round which is a hand rail with rings for the observing tent Thus the instrument is completely isolated from the stage on which the observer stands The instrument is hoisted up by a crane at one angle [3]

These important but tedious preliminaries having been completed, the great work of measuring the most northern base for the great arc series was commenced in the end of 1834 The region selected for this measurement was the Dehra Dún, a beautiful valley between the Siwalik hills and the Himalayas, 2,000 feet above the sea The western end of the base line is 1,886 and the eastern 2,073 feet above the level of the sea The measurement was commenced on December 1st, 50 comparisons having first been made between each of the six compensation bars and the iron standard, while the standards A and B were compared with each other 101 times As soon as the base was measured it was remeasured in reverse order by Waugh and Renny, the error being 2 396 inches The whole distance was 7 42 miles On March 28th, 1835, the work of measuring was completed The uncultivated part of the country, over which the base line passes, was afterwards purchased by Captain Kirke, who called it Arcadia, in compliment to the great arc series Colonel Everest's head quarters were at Hatipaon, in the Dehra Dún, whence

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[1] The heliotrope is a circular mirror, 10 to 12 inches in diameter, fitted for vertical and horizontal motion

[2] The lamps constructed in 1830 consisted of a parabolic reflector 12 inches in diameter, applied to an argand burner, the whole inclosed in a wooden shed with a glass window, which served as a packing case in travelling

[3] See an article on the detail of the working of the Great Trigonometrical Survey, describing the duties in the field, the rules for selecting stations the heliotrope and other apparatus, in the 'Professional Papers on Indian Engineering,' vol iv p 303

he commanded a view of the lovely valley The base was transferred, by triangulation, to the peaks of the Siwalik hills, called Amsot and Banog, which are visible both from Dehra and from the Gangetic plain During this period Colonel Everest's health suffered very severely, and he was ordered home, but this was impossible, as none of his staff could then have taken his place

Between October 1834 and June 1835, all the horizontal angles across the plain, from the Chambal to the foot of the Siwalik hills, were taken The instruments used were two three foot theodolites, one by Troughton and the other by Mr Barrow, the instrument maker whom Colonel Everest had brought out from England, and established as head of a factory at Calcutta Barrow's theodolite was partly composed of portions of the old instrument of Colonel Lambton, and the circle was graduated at Calcutta by Barrow Members of the surveying staff were now rapidly gaining knowledge and efficiency

An observatory was formed at Kaliana, near the foot of the Siwalik hills It consists of a room 20 feet long by 12, terminated at either end by a semicircular bow, and two side rooms Pillars are passed up through the floor, and free from contact with it, and opposite each there are two meridional apertures 24 inches wide Here one of the double vertical circles was placed on a column of carved sandstone, surmounted by a capital of brass The instrument is three feet in diameter, and consists of two circles with a telescope between them These astronomical circles were found to vibrate so much as to render accuracy impossible At first this was attributed to the wooden tripods on which they were placed, but the same defect was apparent when they were removed to the stone columns, and it became evident that they were top heavy Everest set himself resolutely to work to devise a remedy He was ably assisted by Syud Mohsin, a native of Arcot, who came to Calcutta under the patronage of Colonel Blacker, the Surveyor General, and was engaged by Everest in 1830 The task was one of great delicacy, and requiring an intimate knowledge of the subject, as well as much mechanical skill Finally, however, the great surveyor and his native colleague achieved a complete success

On the 1st of October 1836, Colonel Everest took the field with both the large theodolites, and four 18-inch altitude and azimuth instruments He divided his staff into two distinct parties, under himself and Andrew Waugh, and by February 1837 they had con nected the Dehra Dún base with that measured on the Sironj plain near Kalianpúr in 1824 At the latter place another observatory was erected, exactly like that at Kaliana

It then became necessary to re-measure the Sironj base with the same instruments that had been used in the Dehra Dún This work was commenced on December 1st, 1837, and completed on January 18th, 1838 The old base proved to be too short by 2 825 feet, and the error was attributed to want of means of knowing the true length of the chain and the true temperature

In October 1838 Captain Waugh was sent south to revise the angles in the Deccan with Troughton's large theodolite, and he completed a series of triangles over a meridional distance of 260 miles, returning to Dehra in June 1839 To show the wonderful accuracy of these observations, it may be stated that the difference between the length of the Dehra Dún base as measured, and as computed by triangulation from the Sironj base was only 7 2 inches

The difference of latitude between the Kaliana and Kalianpúr observatories, which are on the same meridian, was fixed by simultaneous observations of the same stars with the two great astronomical circles [1] The stars selected for simultaneous observation were 36 in number On the 25th of November 1839 Captain Waugh reached the Kalianpúr observatory, with the instrument called "Troughton," while Everest and Renny remained at Kaliana with "Simms" The series of observations was completed on the 23rd of January 1840, and an arc of amplitude was thus determined on this section of the meridian Waugh then went south to Dumargida near the old Bidar base line, and Everest came down to Kalianpúr Simultaneous observations of 32 selected stars were then commenced on November 24th, 1840, and completed on January 11th, 1841, and another arc of amplitude was determined, From Kaliana to Kalianpúr the arc is 5° 23′ 37″, and from Kalianpúr to Dumargida 6° 3′ 55 9″ In 1841 Waugh proceeded to re-measure the old Bidar base line, after making 57 comparisons between the compensation bars and the standard The difference between the length as measured, and as computed from the Sironj base, was 4 296 inches

Thus were brought to a close the operations of the great arc of India series, which extends from Cape Comorin to Banog in the

[1] By the simultaneous observations of the same stars, the errors in the catalogued places of stars were eliminated

Himalayas. The portion from Cape Comorin to Dumargida and the Bidar base is dependent on Lambton's chain measurements That from Dumargida to Banog depends on the iron standard bars A and B, and the brass standard scales B was sent to England in 1843–4, and deposited at Southampton A was at first deposited in the fort at Agra, and now remains with the rest of the apparatus in charge of the officers of the Survey

In these observations Everest deemed symmetry essential to accuracy in his triangles ("triangles bien conditionnés"), and allowed no angles to be less than 30° or greater than 90° The total cost of Everest's Great Arc Series was 89,833*l*, and the area covered 56,997 square miles [1]

In 1835 Colonel Everest had had a serious and almost fatal illness, and at one time his recovery was pronounced to be beyond all hope In September 1837 the Court of Directors appointed Major Jervis, an engineer officer who had been engaged in some of the surveys in the Bombay Presidency, to succeed Colonel Everest as Surveyor General in the event of his death, that the work might not be impeded Major Jervis had made himself well known in England by reading papers and submitting proposals for improved methods of conducting the surveys,[2] and eventually the President and several Fellows of the Royal Society addressed a memorial to the Directors of the East India Company, urging them to adopt the views of Major Jervis, without alluding to the great services of Colonel Everest and his admirable staff This proceeding excited great indignation in those distinguished officers who had borne the heat and burden of the day, and gave rise to a series of letters addressed to the Duke of

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1 There was an interesting discussion on the Great Indian Arc and the figure of the earth, between Archdeacon Pratt and Captain Tennant See the "Philosophical Transactions, 1855" (p 78) papers read before the Astronomical Society in January and June 1857 and the "Journal of the Asiatic Society of Bengal," xxviii p 20 Archdeacon Pratt held that it would be necessary to allow for the effect of mountain refraction on the plumb line, in calculating the curvature of the earth

2 See his "Address delivered in the Geographical Section of the British Association at Newcastle on August 26th, 1838, on the state and prospects of the Surveys in India, with a prefatory sketch of the principles and requirements of Geography, by Major Jervis, appointed provisionally Surveyor General of India, with introductory remarks, by Sir George Back, Vice President of the Section"

It is published in Vol iv of the "Bombay Geographical Society's Journal" pp 157–189 (1840,) and was printed separately at Torquay

Sussex[1] as President of the Royal Society, from Colonel Everest, remonstrating against the conduct of that learned body These letters are written in a vein of humorous sarcasm, and they so completely gained the writer's object that nothing more was ever heard of Major Jervis in connection with the Surveyor Generalship Useful service was, however, unintentionally done by arousing the great Surveyor's indignation, for his letters contain many interesting details which would otherwise have been lost

The labours of Colonel Everest, as Superintendent of the Great Trigonometrical Survey of India, are by no means comprised in the Great Arc Series He also completed the Bombay Longitudinal Series, and designed and partly carried out a scheme for covering Bengal and Behar with a gridiron of trangles

The Bombay Longitudinal Series had been commenced by Everest himself, as long ago as 1822, and he had reached as far as the meridian of 76°, when he received the news of Lambton's death This portion was revised by Lieutenant Jacob in 1840–41 During Everest's absence in England, Captain Jopp, the Deputy Surveyor General at Bombay, proposed the continuation of the work in 1827, and Lieutenant Shortrede[2] was appointed to undertake it But these officers committed the great mistake of commencing from a base of their own, unconnected with Lambton's triangulation, and this too, in the teeth of remonstrances from Colonel Hodgson, then Surveyor General at Calcutta They measured an independent base on the Karli plain, 40 miles east of Bombay, with a steel chain made by Cary The rest of their work, as regards observations of angles and celestial azimuths, was considered by Colonel Everest to be slovenly and objectionable, and he set it aside When Lieutenant Shortrede resigned in 1836, Lieutenant Jacob was appointed to succeed him, and took the field in October 1837[3] His labours were completed with the revision of Everest's old work by himself and Waugh, and thus the Bombay Longitudinal Series was finished in 1841 It is

[1] Published in a pamphlet by Pickering, in 1839

[2] Author of "Logarithmic and new Astronomical and Geodesical Tables," by Robert Shortrede, Captain E I C S (Edinburgh 1844) He afterwards had charge of the Punjab Revenue Survey, from 1849 until 1856 General Shortrede died at Blackheath in 1868

[3] Between 1845 and 1848 Jacob made a catalogue of double stars from observations at Poona, with a five foot equatorial by Dollond (*Memoirs of the Astronomical Society*, xvii p 79) He afterwards had charge of the Madras Observatory, from 1848 to 1856 See the section on Astronomical Observations in India

315 miles in length The area surveyed is 15,198 square miles. Total cost 13,742*l*

A complete revision of the famous old survey by Major Rennell was also designed by Everest He resolved to originate several Meridional Series from the Calcutta Longitudinal Series, to terminate at the foot of the Himalayas, and eventually to be connected by another Longitudinal Series along the base of the mountains This is the gridiron, in contradistinction to Lambton's network system of triangles The plan was approved in 1832, and nine stations about 60 miles apart, were selected on the Calcutta Series, as origins of as many Meridional Series, namely,

1 *Budaon*, passing through Gwalior and the western part of the North-West Provinces to Dehra
2 *Ranghír*, through the western part of the North-West Provinces
3 *Amua*, going through the central part of the North-West Provinces and Oude
4 *Karara*, do do
5 *Garwani*, do do
6 *Gora*, going by Gorakhpur, through the eastern part of the North-West Provinces
7 *Hurilaong*, through the Lower Provinces
8 *Chindwar*, do do
9 *Parisnath*, which goes both north and south from the Calcutta Series, through the Lower Provinces
10 *Maluncha*, also going north and south through the Lower Provinces

Thus the North-West Provinces, Rohilkhand, Oudh, Bahár, and half Bengal would be crossed by lines of primary triangles, sixty miles apart

The first series taken in hand was that of Parisnath, under Lieutenant Western The northern portion was executed between 1832 and 1835, and the southern part, extending to Bálasore, under Colonel Boileau, between 1835 and 1840 The Budaon Series was commenced in 1832 by Lieutenant Roderick Macdonald, who died at his post, and finished by Captain Renny [1] The Ranghír Series was begun by Captain Waugh in 1834, and completed in April 1840 The Amua Series was begun in 1834, and finished in June 1839 [2]

[1] Vol ix, pt i [2] Vol ix, pt. iii

The northern connecting series was also proceeded with in Colonel Everest's time. Captain Du Vernet connected the Great Arc Series with that of Ranghir between 1841 and 1843, and in November 1842 Captain Waugh continued the work thence to the head of the Amua Series, through the Terai north of Rohilkhand, a fever haunted country covered with dense forest and brushwood. Everest designates this piece of work by Andrew Waugh "as complete a specimen of rapidity "combined with accuracy of execution as there is on record in the "volumes."[1]

The Superintendent of the Great Trigonometrical Survey finally quitted the scenes of his labours and triumphs in 1843, and retired from the service after having been connected with the surveys for twenty-five years. He refused the knighthood which was then offered to him, but accepted it with a C.B. in 1861. He had completed one of the most stupendous works in the whole history of science. No scientific man ever had a grander monument to his memory than the Great Meridional Arc of India. Everest's was a creative genius. The whole conception of the survey, as it now exists, was the creation of his brain. He entirely altered and revolutionized the old system of Lambton by substituting the gridiron for the network method. He introduced the compensation bars which have measured every base in India down to the present day. He invented the plan of observing by heliotrope flashes, and the system of ray tracing, and designed the plan for the towers. There have been modifications and improvements since his time, but nearly everything in the surveys was originated by the great geodesist. Sir George Everest died in 1866. In one of his letters to the Duke of Sussex, he speaks of two of his assistants as having "attained a degree of "accuracy and perfection of skill which it would be impossible "to surpass." One of these, now Sir Andrew Waugh, was his successor.[2]

Records of the labours of Sir George Everest are to be found in the following published and manuscript books:

1. "Account of the Measurement of an Arc of the Meridian."—(London, 1830. 4to.)

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[1] Budaon Series, cost 17,259*l*. Area 12,468 sq. miles.
Ranghir Series, cost 11,837*l*. Area 16,087 sq. miles.
Amua Series, cost 10,495*l*. Area 5,565 sq. miles.

[2] The other was Major Renny Tailyour.

2 "Account of the Measurement of two sections of the Meridional Arc of India," by Lieut-Colonel Everest—(London, 1847 4to)

3 Account of the Compensation Bars, in the *Asiatic Researches*, xviii p 189

4 Edinburgh Review (1848) Vol 87, p 372

5 A Series of Letters addressed to H R H the Duke of Sussex, by Lieut-Colonel Everest (London, Pickering 1839)

6 The operations of the Trigonometrical Survey from January 1823 to 1837 Great Arc Series, Bidar to Sironj and Dehra Vol 7, parts I and II, with Maps and Appendix to part II, MS

7 Calcutta Longitudinal Series, with a map Vol 8, part I MS

8 Bombay Longitudinal Series, with a map Vol 8, part II, MS

9 Budaon Series Vol 9, part I, MS (Skeleton maps)

10 Ranghír Series Vol 9, part II, MS (Maps)

11 Amua Series, &c, with maps Vol 9, part III, MS

12 Himalaya Longitudinal Series Vol 9, part IV, MS

13 Pilibit Series Vol 9, part V, MS

14 "Remarks respecting the errors likely to arise from the false position of the fixed axes of the pendulum," by George Everest *Memoirs of the Royal Astronomical Society*, IV, p 29

15 "On Instruments and Observations for Longitude for travellers on land," by Colonel G Everest *Journal of the Royal Geographical Society*, Vol XXX, p 315

16 "Geodesical operations in India," by Sir George Everest *British Association Reports*, 1844, p 3, and 1845, p 25

The obituary notice of Sir George Everest, by Sir Roderick Murchison, in his anniversary address for 1867, will be found in the *Journal of the Royal Geographical Society*, Vol XXXVII, p CXV

There is another obituary notice in the address of the President of the Astronomical Society, on February 8th, 1867 *Proceedings*, vol XXVII p 105

# VI

# SECOND PERIOD OF THE TOPOGRAPHICAL SURVEYS 1823—1843

## The Revenue and Topographical Surveys

During the period from 1823 to 1830 there was a Surveyor General at Calcutta, and Deputy Surveyors General at Madras and Bombay The post at Calcutta, from 1823 to 1827, was held by Colonel Valentine Blacker, whom Sir Andrew Waugh speaks of as, with the exception of Everest, the ablest and most scientific man that ever presided over the Department [1] The revenue surveys in the North West Provinces were commenced under his auspices, and his thorough appreciation of the importance of the surveys on a geodetic basis is shown in his able paper on the subject, which has been reprinted by Sir Andrew Waugh Colonel Blacker died of fever in 1827, and was succeeded by Colonel Hodgson, who had previously held the office from 1821 to 1823, and who now held the post until 1829, when he returned to England, in the expectation of being employed on the engraving of the Indian Atlas [2] Major H Walpole acted as Surveyor General for a short time in 1829–30 In the same year Colonel Everest assumed the duties both of Superintendent of the Great Trigonometrical Survey and Surveyor General of India, and in about 1834 the posts of Deputy Surveyor General at Bombay and Madras[3] were abolished

There was convenience in placing the whole Department under one head, but it must be confessed that, owing no doubt to the absorbing nature of Colonel Everest's duties connected with the great arc, and to the difficulties which surrounded him in the organization of his Department, the progress of the geographical delineation of

[1] Parliamentary Paper, April 1851

[2] This is the same officer who surveyed part of the Himalaya with Captain Herbert (See page 81) John Anthony Hodgson was born at Bishop Auckland on July 2nd, 1777, and went to India as a cadet in 1799 After his return to England, he lived at Durham He became a Major General in 1845, received a command in India, and died at Ambála on March 28th, 1848 Hodgson was also an accomplished astronomer See the section on Astronomical Observations

[3] Captain D Montgomerie had been Deputy Surveyor General at Madras since July 1829 A map of the peninsula of India, to be compiled from the surveys, had been called for so long ago as 1819, and in 1830 Montgomerie submitted a map of most of the Madras Collectorates on a scale of four miles to the inch, with a sketch map of southern India, on a scale of 24 miles to the inch, as a key

the country had languished in some degree during the period of his incumbency

In 1828, Mr J S May, the Superintendent of the Nuddea rivers, surveyed and made maps of the Hugli, Bhagirathi, Jalangi, and Matabhanga, and J Prinsep lithographed maps of the Hugli and Ganges, from old surveys by Colebrooke, corrected up to his own time from May's work

The revenue surveys in the North-West Provinces were commenced in 1823 They were undertaken mainly with a view to forming a settlement for the land revenue, and the correct delineation of boundaries of estates was considered of more importance than accurate topographical detail, while rapidity of execution, rather than good mapping, was the object of the surveyor The revenue survey was divided into two parts, scientific and native The scientific survey laid down, on a scale of four inches to the mile, the village boundaries, and the main geographical features of the country The native survey consisted of a rough plan of the village and fields, called a *shujreh*, and the list of the fields with their measurement, or *khusrah*

Between 1822 and 1842, the districts west of the Jamna (Hairianah, Panipat, Bhattiana, Delhi, Rohtak, Gurgaon, Mattra, and Agra,) were surveyed in this way by Captains W Brown, Simmonds, Oliver, Wroughton,[1] and Fordyce, the districts of the Doab by Captains Fraser, H Lawrence, Wroughton, W Brown, Abbott, and Stephen, and those of Rohilkhand by Captains Birnie, Brown, Bedford, Wroughton, Fraser, and Abbott

Abbott and Stephen, between 1839 and 1842, completed a survey of Bandalkhand in three maps, which superseded the old route survey of Franklin, and showed great changes in the country Several villages marked on Franklin's map are not found in the later survey

The districts round Benares were surveyed from 1839 to 1841 by Abbott, Wroughton, Maxwell, Fordyce, and H Lawrence, whose work superseded the old route surveys A survey of the Sagar and Narbada country was completed by Captain Wroughton in 1842, while that of Bahar and Bengal was commenced in 1837, and was still progressing at the time of Everest's retirement

Lieutenant Thuillier, who entered the service in 1832, and is now Surveyor General of India, was engaged on the survey of Ganjam and

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[1] See a statistical return of the Mattra District (Act, 1835), by Captain Wroughton —*Journal of the Asiatic Society of Bengal*, v, p 216

Orissa, in conjunction with Lieutenant Smyth,[1] from 1839 to 1842, and afterwards surveyed the districts of Silhet and Cachar A rough survey was also made of Chittagong, for a district map, between 1835 to 1841, and in 1831 Lieutenants Norris and Weston surveyed the Berar and Nagpore country, and made a map, which contained much detailed geographical information

The topographical details of these Revenue Surveys were tolerably well executed until 1834, when a conference of surveyors was held at Allahabad, by order of Lord William Bentinck The great object was to get the surveys done, in order to commence a new system of revenue settlement A new plan was therefore adopted, introducing economy and rapidity, and sacrificing quality for quantity The maps were only required to delineate village boundaries and sites, with rough outlines of roads and the courses of rivers, and were mere skeleton sketches They preceded the Great Trigonometrical Survey and thus a proper connexion was not in the first instance established between the two operations Major Bedford was appointed Superintendent of the Revenue Surveys of Bengal, under Colonel Everest, in the end of 1838

On the first appointment of Captains Waugh and Renny to the Trigonometrical Survey in 1832, Colonel Everest sent them to explore the wild jungly country between Chunar and the sources of the Son and Narbada, up to Jabalpur They completed this service, and submitted a topographical and geological report in 1834[2]

The breaking out of the Burmese War led to the acquisition of much valuable geographical information in the direction of the north-east frontier of Bengal, and of that vast unknown region beyond, which then, as now, was delineated only from the maps of d'Anville Captain Bedford and Lieutenants Wilcox and Burlton were sent to explore the Brahmaputra towards its source in 1825, under instructions from Colonel Blacker, then Surveyor General Burlton surveyed the Brahmaputra as far as Sudiya, Bedford went up the

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[1] Their memoir on the Ganjam district is preserved in the Geographical Department of the India Office It contains an account of the boundaries, area divisions, soil, productions, population, ports, lakes, &c Their new map is in 15 sheets (and an index), on a scale of four miles to the inch

[2] A manuscript volume containing the journal of the route from Shergotty to Chunar, and thence to Jabalpur, by Lieutenants Waugh and Renny, is preserved in the Geographical Department of the India Office At the end there is a "Geological Journal," with coloured sketches of the route

rivers Dihong (Sanpu ?) and Dibong until he was stopped by wild frontier tribes, and Wilcox made one journey beyond the frontier up the Brahmaputra valley, and in another penetrated to the banks of the Irawadi[1] Captain Boileau Pemberton surveyed the territory of Manipur and surrounding country, and portions of Cachar, between 1825 and 1830, and from 1830 to 1837 Dr Richardson and Captain McLeod made exploring journeys from Moulmein to Ava and to Kiang Hung near the Chinese frontier To this day no explorer has succeeded in adding, in any appreciable degree, to the knowledge conveyed by the discoveries of Bedford and Wilcox, as regards the region beyond our north east frontier, and towards the sources of the head waters of the Brahmaputra and Irawadi Captain Pemberton's exceedingly valuable large map, compiled from the route surveys of all these officers, was lithographed at Calcutta in 1838[2]

In 1830 a survey was commenced to connect the map from Goalpara, where it terminated in Captain Wilcox's survey of the Assam valley, with the surveys of the Ganges In 1834 Lieutenant Ommanney was engaged in tracing the line of the Brahmaputra from Goalpara, round the difficult country at the root of the Khasia

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[1] "The Memoir of the Survey of Assam, 1825–28," with a detailed account of the discoveries, and a map, by Lieutenant Wilcox, will be found in the *Asiatic Researches*, vol xvii, p 314

[2] The record of these surveys will be found in the following printed and manuscript books —

Vols xvi and xviii of the *Asiatic Researches*

No xxiii of the *Selections from the Records of the Bengal Government* (1855)

"Report on the Eastern Frontier of British India," by Captain Pemberton (Calcutta, 1835)

Journal (abstract) of an expedition from Moulmein to the Chinese frontier, in December 1836, by Captain McLeod —*Journal of the Asiatic Society of Bengal*, vi, Pt ii, p 989 The Manuscript Journals of Captain McLeod's and Dr Richardson's expeditions are preserved in the Political Department of the India Office They were printed by order of the House of Commons in 1870, with a map compiled by Mr Saunders Captain McLeod's original map appears to be lost

Original Journal of Captain James Bedford on the Brahmaputra and Dihong 1824–25 MS

Note book of route from Kusan on the Dihong, towards the source of the Irawadi in 1826, by Lieutenant Wilcox MS

Field book of the survey of part of the Brahmaputra in 1825 MS

Survey of the Brahmaputra from Goalpara to Bishanath in 1828 MS

These manuscript volumes are preserved in the Geographical Department of the India Office hills, to within thirty miles of Dacca, when a sudden order of the Government directed the work to be suspended, thus rendering it comparatively useless for want of the connecting link which it would only have taken three months to complete [1]

In 1835 Mr Fergusson made a sketch survey of the lower Ganges and Brahmaputra, from Jafarganj to the sea, which was combined in a small atlas published at Calcutta by Mr J B Tassin, and a topographical survey of the river Hugli from Bandel to Garden Reach was compiled and published in 1841, by Mr Charles Joseph [2]

The survey of the Nizam's territory was progressing throughout the period of Colonel Everest's incumbency, having been commenced in 1816 The officers engaged upon it were Captains Garling, Young, Macpherson, Du Vernet, Morland, and Crisp The survey, based on the trigonometrical operations of Colonel Lambton, progressed systematically and steadily It was conducted on the principles of the Madras Military Institution Survey, and the maps are full of topographical detail They were accompanied by several volumes of memoirs, which are deposited in the Geographical Department of the India Office

Several districts were re surveyed, and the surveys of others were completed in the Madras Presidency, including Nellor, Vizagapatam, Salem, Ganjam, and the Arcots, between 1833 and 1840, by Captains Snell and Macpherson In the Bombay Office some maps were compiled, from compass and perambulation surveys not based on triangulation, of Kach, Katiwar, part of Gujrat, Ahmedabad, and Surat Captain Grafton and Lieutenant Boyd were surveying in the Deccan in 1829, and a survey of the South Konkan was executed in detail by Captain Jervis, between 1824 and 1829, but it was grounded on imperfect triangulation, and is now obsolete [3] This is the officer who was to have succeeded Colonel Everest, and, during the time that he was in England in 1837, he obtained a donation of 1,000*l* from the Court of Directors, "as a testimony of their high sense of the value of his labours"[4] In the same year he wrote a memoir

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1 "James Prinsep In the Journal of the Asiatic Society of Bengal," iv, p 63
2 See the "Calcutta Review,' iii, p 428
3 "Bombay Quarterly Review," p iii, 133
4 Nov 10th, 1837 (No 2,670)

on the surveys in India, which is published in the "Journal of the Royal Geographical Society"[1]

In 1841 a map of Sind was compiled from the survey of Alexander Burnes and other sources

The Revenue Surveys were under Major Bedford from 1830 to 1840, and in 1844 Major Wroughton succeeded, and was Superintendent until 1847, when he made over the work to Captain Thuillier, and died in 1849

On the whole, although much was done both as regards exploration and the filling in of topographical details, the incumbency of Sir George Everest will be more memorable for the great scientific results of his labours as a geodesist than for the quantity of reliable material that was furnished to the map makers It was said of him that "he would have nothing to do with researches which he "did not think admitted of the accuracy he cultivated, lest his "assistants, whom he had trained with so much care and labour, "might lose their aptitude for his objects"[2]

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[1] Vol vii, p 127 (1837) It is re published in the *Madras Journal of Literature and Science*, vol vii, p 424 Major Jervis retired in 1842 In 1845 he published a translation of Baron Hugel's travels in Kashmir and the Punjab In 1855 he was appointed the first director of the Topographical Depôt of the War Department, and died in 1858 See an Obituary Notice of Major Jervis, by Professor Phillips, in the "Transactions of the Geological Society"

[2] "Proceedings of the Astronomical Society," xxvii, p 105

# VII
# THIRD PERIOD OF THE TRIGONOMETRICAL SURVEYS 1843–61

## Sir Andrew Waugh as Superintendent of the Great Trigonometrical Survey

When Sir George Everest retired, he recommended that his able and indefatigable lieutenant, Andrew Waugh, should succeed him In doing so he thus spoke of his successor "He is beloved and "respected by all the subordinate members of my department, and "held in honour and esteem by all who know him personally His "talents, acquirements, and habits as a scholar, a mathematician, "a gentleman, and a soldier, are of a high order" Colonel Waugh took charge in 1843,[1] and, like his predecessor, received the appointments both of Superintendent of the Great Trigonometrical Survey and Surveyor General of India His first work was to complete Sir George Everest's project for the triangulation of the important region between the Great Arc Series and Calcutta, including the North West Provinces and Bengal

Lambton's system has been to throw a network of triangles over the whole face of the country But Everest considered this to be unnecessarily laborious, and that nothing more was required than to execute meridional series about a degree apart, tied together at their ends by longitudinal series This is termed the gridiron system, and is analogous to the French and Russian methods Sir George Everest had projected a gridiron of which the Great Arc and a Calcutta Meridional Series formed two sides, the Calcutta Longitudinal Series and a Series along the base of the Himalayas being the other two, and ten Meridional Series, 60 miles apart, originating from the Calcutta Longitudinal, and ending in the Himalayan Series, forming the grating It has been seen that three of these, namely, Budaon, Ranghir, and Amua, had been

[1] Andrew Scott Waugh, son of General Gilbert Waugh, the Military Auditor General of Madras, was born in 1810 He entered the corps of Bengal Engineers in 1827, became garrison engineer at Allahabad in 1830, and joined the survey in 1832

completed in Everest's time On assuming the command, Colonel Waugh set himself steadily to work to finish his old chief's project

The Karara Meridional Series comes next to the Amua, emanating from a hill called Karara on the Calcutta Longitudinal Series, and passing through Rewah, Allahabad, and Lucknow, to the Terai The first part passes through a hilly country covered with pestiferous jungle, and the rest is in the Gangetic valley The work was commenced in February 1838, under Mr Scully and Lieutenant Jones, but the whole party was prostrated with jungle fever, of which Mr Scully died In February 1842, Lieutenant Shortrede took charge of the Karara Series, but he retired in 1845 It was then arranged that Mr Armstrong should advance from the south, while Lieutenant Du Vernet carried a series of triangles from the Amua Series to the meridian of Karara, and thence turned south until a junction was effected with Armstrong's work In May 1845 this junction was established The area surveyed covered 5,819 square miles, at a cost of Rs 1,34,908 [1]

Next comes the Gurwani Meridional Series, 235 miles long It was begun in December 1845 by Lieutenant Du Vernet, and completed on May 24th, 1847, the 18 inch theodolite by Syud Meer Mohsin being used for measuring angles in the first season, and Colonel Waugh's 24 inch in the second The positions of Jaunpur, Oudh, and Faizabad, were fixed by secondary triangulation The area of the operations covered 6,298 square miles, and the cost was Rs 53,019 [2]

The next is the Gora Series, 208 miles long, which was commenced by Lieutenant Jones in 1844, but he died of jungle fever Lieutenant Garforth then took charge, and completed the series Of the stations, six were on hill tops, and 23 were towers in the valley of the Ganges The area is 4,416 square miles, surveyed at a cost of Rs 76,948 [3]

Then comes the Hurilaong Series, 208 miles long, which was executed by Mr Armstrong between 1848 and 1852 Of the 32 stations 7 were placed on hills, and the rest were marked by towers The series crosses the rivers Ganges and Gogra near their junction

Then follows the Chundwar Series, 181 miles long, of which 86 is through hill country, with 11 stations, and the rest in the Gangetic valley, where 19 towers had to be erected It was commenced by

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[1] Vol x, pts 1 and 2 [2] Vol x, pt 3 [3] Vol x, pt. 4

Mr Logan, in December 1843, and completed in April 1846 The area is 3,565 square miles, surveyed at a cost of Rs 64,504 [1]

The Parisnath North Meridian Series [2] was completed by Mr Nicolson between 1850 and 1852, and lastly the Maluncha Meridional Series was commenced by Captain Renny Tailyour in 1844 But, he was called away to serve as Brigade Major of Engineers in the Gwalior campaign, and was present at the battle of Máhárájpur Lieutenant Reginald Walker then took up the work, and completed it in 1846 The length is 157 miles, a large proportion being over very unhealthy ground The area was 4,765 square miles, and the cost Rs 52,878 [3]

The eastern side of Everest's gridiron is formed by the Calcutta Meridional Series, originating from his base line in the Barrackpoor road, passing north parallel to the Hughli and Bhagirathi rivers, and ending at a new base line at Sonakhoda, near the foot of the Darjiling mountains The preliminary work of selecting stations was begun by Mr Lane in December 1843, Mr Peyton took charge in 1844, and the series was completed in 1848 It consists of a simple series of triangles, and all the 56 principal stations necessitated the building of a tower The area surveyed is 4,136 square miles, at a cost of Rs 1,10,302 [4]

We now come to the North Eastern Himalaya Series which connects the northern ends of all these meridional series, and the dangers and difficulties in the execution of which were far greater than have been encountered in the majority of Indian campaigns Military service, plentifully rewarded by the praise of men and by prizes of all kinds, is neither so perilous nor so honourable as that of the Indian Surveyor, who devotes great talent and ability to scientific work in the midst of as deadly peril as is met with on the field of battle, and with little or no prospect of reaping the reward that he deserves His labours, unlike those of a mere soldier, are of permanent and lasting value, but few know who obtained the valuable results, except the gallant surveyor's immediate chief and colleagues The North Western Himalaya Series was the most desperate of these grand undertakings, and the average slaughter was greater than in many famous battles

This memorable series was commenced in 1845, and completed in 1850, and was the longest series between measured bases in the

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[1] Vol xi, pt 2 [2] Vol xi, pt 4 [3] Vol xii, pt 2 [4] Vol xii, pt 4

world, being 1,690 miles long from the Dehra Dun base to that of Sonakhoda, in Purneah. It was originally intended to have been carried along the Himalaya Mountains, but the Nepalese Government refused to allow the operations to enter their territory. So, after crossing the hills of Gurwhal and Kumaon, the triangles were brought down into the Terai near Bareilly, whence they continued to pass through the deadly tracts of marsh and jungle which fringe the Himalayas. The first and second parts were, as has already been stated, performed by Du Vernet and Waugh himself; and the next section, as far as the head of the Chandwar Series, was completed, amidst great difficulties, by Mr. Logan, who did the work admirably, observing with Barrow's great theodolite. In one season 40 natives died of jungle fever; Mr. Logan was himself prostrated, and in 1847 the whole surveying party was conveyed in a helpless condition from fever to Goruckpore. In 1847 Lieutenant Reginald Walker took charge; but he also was attacked by the terrible scourge. He hurried towards Darjeeling, and was found dead in his dooly when it arrived, on April 24th, 1847. Mr. Charles Lane completed the eastern end in 1848, when Colonel Waugh himself joined the party, to carry on operations for fixing the heights of Himalayan peaks. The completion of the worst part of this series is due to the ability, courage, and perseverance of Mr. George Logan, who died from the effects of diseases contracted in the Terai, about three years afterwards. Of the five officers who had charge of the series at different times, two retired, and two fell victims to the climate.

The mightiest of the Himalayan peaks are visible from the principal trigonometrical stations of this series, and were fixed by measurements with the great theodolite. The primary difficulty of the computer was the identification of numerous points, the positions of which had been observed by different persons from different points of view. The series was carefully projected on a scale of four miles to an inch, and the rays emanating from the stations of observation exactly drawn. Their intersection defined the points sought for. The area of the largest triangle to a Himalayan peak is about 1,706 square miles, with a side 151 miles long. The heights of 79 peaks were fixed, of which 31 have names, and the rest only numbers. Their positions are correct within a quarter of a second as regards latitude and half a second as to longitude, and the heights are probably true to within 10 feet, all being too low, if anything, owing to deflection due to mountain refraction. No. 15 peak, the highest of all, 29,002 feet above the sea, was well named by Colonel Waugh, after his old chief, Mount Everest

The N E Himalayan Series [1] covered an area of 15,826 square miles, exclusive of the operations of the mountain peaks in Sikkim, which included 73,920, or a total area of 89,746 square miles The cost of the survey was Rs 2,14,257

Colonel Waugh then proceeded to measure a base at the junction of the N W Himalaya and Calcutta Meridional Series, to verify both triangulations, and with a view to the future extension of operations eastward into Assam The site selected was an unbroken level plain near Sonakhoda, and the measurement was performed in the season 1847–48 Waugh was assisted by Captain Renny Tailyour, Mr Logan, and Mr Lane, but the whole party suffered severely from fever Colby's compensation apparatus, brought out by Everest in 1830, was used, and the measurement was proved by a system of minor triangulation in four sections The bars were compared with the standard 53 times before measurement, 60 at the middle, and 80 times afterwards [2]

With the Sonakhoda base Colonel Waugh completed the project of Sir George Everest, for placing a gridiron of trigonometrical series over the North West and Lower Provinces Accurate data were now supplied for the complete filling in and mapping of this important region

Operations were progressing to the south at the same time In 1842 Captain Jacob had commenced the South Konkan Series from a side of the Bombay Longitudinal Series, but was obliged to go home owing to ill health He was succeeded by Lieutenant Harry Rivers, of the Bombay Engineers, who worked with an 18 inch theodolite, made by Dollond under instructions from Kater This series is not, in Colonel Waugh's opinion, in the first rank of geodetical operations, but it is sufficiently accurate for geographical purposes The series passes through Mahabaleshwar, and goes south as far as Goa[3] It was completed in 1844, and Rivers then took up the North Konkan and Khanpisura Series, which extends north as far as Nimach

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[1] Vol xv, of the Trigonometrical Operations, MS
"Calcutta Review," vol xxxviii (1863)
"Journal Asiatic Society of Bengal," vol xxxi (1862), p 32

[2] Vol xii, pt iv

[3] Vol xiv, pt i

Sir George Everest had also projected the execution of a chain of triangulation along the east coast of India, from the Calcutta base line to the observatory at Madras, and two of the Meridional Series, namely, those of Parisnath and Malancha, were to be extended south from the Calcutta Longitudinal Series, to join it. The South Parisnath Series was commenced as early as 1832 by Lieutenant Western, assisted by Lieutenant Boileau. The next year Captain Macdonald was sent to take charge, but fell a sacrifice to the arduous nature of the work, and in 1835 Boileau and the whole party were prostrated by sickness. The series was completed in 1839. The work is second rate, but will answer all purposes of geography.[1]

The Coast Series was commenced by Captain Thorold Hill, who had previously, from 1845 to 1847, been engaged on the South Malancha. He was supplied with a new 24-inch theodolite in 1847, and began the coast operations from the Calcutta base line, but found extreme difficulty in crossing the flat swampy country, intersected by creeks between Calcutta and Balasore. His health suffered so much that he was obliged to go to sea for two years, and thus progress was very slow. He was replaced by Mr. J. Peyton.

After the measurement of the Sonakhoda base, Colonel Waugh was free to undertake a work originated by himself, and the acquisition of Sind and the Punjab offered a vast field for fresh operations. He conceived a project for forming a gridiron of triangulation to the westward of the Great Arc Series, to include all the newly acquired territory, which entailed more labour and was on a grander scale even than Everest's gridiron to the eastward. Colonel Waugh's plan commenced with the Great Arc Series, having the Dehra Dun base at the north, and the Sironj base at the south end. From the Dehra base a N.W. Himalaya Series was to be extended to near Attock, where a new base was to be measured; while from the Sironj base the line of the Calcutta Longitudinal Series was to be extended to Karáchi, to be called the Great Longitudinal Series (Western Section). At Karáchi another base was to be measured, and a Great Indus Series was to form the western side of the quadrilateral. Finally, a set of intermediate Meridional Series was to complete the gridiron. This magnificent project was commenced

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[1] Vol. xiii, pt. i.

in 1847–48, with the Longitudinal Series from the two bases at Dehra Dun and Sironj.

Lieutenant Du Vernet began the North West Himalaya Series in 1847 from the Dehra Dun base, but in the following year an insurrection in the Jaswán Dun drove the party from their work. The triangulation was proceeded with by Mr Logan, who reached Attock in 1853. The series consists of 77 principal triangles, in quadrilaterals and polygons, covering an area of 33,000 square miles. The direct length is 416 miles, and there are no towers, as all the stations are on mounds or hill tops.

The western section of the Great Longitudinal Series was commenced from the Sironj base by Captain Rennie, assisted by Captain Strange, of the Madras Cavalry, in the end of 1848. After the first season Renny, who had done such excellent service during 16 years, retired from the Survey Department,[1] and Captain Strange took charge of the series. He was assisted by Lieutenant Tennant, R.E., Mr C. Lane, Mr Rossenrode, Mr Burt, and Mr McGill. The triangulation had to be taken across the rugged range of Aravulli mountains, then over the great Thurr or desert to the north of the Rann of Kach, and finally across the Indus valley to Karáchi, which place was reached in April 1853, after five seasons of very severe work. This series is 668 miles long, consisting of 173 principal triangles, and covering an area of 20,323 square miles. Of the 117 stations only 22 are towers.

A few details respecting the progress of Captain Strange's party will give a general idea of the obstacles to be encountered in work of this kind. The great difficulty, peculiar to this series, was the crossing of the desert. No geodesical operation of the first order had, at that time, ever been conducted in a desert, and experience was therefore totally at fault as to the probable obstacles to be encountered. Stations had to be selected, in the first instance, by an advanced party. At each station a masonry platform had to be erected in a country entirely composed of sand, and destitute of building materials. After this had been accomplished, the main party engaged in taking the final observations, numbering 200 men,

[1] On the death of his father in 1849, he succeeded to the estate of Borrowfield, in Forfarshire, and retired from the service, taking the name of Tailyour. He is now Major Thomas Renny Tailyour, of Borrowfield. His eldest son is named after his old colleague, Waugh.

had to be maintained in the desert during a whole season The desert furnished only three things useful to man or beast, namely, grass, immediately after the rainy season, limited supplies of milk, and brackish, or, more correctly, salt water in deep wells, scattered at wide intervals The approximate series was conducted by Mr J Rossenrode, to whose courage, energy, and sagacity as a pioneer Captain Strange attributed, in no small degree, the success of the undertaking The information gained by Mr Rossenrode while conducting the approximate series with a small party was invaluable in organizing the arrangements necessary to maintain the main body during the succeeding season These arrangements involved the supply of provisions of every description for 200 men during several months, and also the distribution of these provisions to the numerous detachments into which the party was necessarily divided For this purpose, depôts had to be established beforehand, throughout the tract to be crossed Special arrangements were also necessary for supplying the people with water from distant wells Being favoured with good weather, and immunity from sickness, the final triangulation of the desert was completed in one season, 1851-52 In November 1852 Captain Strange's party finally marched across the desert from Deesa to the verge of the Indus valley, and commenced work in Sind These arrangements, requiring so much calculation and forethought, remind one of the precautions and minute attention to details which alone enabled McClintock to explore the Arctic Regions in search of Franklin Like McClintock, the leader of the Great Longitudinal Series had to form depôts of food at certain intervals for his people, and to calculate exactly the weight of the food consumed by each man, and the weight his camels (the sleighs of the Thurr) could carry at each trip

The principal stations in Sind are from 12 to 20 miles asunder, each defined by masonry pillars four feet in diameter, surrounded by a platform for the observer's tent, according to Sir George Everest's pattern They vary in height from 8 to 35 feet, according to the nature of the country intervening between two points of observation When the only practicable view is obstructed by trees or houses, the practice is to remove them, paying the owners fair compensation in communication with the village authorities Captain Strange's party reached the borders of Sind, and commenced operations on the 8th of December 1852 The first station was Chorth, where it was necessary to observe from a tower 37 feet high, the side being 22 miles long, and crossed by the Indus The view was obstructed by a dense *babool* jungle, intersected, in many places, by sheets of water It was a tedious task to clear the line, and then it was long before the signal could be made out at the other station of Helaya, 22 miles away After a wearisome detention of 25 days, and much painful straining of the eyes, occasional faint glimpses of Helaya were caught, and at length the angle was satisfactorily observed At the next station of Kanad there were fresh misfortunes The tower, 39 feet high, began to emit a crackling sound towards evening, and luckily the great theodolite had not been placed, when one of the angles fell in These Sind towers were built of alternate layers of wetted earth and stout branches, but this one had been carelessly thrown up In rebuilding it a ramp was raised round the walls for two thirds of their height At another place the great theodolite narrowly escaped destruction from a hurricane, and was rescued by the desperate efforts of its guardians, amidst the roar of the tempest, in a night of inky darkness Such are the sort of harassing difficulties and delays which form the daily life of the surveyor, but which are ever cheerfully faced and overcome Captain Strange and his party had their full share, but at length their work was completed, and the last angle of the series was taken at Magar Pir Station, on the 22nd of April 1853

At the western terminations of these two Longitudinal Series it was necessary to measure bases

Accordingly, Colonel Waugh selected a site for the northern base in 1851-52, in the Chuch Doab, near Attock, and the chief officers of the survey, Walker, Montgomerie, and Strange, were summoned to assist at the measurement George Logan was also there at the commencement He adhered to his post, with undaunted resolution, though the hand of death was on him He had been at the measurement of every base since 1831, but here he was forced to succumb, and this brave and zealous officer died at Musuri, on the 10th of June 1854, aged 45

The ground at the Chuch base was more level than at any previous one and as the plain was studded with ancient mounds, the termini were placed on two of them The stone piers used by Everest in 1834 for bar comparisons, were brought all the way from Dehra Dún in a platform cart, and set up on Dec 2nd, 1853 On the 6th there was a violent shock of earthquake Many comparisons were made with the standard, but the length of the compensation bars was found, as on former occasions, not to be constant during a single hour of the day, owing to the dissimilar radiating power in the brass and iron The only available remedy was to compare them with the standard, under circumstances exactly identical with those prevailing during the measurement

The verification triangles of the Chuch base were executed by Lieutenant Montgomerie, with Barrow's great theodolite

On the completion of this measurement, the apparatus was sent down to Karáchi, where Mr Rossenrode had already selected the ground It is a nearly uniform ascent from the south to the north end, with masonry towers at the termini The verificatory triangulation was effected by Lieutenant Tennant previous to the measurement, and the apparatus was delivered over to Captain Strange, who had the principal charge of the Karáchi base operations, under Colonel Waugh Syud Mohsin, the mathematical instrument maker, came round by sea from Calcutta The Surveyor General himself had been overworked with his multifarious duties, and had been prostrated by fever, but joined the party at Karáchi, on December 6th, 1854 Montgomerie, Tennant, and Nasmyth were also present

The measurement was commenced on December 6th, 1854, and completed on January 20th, 1855 Lieutenant Tennant also took 810 observations to fix the latitude of Karáchi

Colonel Waugh took especial pains in the preparation of the volume recording the measurement of the Chuch and Karáchi bases, and previously drew up instructions for the selection of sites, and a memorandum to serve as a guide for other base lines that may hereafter be measured No man living has had so much experience, and he made the volume[1] as complete as possible, furnishing detailed instructions and suggestions for every conceivable contingency His final conclusion was that Colby's compensation system was unsatisfactory, and he recommended that the Survey should be equipped with a new apparatus of the most perfect kind, free from all its defects Careful observation, extending over many years, showed that the relative length of the bars changed according to some law independent of temperature He would, therefore, discard the compensation principal, and substitute simple iron bars 10 feet

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[1] MS Vol not numbered

long, coupled by a pair of microscopes revolving round an axis regulated by a level

It remained to complete the quadrilateral by connecting the two bases at Chuch and Karáchi along the Indus valley This operation is comprised in the Great Indus Series, which was commenced at both ends, the parties to meet and connect their work half way The approximate triangulation of the southern half, commencing from Karáchi, was effected in a remarkably short time by Mr W C Rossenrode[1] Major J T Walker took charge of the northern section of the Indus Series in October 1856, with Lieutenant Basevi as his assistant One flank was placed in the Sind Sagur Doab, and the other in the Derajat, with the Indus between them, as far as Sukkur, but below, the series is taken along the western bank of the Indus to Karáchi At the conclusion of the season of 1857 the mutinies broke out and Major Walker joined the moveable column under General Chamberlain at the siege of Delhi, where he was wounded This threw back the work a year, but in 1858 it was resumed The Indus Series was completed in 1860 It is 706 miles long, and covers an area of 2,925 principal and 8,157 secondary triangles Of the 148 stations, 122 in the flat valley of the Indus are towers The heights of numerous peaks in the Suliman mountains were fixed, but political considerations prevented the exploration of that range[2]

In 1856 Colonel Waugh determined to institute a series of levelling operations to determine the height of the base lines in the interior These heights had already been approximately measured by vertical observations between the principal stations The method of determining heights of stations above the sea by taking reciprocal vertical angles, which was the plan which had hitherto been pursued in the Survey, is susceptible of a high degree of accuracy, provided that the observations are taken during the period of minimum refraction,

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[1] This series formed the basis for the Sind and Khalat Boundary Survey, for the conduct of which Captain Strange drew up a set of instructions The line begins at Cape Monze, follows the River Hubb for 80 miles, and then approaches close to the sides of the triangles of the Indus Series The boundary pillars were all connected with the Indus Series This boundary survey was entrusted to Mr J Rossenrode

[2] Blue book Report for three years, ending 1858 59

"Calcutta Review (1863)" vol 38 Major Walker has contributed an interesting paper on the Suliman Range, to the Geographical Society, entitled "On the Highland region adjacent to the Trans Indus frontier of India" By Major Walker of the Bombay Engineers—*Journ R G S*, xxxii, p 303 which occurs between 1 and 3 p m But the series of triangles is the longest in the world, and it became necessary to check the results of the observations by vertical angles, by instituting a series of levelling operations

The series was commenced in the Indus valley in 1858, under the superintendence of Major Walker, and has connected Karáchi with the Chuch, Dehra, and Sironj bases The spirit levels used were 21 inches focal length, and had been made for the Punjab Canal Department The levelling staves were painted, and divided on both faces to feet, tenths, and hundredths, one face being white with black divisions, and the other black with white The operations were commenced by three observers working over the same ground, and the results, as regards agreement with heights previously determined trigonometrically, were remarkably satisfactory The distance from the sea to the Chuch base is 706 miles, and the difference between the result by vertical angles and that by spirit levelling was found to be only 3 feet 2 inches At Dehra the difference was 5 feet 1 inch, and at Sironj, in levelling from Dehra, 1 foot and 8 inches, and from Karáchi to Sironj 2 feet 1 inch [1]

As soon as the measurement of the Karachi base was completed, the survey of Kashmir, and the mighty mass of mountains up to the Tibetan frontier, was commenced, under the superintendence of Captain Montgomerie, who began work in the spring of 1855 with the 14-inch theodolite by Troughton and Simms Great difficulties were encountered from the outset, and manfully overcome The Kashmir Series originates from that of the North West Himalaya between Sialkot and Gurdaspur, and during the first season it was taken across the Pir Panjal range into Kashmir Two of the stations were 13,000 and 15,000 feet above the sea Building materials had to be dug out of the snow for the station pillars, and the observers were detained at one station for 22 days, owing to the storms of snow and the foggy weather Afterwards, as the party penetrated into the mountains, the height of the stations averaged 17,000 feet, and luminous signals were used from peaks 19,000 and even 20,000 feet above the sea Between 1855 and 1861 the triangulation was extended over 93,500 square miles Mr Johnson, one of the party, took observations from a station which

1 "Tables of Heights in Sind, the Punjab, N W Provinces, and Central India, for May 1862" (Calcutta 1863) Major Walker communicated a paper on the methods of fixing the heights of Stations, in use in the Great Trigonometrical Survey of India, to the Astronomical Society —*Memoirs Astronomical Society* xxxiii, p 103

was 20,600 feet above the sea, and marks were erected on peaks as high as 21,480, while a peak on the Karakorum range temporarily called K 2 was found to have a height of 28,290 feet, and to be second only to Mount Everest This most difficult and laborious survey is remarkable for its accuracy and in a circuit of 890 miles, only a discrepancy of $\frac{8}{10}$ of a second in latitude and of $\frac{1}{10}$ in longitude was found In the Kashmir Series the topographical filling in by plane table advanced with the triangulation, both being under Captain Montgomerie

Of the Meridional Series forming the bars of Colonel Waugh's gridiron, the Jogi Tila, executed by Captain Walker and Lieutenants Tennant and Brownlow, passes by Jhelum, and is stopped by the Great Desert The Gurhagarh Series is on the meridians of Amritsir and Firozpur, and extends south, joining the Arumlia Series by Captain Rivers, at Ajmir It was commenced by Lieutenant Tennant, but almost entirely executed by Mr Shelverton It was designed for the incorporation of the Revenue Survey with the general map of the Punjab Captain Nasmyth, after triangulating Katiwár and Kach, connected his work with the Great Longitudinal Series

In 1855 Captain Strange was appointed to take charge of the Eastern Coast Series, succeeding Mr Peyton, who was invalided Captain Strange left head quarters at Masauri on the 17th of October for Cattack, and visited the fine observatory at Lucknow on his way [1] The early reports of this Coast Series record a yearly succession of disasters, disappointments, and failures, and it takes rank among the most difficult of the whole survey Captain Strange was ably assisted by Mr W C Rossenrode, who pushed forward the approximate series, and by Mr Clarkson The difficulties consisted in an inaccessible country, unhealthy climate, unfavourable state of the atmosphere, and an inefficient native staff At one station the party was detained for 19 days before they could obtain observations In 1856–57 Mr Clarkson completed the Sambalpur Series, Mr Shelverton commenced a secondary series from the Chilka lake to Balasore, to fix the coast line, and some progress was made in the main triangulation But the whole party suffered from a jungle fever, producing the utmost debility and depression both of mental and physical powers, and six men died of cholera In 1857–58

[1] The Lucknow observatory, with its instruments and the whole of its valuable series of observations, was entirely destroyed during the mutiny

further progress was made, but in August 1860 Captain Strange, in consequence of his promotion, regimentally, to the rank of major, was obliged to retire from charge of the series, and from the Survey Department, after a service in it of thirteen years In addition to his ability as a surveyor, his rare knowledge of the mechanism of mathematical and astronomical instruments, his never failing resource in an emergency or when any accident happened, and his inventive faculty, rendered him a pre eminently valuable member of the Survey He was succeeded in the charge of the Coast Series by Captain Basevi

The Superintendent of the Survey designed and saw the commencement of two more important Longitudinal Series, one from Calcutta to the eastward, and the other extending from the Sona khoda base into Assam

Sir Andrew Waugh became a Major General, and was knighted in 1861 He retired in March 1861 after having held the appointment for 17 years When he returned to England, he took with him the appreciative thanks of his Government, and the attachment of a splendid staff of surveyors who had been trained under his auspices [1] He had pushed forward the great work with such ability and energy that his successor could see his way to its completion in a specified number of years

The results of Sir Andrew Waugh's labours will be found in the following volumes —

(1) Vol 10, parts 1, 2, 3, and 4 Accounts of the Karara, North Longitudinal connecting Amua and Karara, Gurwani, and Gora Series MS

(2) Vol 11, parts 2, 3, and 4 Chandwar, Hurilaong, and North Parisnath Series MS Part 1 of this volume is wanting

(3) Vol 12, parts 2, 4 Malancha Series Calcutta Meridian Series Measurement of the Sonakhoda base MS Parts 1 and 3 are missing

(4) Vol 13 Part 1 Southern Parisnath Series MS The remainder is missing

(5) Vol 14 Part 1 South Concan Series in the Bombay Presidency MS The remainder is missing

(6) Vol 15, and appendix in a separate volume The North East Longitudinal Series MS

[1] The whole staff, 191 in number, presented Sir Andrew Waugh with a service of plate in 1862

(7) Volume on the Chuch and Karáchi base lines; not numbered MS

(8) "Report by Colonel Waugh on the extent and nature of the operations of the Grand Trigonometrical Survey," with Appendices Called for by Mr Joseph Hume, and presented to Parliament in April 1851

(9) Report on the Surveys of India, by Sir Andrew Waugh, for the three years ending 1858–59

(10) Report on the Surveys of India, by Sir Andrew Waugh, dated January 31st, 1861, being his last

(11) "Calcutta Review" for 1842, vol 4, p 62 On the Great Trigonometrical Survey

(12) "Calcutta Review" for 1863, vol 38 On the Great Trigonometrical Survey This article is by Colonel Walker

(13) "Journal of the Asiatic Society of Bengal" for 1862, vol 31, p 22

The labours of the survey under Sir Andrew Waugh were brought to public notice in several of the annual addresses of the Presidents of the Royal Geographical Society,[1] and in 1856 he was awarded the Gold Medal

A history of the operations of the Great Trigonometrical Survey down to the time of Sir Andrew Waugh's resignation, compiled from the reports, by H Duhan, personal assistant to the Surveyor General, will be found in five articles in the "Professional Papers on Indian Engineering," edited by Major J G Medley, C E, (Rurki), vol ii, p 285, and p 398, and vol iii, pp 94, 305, and 402 The articles are illustrated by a map showing the direction of the series and by prints of the astronomical circle by Troughton and Simms, of a sketch representing the measurement of a base line, of an observing tower, and maps of the Tso Morari lake and of the Baltoro glacier in Tibet, as surveyed by Captain Godwin Austen The fifth article describes the operations of the Kashmir Survey

[1] By Sir R Murchison in 1844 and 1845, Lord Colchester in 1846, Mr Hamilton in 1848 and 1849, Admiral Smyth in 1851, Lord Ellesmere in 1855, Admiral Beechey in 1856, and Lord de Grey in 1860

# VIII
# THIRD PERIOD OF THE TOPOGRAPHICAL SURVEYS
# 1843–61

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## THE REVENUE AND TOPOGRAPHICAL SURVEYS.

GREAT progress was made in the Topographical and Revenue Surveys during the administration of Sir Andrew Waugh, who was admirably supported by Major Thuillier, his Deputy in the Surveyor General's Office, from 1847.

In 1851 the Official Manual of Surveying for India, by Captains Smith and Thuillier, was published,[1] a thick volume divided into five parts —

1 Geometry and trigonometry
2 Surveying instruments
3 Surveying
4 On native field measurement (*khasrá*)
5 Practical astronomy, and its application to surveying

The great value of Colonel Thuillier's Manual lies in the sound instruction it supplies to surveyors For the last quarter of a century it has been the means of inculcating strict professional principles and rigorous procedure in the Revenue Settlement Department It contains clear explanations of the method of preparing and surveying village circuits, of the mode of demarcating and of keeping native records, and of the system of collecting and utilising statistical information

Captain Boileau prepared a new and complete set of traverse tables, chiefly for the use officers of the Revenue Survey It was

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[1] "Manual of Surveying for India, detailing the mode of operations in the Revenue Survey of Bengal,' compiled by Captains R Smyth and H L Thuillier (Calcutta, 1851) "Calcutta Review,' vol xvi, p 321, 1851 A second edition of the "Manual,' with additions, was published in 1855 In 1875 Colonel Thuillier brought out the third edition of the "Manual of Surveying for India" The work was carefully revised, improved, and extended, and some of the elementary portion gave way to more useful and valuable professional papers in the Appendix It was brought up to date in all essential particulars The Appendix to the third edition contains Sir Andrew Waugh's "Instructions for Topographical Surveying," a memorandum on the use of the plane table, and many useful tables

the first that was calculated to single minutes, or carried out to five places of decimals[1]

The Revenue Survey is conducted as follows —The settlement officers mark the boundaries of the *pargana*, and furnish the surveyor with a rough sketch demarcation map, called *thak-bust* With this map men go round, fixing the stations and clearing the ground for measurements The surveyor then runs a line from station to station, as near the boundary as possible, entering every measurement in a field book, and parties of village boundary surveyors do the same with the villages The *khasra*, or field measurement by natives, is checked by the general survey, and the physical details are filled in by the plane table The *pargana* maps are drawn on a scale of one mile to an inch, and the zillah or district maps four miles to an inch The plans of cantonments are drawn on a scale of 12 or 18 inches to a mile

One important object of the Revenue Survey is to fill up the outlines fixed by the Great Trigonometrical Survey, and, as the "Calcutta Review" expresses it, "to put sinews and flesh on the colossal skeleton which that survey constructs"

In 1861 Sir Andrew Waugh published his "Instructions for Topographical Surveying,"[2] in which, adopting the rules laid down in Thuillier's Manual as a basis, he developes the system best suited to surveys purely topographical in character The special province of the Revenue Surveys is to define the boundaries of estates, while Topographical Surveys are mainly for the measurement and delineation of natural features in wild districts or native states The stations of the Great Trigonometrical Survey give the topographical surveyor four initial elements required for commencing a survey, namely, a point of departure with latitude and longitude, a base, an azimuth or true direction of the meridian, and the height above the sea But the great stations are too far from each other for use in filling up topographical details, and the principal triangles have,

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[1] "A new and complete set of traverse tables, showing the differences of latitude and the departures to every minute of the quadrant, and to five places of decimals, together with a table of the lengths of each degree of latitude and corresponding degree of longitude from the equator to the poles, with other tables useful to the Surveyor By Captain J T Boileau (2nd ed London, 1839)

[2] "Instructions for Topographical Surveying," by Lieut Colonel Sir Andrew Waugh, for the use of the Surveying Department (Rurki, 1861) Also printed in the third edition of Thuillier's "Manual of Surveying for India," Appendix, p iii (Calcutta 1875)

therefore, to be broken up into smaller ones by the Ray Trace System, introduced by Sir George Everest.

Rapid progress was made with Revenue Surveys under Sir Andrew Waugh, by Blagrave in the Jallandar Doab, Gastrell in the Sundarbans, O'Donel in Arakan,[1] and Van Renen in Nagpur. The Haidarabad Survey, which had been progressing since 1818, was suspended in 1852, owing to the mismanagement of the officer in charge, but in 1855 it was resumed by Mr. Mulheran, an excellent surveyor, who made good progress, and successfully carried a branch series of triangles from the Great Arc to Nagpur, during the rising of Tantia Topee. A survey in Ganjam and the Cattack Mehals proceeded under Captains Saxton and Depree.[2]

The first *khasra* survey of the Punjab proved a failure. It was made by plane table to which native made compasses were attached, which were in the last degree uncertain and confounding. A book of instructions was issued for their use, and a great deal of work was done with them at a very considerable expense. The surveyors to be employed were the *patwaris* of villages. In 1856 it was reported that all the work done in this way was utterly useless, and that the system had broken down. Colonel Meadows Taylor had meanwhile been ordered to introduce it into the Haidarabad Assigned Districts, but had reported that it would be quite impossible to work out the system as proposed. He was, however, ordered to use the plane table, instead of the cross staff and chain used in the Bombay Revenue Surveys, and he adopted a plan of his own, by working by back and forward sights only, as with a theodolite. The method was readily learned by native assistants, who became wonderfully expert and correct. The work had been cheap and comparatively rapid, and when tested by scientific processes in connexion with the points of the Great Trigonometrical Survey, it had proved very satisfactory. A good deal of work was done in 1856–57 in the Nuldrug district, and Colonel Meadows Taylor was ordered to prepare an establishment for the Revenue Survey of the whole of the Assigned Districts, of which he was to have been the head. But the mutiny broke out in 1857, causing a suspension of work,

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1 See "Notes on the tribes of the Eastern Frontier," by J. H. O'Donel. Nos. 1, 2, and 3, in the *Journal of the Asiatic Society of Bengal*, vol. xxxii. (1863.)

2 Registers of computations of triangles, &c., &c., for the Ganjam Survey, from 1845 to 1864, are preserved in the Geographical Department of the India Office.

and when quiet was restored a part of the Bombay Revenue Survey establishment was set to work in Berar

The most interesting and valuable of the Topographical Surveys executed in Sir Andrew Waugh's time are undoubtedly those of Kashmir and the Sind Sagar Doab, under Montgomerie and Robinson

After the Sutlej campaign, Captain Robinson was employed on a military reconnaissance of the Hazára hill district, and as soon as the second Punjab war was over he was ordered to survey the Salt Range Sir Andrew Waugh speaks of the result as an admirable work, to which Captain Robinson's great talent for topographical delineation has imparted the highest character for fidelity and beauty of execution

Robinson's work comprises a complete survey of the whole highland country of the Sind Sagar Doab, between the rivers Indus and Jhilam [1] From the nature of the country this was a work of great difficulty The area amounts to 10,554 square miles, and the cost of the survey was Rs 1,93,465 The region is the scene of some of the exploits of Alexander the Great, and includes the site of ancient Taxila, the burial place of Bucephalus Here too is the line on which India has been invaded from the days of Alexander to those of Nadir Shah The country abounds in strong positions, and an elaborate and accurate map is important in a strategic point of view, and in facilitating public works operations The map, which is on eight parts published in 28 large sheets on a scale of one inch, comprises the whole of Rawal Pindi and Jhilam, including the Salt Range, and the hilly parts of Shahpur and Liah The greater portion consists of elevated plateaux of marl and clay, resting in basins of sandstone and limestone, supported by the Salt Range and several parallel ridges, which run east and west These ridges, some of them rising like fish fins, others expanding into mountains nearly 10,000 feet high, protect the surface from denudation, but the water, acting on the underlying sandstone, is constantly washing it away, and cutting up the country into a series of deep and intricate ravines, in the bottoms of which the richest cultivation is found The drainage of the country thus becomes exceedingly complicated,

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[1] "General Report of the Survey of the Kohistan of the Sind Sagar Doab," by Captain D G Robinson, Bengal Engineers, F R G S, Seasons 1851–59 MS Volume in the Geographical Department of the India Office, with an introduction by Sir Andrew Waugh

but it was made the fundamental part of the field sketching, and is delineated on the map with admirable exactness.[1] Captain Robinson trained 17 surveyors. The work was commenced in 1851 and completed in 1859.

The Topographical Survey of Kashmir proceeded *pari passu* with the main triangulation, and both were under the superintendence of Captain Montgomerie. The filling in was executed by the plane table, on a scale of two miles to the inch for the valleys, and of four miles for Ladak and the wilder region. A plan of the city of Kashmir, with the lake and suburbs, was also executed on a scale of two inches to the mile. This work was in full swing when Sir Andrew Waugh retired, and several of those who were afterwards leading officers in the survey, such as Montgomerie, Basevi, Godwin Austen, and Melville, were partly trained in the Kashmir mountains. Godwin Austen, especially, sketched some most difficult ground with great taste and skill, including the enormous glaciers of Little Tibet, one of them 36 miles long. One of the most distinguished of the Kashmir surveyors was Elliot Brownlow, who was slain at the siege of Lucknow. "His adventures and achieve-
"ments in the snowy mountains, and his hardihood and endurance,
"were the theme of much praise amongst his brother surveyors. He
"had intended to devote his rare and splendid qualities as a mountain
"surveyor to the exploration of Central Asia on rigorous principles."[3]

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[1] Colonel Robinson speaks of this service as eight years of hard but pleasing labour. He says of the maps, that "they are not likely to be of great interest as mere indi-
"cations of the geography of that part of India, but they are valuable as indicating,
"with complete fidelity, the extraordinary geographical contortions of that wild district,
"and it is much to be regretted that the adjacent countries have not been surveyed
"with the same care."—*Letter from Colonel Robinson to C. R. Markham, Oct.* 1866.

[2] Colonel Robinson was a surveyor of 19 years standing, from 1845 to 1865. He originated the present accurate style of delineating ground, and trained many of the best men who have had charge of Topographical Survey parties, and in the Surveyor General's Office. The paper on the use of the plane table in Sir Andrew Waugh's "Instructions for Topographical Surveying," was by Colonel Robinson. He commenced the Topographical Survey of Central India, and was in charge of it from 1859 to 1863. In 1863 he officiated for Colonel Walker during his absence in Europe, and drew up the Report for 1863–64. In April 1865 he took charge of the Revenue Surveys during Colonel Thuillier's absence, but shortly afterwards he was invited to accept the Director Generalship of Telegraphs, a Department of which he has had charge from 1865 to 1877, and which he has now brought to a high state of efficiency.

[3] Colonel Thuillier, in a paper read before the Asiatic Society at Calcutta, on July 6th, 1859.

Between 1849 and 1853, Lieutenant Walker, the future successor of Sir Andrew Waugh, executed a military reconnaissance of the Trans Indus region from Peshawur to Dera Ismail Khan, single handed

# IX
# FOURTH PERIOD OF THE TRIGONOMETRICAL SURVEYS
# 1862—70

## Colonel Walker and the Great Trigonometrical Survey

On the retirement of Sir Andrew Waugh, the two offices of Surveyor General and Superintendent of the Great Trigonometrical Survey were once more separated, after having been united in one person since 1830 Colonel Thuillier became Surveyor General, and Colonel Walker was appointed Superintendent of the Survey, on the 12th March 1861 James Thomas Walker joined the Bombay Engineer Corps on December 9th, 1844, and served in the Punjab campaign at the siege of Multan and battle of Gujerat, and in various affairs on the Trans Indus frontier under Sir Charles Napier, Sir Colin Campbell, and Sir Neville Chamberlain After the annexation of the Punjab in 1849, he was ordered by Lord Melville, who then commanded at Peshawur, to make a military survey within ten miles radius of that station, which was afterwards extended to embrace the whole of the British territory beyond the Indus, as far south as Dera Ismail Khan On the completion of this important work, he became a member of the Great Trigonometrical Surveying Department, and had latterly been in charge of the Great Indus Series, and of the spirit levelling operations In 1857 he was wounded at the siege of Delhi He assumed charge of the Great Survey, with the invigorating prospect, which had been denied to his predecessors, of completing the grandest series of survey operations ever undertaken in the world, during his own incumbency

As Sir Andrew's first work was the completion of some of the Meridional Series in Everest's eastern gridiron, so Colonel Walker's opening labour was the completion of the great north western gridiron, designed by Sir Andrew Waugh The Rahun Meridional Series, after six years of work, was finished by Mr Keelan in 1863, by being connected with the Great Longitudinal Series (western branch) It is 457 miles long, its triangles cover an area of 23,620 square miles, and the total cost was Rs 201,609 The Gurhagarh

Series, under Mr Shelverton, having occupied five years, was completed in 1862, by being joined to the Arumlia and Khanpisura Series brought up from the Bombay Longitudinal Series to the Great Western Longitudinal Series and thence from Bombay to Ajmir by Captain Rivers Its length is 587 miles, covering an area of 19,096 square miles, and the cost was Rs 1,08,212 An oblique series was also brought up from Mithankot near the junction of the Indus and Garra, to a side of the Gurhagarh Series, being 300 miles long, with an area of 8,142 square miles It was begun by Lieutenant Herschel in 1860, and completed by Mr Shelverton in 1863, Mr Ryall working zealously under him, and clearing 300 miles of trace This is called the Sutlej Series, and cost Rs 80,743

But Colonel Walker's first work was the measurement of a base line at Vizagapatam, nearly in the same latitude as Bombay, at which point the Longitudinal Series, from Bombay to the Bidar base line, was eventually to touch the east coast The Coast Series in charge of Captain Basevi, had already been completed from Calcutta to Vizagapatam Captain Basevi was engaged during the season of 1861 in selecting a site, but he met with much difficulty, owing to the numerous irrigation tanks with which the district is studded At length he found a suitable site on an undulating plain near the military station of Vizagapatam, and about 15 miles from the port of Bimlipatam Trenches were dug to carry away the rainfall of the monsoon, but, notwithstanding this precaution, the line was submerged in the following October, and was not drained off without much trouble and exertion

In the autumn of 1862 Colonel Walker arrived with Colby's compensation bars and microscopes, the same that had been brought out to India by Sir George Everest, and had measured every base line since that time Colonel Walker was assisted by Captains Basevi and Branfill, and Lieutenant Campbell The base line measurement occupied two months, and was finished on the 5th of November 1862 The line is 6½ miles long, and was divided into three verificatory sections, checked by a double series of triangles, one on each flank of the base These tests of accuracy were most satisfactory The difference between the measured length, and the length as computed from the triangles commencing at the Calcutta base, was half an inch When it is considered that the distance from Calcutta is 480 miles, and that the Coast Series passes through a region of dense jungle, such accuracy is perfectly marvellous

Colonel Walter, mindful of the maxim that "the ends of a base line should be guarded with religious veneration," gave much attention to the measures for their preservation at Vizagapatam In India such marks are viewed with cupidity not unmixed with fear The natives have an idea that money is buried under these mysterious monuments erected by the western strangers, while they feel a dread that they may cast a spell over the district Hence they are exposed to a double danger, and those at Sironj were actually destroyed At Vizagapatam substantial domes of cut stone masonry without openings were built over the marks at each end of the base line, and put in charge of the police

After the measurement, Captain Basevi was sent to make a reconnaissance in the almost unknown Jaipur territory, with reference to the extension of the Bombay Longitudinal Series to the East Coast The whole party was attacked by fever, but the result was a good preliminary map of Jaipur, and a valuable memoir by Captain Basevi [1]

Meanwhile Captain Branfill connected the Vizagapatam base line with the principal triangles of the Coast Series, and in December 1863 he commenced work near Guntur, with a view to the extension of the Coast Series to Madras The Madras Observatory is the only one in India at which systematic observations for longitude have been taken for a number of years, and it is very important to connect the Coast Series with it It will be remembered that this Madras Observatory was the fixed point from which Colonel Lambton started with his triangulation in 1802 It was the pivot on which the whole fabric rested [2] Now, after a lapse of 62 years, Captain Branfill was bringing back the triangulation to the old starting point Unluckily several trees interrupted the view between the nearest station and the observatory, and extravagant compensation was demanded for permission to remove them One man wanted Rs 300 for a single branch of a casuarina tree Eventually a pillar had to be erected to overlook the intervening obstacles, and a scaffolding was raised at the observatory, so that the theodolite could be fixed at a height of 63 feet from the ground Thus, in 1864, the Coast Series from Calcutta to Madras was completed

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1 "Report by Capt J P Basevi, R E, on a reconnaissance of part of the Jaipur Territory," forms an Appendix to Colonel Walker's Report for 1862–63

2 See Page 64

In 1865–66, Captain Branfill and his party observed a Longitudinal Series over Colonel Lambton's old ground, from the Madras Observatory to the Bangalor base line. It is 118 miles long, and consists of 23 principal triangles, covering 2,641 square miles. Secondary triangulations were also completed from Guntur to Masulipatam, to fix the positions of the lighthouses on the coast. Most of the party were struck down by fever, and Captain Branfill himself was obliged to go home on sick leave.

In the season of 1866–67, Lieutenant Campbell took charge of the party at Bangalor. He extended the triangulation for some distance to the westward, and south for 60 miles in the direction of Cape Comorin. He also successfully re-measured two of the last years' triangles, which had been rejected owing to the grazing of the rays of light against the slope of an intervening hill, which caused an error of 3″·8. This error was reduced to 0″·7.

Colonel Walker now gave orders for the re-measurement of the Bangalor base line. In 1861 Professors Airy and Stokes, at the request of the Royal Society, had reported upon Colonel Lambton's Surveys. They were of opinion that, owing to his instrumental appliances having been far less complete than at present, his work, though executed with the greatest care and ability, admitted of being improved in every part; and they expressed a hope that the whole of his survey would be repeated with the best modern appliances. The Superintendent, therefore, resolved to re-measure the bases at Bangalor and Cape Comorin, and to revise the intervening triangles.

In 1867 Lieutenant Campbell selected a site for the new base near Bangalor. Colonel Lambton's terminal marks were still in existence, and in good preservation, but the surface of the country was much changed. Irrigation tanks, as well as a lofty railway embankment, now cross Colonel Lambton's base line. Hence the necessity for a new site.

Colonel Walker was prevented by a severe accident from going south to measure the new Bangalor base, and he deputed Mr. Hennessey, one of his most trusted assistants, to take his place. The length of the base line is 6·84 miles, and, like that at Vizagapatam, it was divided into three verificatory sections, with triangulation on both flanks. The difference between the result by measurement and that by calculation from the Vizagapatam base was again only a quarter of an inch. Lieutenant Rogers, a young officer who now commenced his career in the survey, connected the base with the main triangulations, and with Lambton's base and his astronomical station at Dadaguntah.

Captain Branfill then proceeded to Cape Comorin, to select a base line site at the southern extreme of the Great Arc. He found the country studded with rocky precipitous hills, and large groves of palmyra palms, but at last he found a site near Lambton's old station at Punnae, and prepared the ground. The measurement of the base, during the season of 1868–69, was entrusted by Colonel Walker to Captain Basevi, with Branfill, Herschel, and Rogers to assist him. This is the last base necessary for the verification of the triangles within the limits of India proper, and the tenth that was measured with the compensation bars brought out to India by Sir George Everest in 1830. The system adopted was to divide the line into three sections, measure the central one, which is 1.68 miles long, four times over, and determine the length of the other two from the central one by triangulation on both flanks. The latter operation was performed by Lieutenant Rogers, and the result of the measurement was highly satisfactory.

Thence the Bangalor Meridian Series was brought up to join the Bidar base line. This work was executed by Lieutenant Rogers and Major Branfill in two sections. The northern section from Bangalor was carried on without intermission by Lieutenant Rogers, until he effected a junction with Sir Andrew Waugh's southern section of the Great Arc, on the 1st of March 1872. The southern section was taken across the Palni Hills in 1871, and the heights of several peaks, 5,000 to 7,550 feet above the sea, were fixed, which are not indicated on existing maps. The revision of the southern portion of the Great Arc was completed in 1874, and thus the last of the old links, which might have been objected to as weak and faulty, have been put on a par with the best modern triangulation. Major Branfill then proceeded to reconnoitre the Gulf of Manar with a view to connect the triangulation of India and Ceylon. He selected an island called Kachi tiva, half way between Ramaswar and the island of Neduven-tiva, on which a base was measured between two stations about a mile apart. From this base the positions of the two next stations on Neduven-tiva, erected by the Ceylon Government were fixed, and Colonel Fyers, R.E., the Superintendent of the Ceylon Survey, will complete the connexion.

In 1874 the Ramnad Longitudinal Series was commenced, to extend along the parallel of $9\frac{1}{4}°$ eastward from the Great Arc to

Ramaswai, with a view to the connexion between the triangulations of India and Ceylon. A "Madras Coast Series" is to proceed from Ramnad along the eastern coast, to join on to a side of the principal triangulation in the vicinity of Madras. In 1876 Major Branfill completed the Ceylon connecting triangulation, and on May 9th, 1876, made over his charge to Captain W. M. Campbell, R.E.

While this important revision of Colonel Lambton's work was proceeding, the Superintendent continued to push forward the other survey operations with vigour and judgment. In September 1862 he formed the party under Lieutenant Thuillier for the East Calcutta Longitudinal Series, to extend from the Calcutta Meridional Series to the eastern frontier, and form a basis for the survey of the districts of Naddea, Jessor, and Dacca. Operations were commenced at Chinsura in November, but the party encountered great difficulties. In working through jungle, it is first necessary to cut a narrow glade in a perfectly straight line in the direction required for a station, for 8 or 10 miles. The ground is then reconnoitred for a suitable site, to which a glade is cut from the trial line. Two sides and the included angle thus give the data to ascertain the direct line between the two stations, which is then cleared to bring them in sight. Immense labour is thus involved, and, in a populous country like Lower Bengal, the difficulty is increased by having to make bends to avoid houses and gardens, and by being exposed to worrying litigation for compensations. The towers of unburnt bricks were found to be unsafe in so moist a climate, and masonry walls round the central pillar will be essential.

The country which was the scene of Lieutenant Thuillier's operations was perfectly level, covered with malarious swamps, and intersected by great rivers with densely wooded banks. In the season of 1864–65, 174 miles of trial lines and 314 of final lines were cleared through the jungle. Cholera and fever were raging in the country, and twenty men of the party fell victims. Yet Thuillier remained steadily at his post, and made satisfactory progress, completing the series as far as the eastern frontier in 1866–67, on the parallel of 23°. It is 210 miles long, and consists of 41 triangles, every station necessitating the erection of a tower.

Lieutenant Thuillier then commenced a Meridional Series on the meridian of 90°, called the Brahmaputra Series, to complete the basis for the surveys of Naddea, Jessor, Dacca, and other parts of Eastern

Bengal Again the ground was level and covered with vast swamps During 1867–68 upwards of 700 miles of glades were cleared through heavy jungle, and ten towers were built, the season being entirely devoted to preliminary operations But in 1868–69 the measurement of the triangles was commenced with a 24 inch theodolite by Troughton and Simms At the same time Lieutenant Larminie commenced a chain of secondary triangles to be carried through the valley of Assam, where the Revenue Survey operations are in progress A series of triangles from Calcutta to Port Canning was commenced by Mr Ryall, but it was permanently interrupted by litigious fellows through whose gardens the line had to be taken Half Mr Ryall's time was passed in the courts of law, and Colonel Walker represented the urgent necessity for extending the provisions of Act VI of 1857 to the officers of the Survey Department The Brahmaputra Series was completed by Captain Carter in 1874, and in the following year the party was reorganized and transferred to Burma under Mr W G Beverley The secondary triangulation in Burma is designed with a view of fixing all prominent buildings and other objects in large towns for the purposes of topographical and geological surveys, while positions of lighthouses along the coast are also to be fixed for the marine survey Mr Beverley executed a very satisfactory amount of work during the season of 1875–76

The Eastern Frontier Series was commenced by Mr C Lane in 1861–62, near the western extreme of the Assam valley He was ably seconded by Mr Rossenrode, and in 1862–63 they were in Independent Tipperah, and working down towards Chittagong The physical difficulties to be overcome were very great[1] In 1865–66 Mr Rossenrode assumed charge, and the series was brought down to the eastern frontier towards Akyab, and through Arakan In 1867–68 and the following year the party crossed the difficult range of hills between Arakan and Prome, and pushed their operations into British Burma, whence they extended the series in a S E direction to Moulmain Mr W C Rossenrode continued the work in 1875-76, but, worn out with a long series of arduous and successful achievements he retired on a pension at the close of the season of 1876 Mr Rossenrode entered the Department in 1839 under Sir George Everest, and especially distinguished himself in

[1] See Extracts from a "Report on Independent Tipperah," by C Lane, Esq, in Colonel Walker's Report for 1862–63 (Appendix)

the work of the Great Longitudinal Series under the late Colonel Strange. Colonel Walker, in his last Report, speaks of this officer in terms of the highest praise.

Meanwhile, in 1871–72, the triangulation in the Assam valley was continued to the eastward by Mr. W. G. Beverley, through the Sibsagar district, but progress was slow owing to the extraordinary difficulties. The whole surface of the country is covered either with patches of forest, or with dense jungles of bamboo and long grass, and the entire length of line between continuous stations had to be cleared. In 1874 the triangulation reached Sibsagar, and various points were fixed in the Daphla Hills to the north, and in the Naga Hills to the south east; but the party sustained a serious loss by the death, from fever, of Mr. G. A. Harris, a painstaking and valuable member of the Department. During the season of 1875–76 Lieutenant Harman had charge of the operations in the Assam valley, and advanced the series from near Sibsagar to Dibrugah, a distance of 41 miles. Thence the approximate triangulation is continued in two branches, one south east to a spur of the Naga Hills, the other north-east across the Brahmaputra to Sadiya.

In the Bombay Presidency a series of triangles was commenced by Captain Haig south of Bombay (on the meridian of Mangalur). He, however, first revised a large portion of the old Bombay Longitudinal Series. In the season of 1862–63 good progress was being made, when a tower, on which the large theodolite had been placed for observing, gave way on one side, and the instrument was so severely injured as to be incapable of further use until it had been repaired in England. It was sent out again overland, reached Bombay in November 1864, and work was re-commenced. The design was to take the series south to Mangalur, and thence east to the Bangalor base line. In 1866–67 Lieutenant Trotter took charge, when the work was still 180 miles from Mangalur, and on the verge of the dense and deadly jungles of North Canara. The whole party was struck down with fever, and Lieutenant Trotter himself was obliged to go home. In the season of 1871–72 the Mangalur Meridian Series was carried over the Western Ghats by Major Branfill; and it was found that the Aneimudi Peak in the Animallé Range has an altitude of 8,837 feet above the sea, nearly 200 feet higher than the Dodabeta Peak on the Nilgiri Hills, which had hitherto been supposed to be the highest mountain south of the Himalayas. In 1873 this series was completed by connecting it with the Longitudinal Series which connects Mangalur with Madras The series passes for above a hundred miles between the coast and the Western Ghats

Two additional Meridional Series are designed to pass south from the old Calcutta Longitudinal, called the Sumbulpur and Jabalpur Series They were in charge of Mr Keelan and Mr Shelverton, who commenced their operations by a revision of a large portion of the Calcutta Longitudinal Series from the Sironj base to the Gora hill station Mr Keelan then worked south, through wild tracts covered with almost impenetrable forest, where his party suffered severely from fever, intending to run into the Coast Series near Madras Mr Shelverton's operations were on the meridian of Jabalpur From 1864 to 1866 he worked through the Central Provinces, and was prostrated by fever, but satisfactorily completed the series in the latter year

As soon as the Jabalpur Series was finished, Mr Shelverton was employed to continue the Bombay Longitudinal Series from the Bidar base line to the Vizagapatam base In 1868–69 he had completed the portion between the Great Arc and the Jabalpur Series, receiving much assistance from the Nizam's Government, which was urgently required, as 72 hill tops had to be cleared of forest for observing stations This series is called the Bidar Longitudinal Series In 1869 Mr Shelverton continued the work towards the coast, chiefly in the valley of the Godavari Here the leader of the party was struck down by fever, and he died in the midst of his labours, adding one more to the list of gallant men who have sacrificed their lives in the cause of science Mr Shelverton was an excellent surveyor, and a man of uncommon energy and determination His name was identified with several of the most important operations connected with the Great Trigonometrical Survey, and his loss was much felt He was succeeded by Mr H Beverley, and in December 1871, Mr Rossenrode took charge, who completed the series in the following April, when a junction was effected with the Coast Series

Mr Rossenrode then commenced a triangulation on the meridian of 82° from the Bidar Series northwards to meet the triangulation on the same meridian which was brought down from the Calcutta Meridional Series by Mr Keelan, and the two parties met, thus completing this series in 1873 The country through which they had to work is one of the most malarious and deadly in India It is the region in which Colonel Everest commenced his career as a trigonometrical surveyor in 1818, when he was stricken down by jungle fever,[1] and it was here then, in 1870, Mr. George Shelverton lost his life. Both the parties of Mr. Rossenrode and Mr. Keelan suffered severely from fever.

In 1872 the Jodhpur Meridional Series was commenced, which was one of the two internal chains of triangles remaining to complete the great north west quadrilateral, the exterior chains of which connect the base lines of Karáchi, Sironj, Dehra Dun, and Chuch near Attock. It is carried northwards so as to close on the Sutlej Series. This work was entrusted to Captain Rogers, who found the country very favourable, being sandy with isolated hills, the chief difficulty being the scanty supply of water. The series was advanced across the deserts of Jasalmir and Bikanir, and the series was completed in 1875. Captain Rogers then commenced the Eastern Sind Series on the meridian of 70° from the Karachi Longitudinal Series to the Great Indus Series.

In the Kashmir Survey Sir Andrew Waugh first combined trigonometrical and topographical work in the duties of one party. Colonel Walker continued this principle in two or three instances, in anticipation of the completion of the Trigonometrical Survey, foreseeing the importance of having his officers trained to topographical work, that their services might eventually be available in filling in the mighty skeleton, which their accurate observations and high mathematical attainments will have completed.

During 1862–63 great progress was made with the Kashmir survey east of Leh. Stations were fixed on the Chinese frontier, and peaks were determined at a distance of a hundred miles from it. On the 21st of April 1864 Lieutenant Carter joined the party as second Trigonometrical Assistant, and helped Captain Montgomerie in observing for latitude, while Godwin Austen and Johnson turned out much effective topographical work. At the close of 1864 the Kashmir Series was completed. It consists of a surveyed area of 70,000 square miles, in every variety of climate and scenery. There is not a valley in these wild regions of perpetual snow that was not visited by the surveyors, the triangulation covering Jamu, Kashmir, Khagan, Ladak, and little Tibet, and peaks were fixed, some of which (among them that named K 2) being second only to Mount Everest. In 1865 Mr. Johnson crossed the frontier, and visited

[1] See page 70.

Ilchy, the capital of Khotan, obtaining two observations for latitude there, and reconnoitring an area of 21,000 square miles [1]

After ten years of uninterrupted labour in Kashmir, Montgomerie went home on leave, and Lieutenant Carter received charge of the party, which was sent to commence a topographical survey of Kumaun and Gurhwal, on a scale of one inch to the mile, with a survey of the tea plantations, eight inches to the mile, and of the stations of Masauri and Landaur, 12 inches to the mile Lieutenant Carter pushed the work forward with much zeal and ability during the time that he was in charge, and on May 1st, 1867, Captain Montgomerie returned, and resumed his labours, extending the triangulation to the two great branches of the Alaknunda, the stations being 12,000 to 17,000 feet above the level of the sea He also undertook a survey of the hill Sanatarium of Ranikhet, and of the Kosi valley which leads up to it The contours of this Ranikhet survey were not filled in by eye, but the heights of a very large number of points were determined trigonometrically, and reflecting levels were employed in getting the run of the lines between the stations Thus a degree of accuracy was obtained in the delineation of the contour lines which has not hitherto been equalled in maps even of the highest class of merit The survey of the Kosi valley, completed by Lieutenant Hill, is on a scale of six inches to the mile In 1872 the Garhwal Survey was continued up the Mana and Niti valleys which drain into the Alaknunda branch of the Ganges, and the field work comprised triangulation of the country east of Naini Tal, up to the Nepal frontier on the Sardah river Among the distant peaks, the heights of which were fixed, was the celebrated Kailas or Gangri, which was formerly measured by General Strachey, and his result proved to be nearly correct The height now established is 22,028 feet In 1873 Captain Thuillier took charge of the Kumaun and Garhwal party, and under him Mr Ryall continued the work among the upper valleys of the Ramganga, Sorju, Gori, and Ralam rivers In 1874 the maximum height reached by the surveyors was 22,040 feet above the sea, and there only remained 1,200 square miles to complete the work, but, as operations in these desolate and inaccessible regions are very expensive, further progress was postponed

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[1] For an account of the Kashmir Survey see the "Journal of the Asiatic Society of Bengal," vol xxix, p 20, and vol xxx, p 99

Meanwhile Captain Thuillier proceeded with a survey of the new forest tracts of Dehra Dún and the Siwalik Hills, while Captain Bailey, as head of a Department of Forest Surveys, demarcated the forests in the same region, including the Jaunsar Bawar forests In 1876 the whole of this work was successfully completed by Captains Thuillier and Bailey, and Mr Ryall We thus have accurate maps, with well delineated terrestrial features, of a tract of country rich in tea and other plantations, and which is steadily rising in importance

Colonel Walker has long had another topographical survey party at work in the Bombay Presidency In 1865 it was engaged, in Bombay Island, in forming a basis of triangulation for a detailed cadastral survey, and in 1866 it was transferred to Katiwár, under Captain Haig, to resume the survey commenced in 1864, but suspended in consequence of a famine in 1865 During 1870–71 Lieutenant Trotter made very satisfactory progress with the Katiwar Survey, and several sheets of the final maps were prepared on a scale of two inches to the mile A few will be printed in Gujráti character for the use of the people Parts of Katiwár are very fertile and populous, while others are in such a wild state as to form the haunts of lions Katiwár being one of the few places in India where the lion is still found Colonel Walker considered it very desirable that the topographical surveys should combine the details of the marine with those of the land surveys by connecting the points along the coast which are common to both by actual measurement on the ground Several copies of the original drawings of the charts of the Gulf of Cambay were, therefore, lithographed for the use of the Katiwár survey, and also of the Gulf of Kach In 1872 the new maps of Katiwár were found to be of great use, for the agent of the Bombay, Baroda, and Central India Railway, on examining them, was induced to lay out an entirely different line for detailed survey from what he had intended when he only had the old maps to judge from By 1873 the number of square miles surveyed in Katiwar was 2,680, chiefly in the northern portions of Jhalawar, bordering on the Rann of Kach Captain Trotter had charge of the survey until nearly the end of the season of 1872–73, when he joined Sir Douglas Forsyth's Embassy to Kashgar, and was succeeded by Major Pullan, who, in 1876, was proceeding with the south west portion of the province The whole Katiwár survey will probably be completed by 1880 Topo graphical operations are also proceeding in Gujrat, where an attempt is being made to utilize the details of the fiscal surveys which have been carried over British Gujrát by the Bombay Revenue Surveyors, and which have been mapped on a scale of from 8 to 12 inches to the mile, by native surveyors, but with no attempt at delineating the configuration of the ground

In 1870 Colonel Nasmyth, who had charge of the Gujrat surveys, was obliged to take sick leave, and died shortly afterwards in Australia He was succeeded by Lieutenant McCulloch Both these officers failed in their attempts to utilize the results of the Bombay Revenue Survey, but Colonel Walker determined to persevere, as he was exceedingly loath to think that no use could be made of them for topographical purposes In 1872 Major Haig took charge, and between the years 1872 and 1876 the subject was much discussed and very carefully considered In August 1876 the final decision, with a view to utilizing the previously executed Revenue Survey maps of Gujrát villages by combining them with the Topographical Survey of the province, was approved[1] Major Haig has continued in charge of the Gujrát survey, assisted by Lieutenant J E Gibbs, and steady progress is being made

Colonel Walker has not failed to push forward those important spirit levelling operations which he himself commenced in Sir Andrew Waugh's time In 1862 Mr Donnelly had completed 242 miles of levelling up the valley of the Ganges, when he was compelled, by severe illness, to close work near Bhagalpur In 1863 Captain Trotter took charge of the levelling party, and got as far as Allahabad, though he and his people were prostrated by fever

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[1] It is as follows —

The maps of the British districts of Gujrát are to be on a scale of 2 inches, and those of all other parts of Gujrat are to be drawn so as to be readily reducible by photography to the 1 inch scale Two sets of maps of the British districts are to be published, one on the 2 inch scale, and the other on the 1 inch to juxtapose with the reduced maps of the Native States The village maps of the Revenue Survey are to be utilized in distinguishing between cultivated and barren or forest tracts, in defining village boundaries, and in giving all the interior topographical details which stand the test of examination by the topographical surveyors The stations of triangulation and traversing are to be placed as frequently as possible at the junction points of three fields, and the corresponding field numbers are to be marked on the maps The field junction points on the external boundary lines, and the internal divisions between cultivated and barren tracts are to be taken from the village maps and inserted on the topographical maps, the numbers for every second or third point being given on the map to facilitate identification

He found the levels of the railway officials to be very inaccurate. In 1864 Trotter brought the series of levelling up to Agra. Karáchi is connected with Calcutta by a line of levels 2,200 miles long, being the longest and probably the best ever executed, besides 830 miles of branch lines, the origin or datum being the mean sea level of Karáchi, and the terminus the sill of Kidderpur Dock, at Calcutta.

In 1866–67, branches were taken from the main line of levels to connect the levels of canals and railways at Delhi, Lahore, Multan, and other places. In 1867–68 a line was brought through Rohilkhund; in 1868–69 a line was taken from Bareli for 350 miles to Lucknow, Cawnpore, and Faizabad; and in 1869–70 Mr. Lane carried a line of levels for 572 miles through Oudh and the North Western Provinces. In 1872 Captain Carter carried the main line of levels to the towers of the Sonakhada base line.

A second volume of levels has been published under Colonel Walker's instructions, recording a portion of these operations,[1] and two sheets of a series of maps showing the various levels of trigonometrical stations, canals, and railroads.

In 1873 Lieutenant Harman commenced a series of levels in the Madras Presidency with the object of connecting and reducing to a common datum several lines of levels executed for railways and canals. He carried a line from Guti to the sea at Karwar, a distance of 304 miles. In 1874 he was relieved by Lieutenant McCullagh, who took a line of levels from the south western end of the Bangalor base line to the Raichur railway station, a distance of 297 miles, connecting it with Harman's work at Bellary. Much important levelling has also been completed by Captain Baird, an account of which will be found in the Section on Tidal Observations.

During the last 16 years there have been parties engaged on purely astronomical observations. In 1861, Mr. Nicolson was sent to fix the positions of the Andaman and other islands which were erroneously placed on the charts; but after taking a series of observations at Port Blair, and fixing its position, this work was handed

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1 "Tables of Heights in N. W. Provinces and Bengal, to May 1865" (Rurki 1866), with an introduction by Lieutenant Trotter.

2 "Spirit Level and Trigonometrical Heights of the Great Trigonometrical Survey of India, with canal and railway levels, compiled from various sources." Sheets 1 and 3 photo zincographed at Dehra Dun in 1867. These two maps comprise the districts of Ambála, Saháranpur, Dehra Dún, and Muzaffarnagar, and are accompanied by printed sheets describing the bench marks, and giving other information.

over to the marine surveyors In 1863, however, two astronomical parties were organized to fix the latitudes of trigonometrical stations, at moderate distances, all over India One was to begin at Calcutta, and observe at each of the stations along the Calcutta Longitudinal Series, whence the Meridional Series of Sir George Everest's gridiron started, while the other was to work north and south at certain stations, about a degree apart, on the Great Arc Series The latitudes were to be observed from the zenith distances of pairs of stars north and south[1] The latitude observations were taken on the meridians of 75° and 78°, by Captains Herschel and Heaviside in 1870, the latter observing with the zenith sector designed by Colonel Strange, near Bangalor and Coimbator In 1870–71 Captain Trotter relieved Captain Heaviside, and the second new zenith sector arrived at Poona, and in 1871–72 the latitude observations were continued by Captains Herschel and Campbell

In 1868 the total eclipse of the sun in India gave some additional work to the scientific surveyors The observations were entrusted to Major Tennant, whom we last met with at the measurement of the Karáchi base, and who had since been in charge of the Madras Observatory He came out from England with instruments supplied by the Royal Astronomical Society, and was joined by Captain Branfill After much careful inquiry, it was decided that the most favourable positions for observing the eclipse, as regarded the probable absence of clouds and rain, would be Bijipur, and Guntur on the east coast Tennant and Branfill observed at Guntur, Herschel, Campbell, and Haig, at Bijipur, and the conclusions arrived at from their investigations were that the *corona*, in an eclipse, was but slightly, if at all, self luminous, while red flames were[2]

In 1876 Captain Campbell, assisted by Captain Heaviside, proceeded to Haidarabad, and during the season completed the measurement of differences of longitude, by electric telegraph, between Haidarabad and Bombay, Bellary and Bombay, Bellary and Haidarabad, Madras and Haidarabad, Madras and Bellary, and Bangalor and Bellary, one officer working at one end and the

[1] At Isanfur, near the northern end of the Punjab plains, the difference between the observed latitude and that computed from triangulation was only 06″ ! ! !

[2] See an article on the eclipse observations for 1868 in the "Professional Papers on Indian Engineering," vol vi, p 93 See also "Revista de España" Tom xvii, No 67 (Madrid, 1870) "El eclipse de sol considerado bajo el punta de vista fisica"

other at the other They received hearty co-operation from Mr Pogson, the astronomer at Madras, and Mr Chambers, F R S, the Superintendent of the Observatory at Bombay

Of late years advantage has been taken of the lines of telegraph, in Europe and America, to determine differences of longitude, and thus to obtain astronomical arcs of amplitude between two places situated on a common parallel of latitude, with reference to the determination of the figure of the earth Formerly such arcs had been measured between points on the same meridian, because in that case it was only necessary to determine latitudes at the extreme points, which is one of the simplest problems of practical astronomy But on arcs of parallel it is longitudes that are required, and their determination within the requisite degree of precision was extremely difficult and laborious When, however, places are connected telegraphically, their differences of longitude can be determined with great precision In September 1871 Colonel Walker, in London, and Major St John, at Tehran, determined the longitude of the latter place to be 51° 24′ 5″ E, the distance between the two stations being 3,870 miles Their determination only differed half a mile from a value previously deduced by Major St John, by combining a telegraphic determination of difference of longitude between Tehran and Karachi, with the trigonometrically ascertained difference between Karachi and the Madras Observatory In 1872, some of the instruments which were ordered in 1863, designed by Colonel Strange, and constructed under his superintendence, arrived in India These were two transit instruments, by Messrs Cooke and Son, of York, two astronomical clocks by Frodsham, two chronographs by MM Secretan and Hardy, of Paris, and electric apparatus Colonel Walker determined to employ these instruments, in the first instance, on the arc of parallel which crosses the Peninsula of India in latitude 13° from Madras to Mangalur, passing through Bangalor midway This arc is of special interest, because it is situated much nearer to the equator than any similar arc that has yet been measured in any part of the globe Its length is 364 miles Captains Herschel and Campbell were selected to carry out the operations, who first made a series of most careful preliminary trials, ascertaining that no sensible influence, in one direction more than another, was exerted by earth currents The mean of all the determinations gives a velocity of 17,000 miles per second, which is materially greater than the velocities deduced in the course of similar operations in Europe and America. But as several relays were used on those lines, and none on these, such a difference is only what might have been anticipated. The preliminary results are, that the difference of longitude between Madras and Mangalur by the trigonometrical measurement is 0h 21m 36.78s, and by telegraph 0h 21m 35.85s. The difference is 0.93s, which is equivalent to 13.95″ seconds of arc. The latitudes and longitudes of the stations of the Great Trigonometrical Survey have, for the last 40 years, been computed with the elements of the figure of the earth known as Everest's First Set of Constants, (equatorial semi axis, 20,922,932 ft, ellipticity $\frac{1}{300.80}$). Subsequent investigations have slightly modified these dimensions of the mean figure, and Captain Clarke gives the following elements in the Appendix to his "Comparison of the Standards of Length" (1866), equatorial semi-axis 20,926,062 ft ellipticity $\frac{1}{294.98}$. Using Captain Clarke's elements, instead of Colonel Everest's, the trigonometrical determination of the difference of longitude between Madras and Bangalor would be diminished by 3.5″, and thus be brought into better accordance with the telegraphic difference, which is still 10.5″ less than the trigonometric difference. This fact is consistent with the result of Captain Basevi's pendulum operations, which show that the density of the strata of the earth's crust is greater under the depressed beds of oceans than it is under lands elevated above the sea level. Thus the direction of the plumb line at Madras, on the east coast, is most probably deflected to the east of the normal to the mean figure, while at Mangalur the direction of the plumb line is deflected to the west of the corresponding normal. The length of the arc between the apparent zenith points is consequently diminished, and must, therefore, be less than the length deduced from trigonometrical observations. The observations to determine the astronomical latitudes of certain stations of the survey have been held in abeyance since 1872–73, as Captains Herschel and Campbell, by whom they are carried on, have been both employed on the longitude observations.

There is a method, independent of triangulation, by which the ellipticity of the earth can be determined, and it seemed important that it should be tested over the same ground as was traversed by the Great Arc Series. This method is by observing the pendulum. The force of gravity increases from the equator to the poles, and a pendulum, which makes a certain number of vibrations in a given time at the equator, will make a greater number at all other points, the number increasing, as a rule, with the latitude. The experiment consists in determining the number of vibrations which a given pendulum of invariable length makes in 24 hours, at the position selected for the operations. Previous observations had been taken chiefly on islands and near the coast, notably by the veteran observer, General Sabine. It was a desideratum to obtain experiments in the interior of continents to combine with those taken near the sea. The Russian Government had caused them to be taken at the principal stations of the Great Russian Arc, and General Sabine was anxious that a series should be observed in India.

The tendency of the plumb line to deviate from its normal direction, in consequence of local irregularities of the earth's crust, is a source of error which requires the most careful investigation. The plummet is supposed to be attracted by mountains and repelled by oceans, and even on level plains deflection is said to exist when the rocks below are of unequal densities, on either side of the plummet. Archdeacon Pratt, after close examination of the effects of this attraction on the operations of the Trigonometrical Survey, came to the conclusion that the probable error caused at Kalianpur, by proximity to the Himalaya was one fourth of a mile, but this only affects astronomical observations. In the triangulations the correctness of the relative distances is of course unaffected.[1]

The pendulum observations give an independent determination of the ellipticity of the earth and throw light on its physical constitution, by determining the intensity of the force of gravity.

In 1864, Colonel Walker, R.E., the Superintendent of the Great Trigonometrical Survey of India, applied to the Secretary of State for India for sanction to undertake a series of pendulum experiments in India in connexion with this survey. His application was strengthened by opinions from several of the most eminent Fellows of the Royal Society in favour of the undertaking, more especially as affording an independent check on the local variations in the direction of the force of gravity, and on the disturbances due to the mountain masses north of India.

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[1] "A series of papers on mountain and other local attraction in India, and its effect on the calculations of the Great Trigonometrical Survey," by John H. Pratt, M.A. (Calcutta, 1862.) These papers are reprinted from the *Transactions of the Royal Society*.

The necessary sanction having been obtained, the Royal Society lent for the purpose of the experiments an astronomical clock by Shelton and two invariable pendulums. The equipment was supplemented by a copper vacuum cylinder and an air pump. It was decided to make the Kew Observatory the base station in this country for the operations, and before the pendulums were sent to India they were swung there by Mr Loewy. The apparatus arrived in India in 1865, and the work was at once commenced by Captain J. P. Basevi, R.E., who had been placed in charge of the operations in India. In the course of the next five years Captain Basevi swung the pendulums at some 19 stations on the Indian arc from Dehra Dun to Cape Comorin, at two stations on the East Coast, and at two on the West Coast of India, and he likewise swung them at Minikoy, an island of the Laccadive group.

In 1870, two convertible pendulums were lent to Colonel Walker by the Imperial Academy of Sciences at St. Petersburg. These pendulums had been used on the Russian arc, and it was hoped that by their means a connexion might be established between the Indian and Russian pendulum operations. An arrangement for measuring the lengths of these pendulums forms part of the whole apparatus, so that they are capable of giving not only relative results, such as are obtained by the invariable pendulums, but also absolute values of the length of the simple seconds pendulum. Captain Basevi had at that time but little opportunity of using these pendulums, and in the spring of 1871 he started for the lofty plateaux of Tibet, taking with him the invariable pendulums only. On his way to Tibet he took observations at Mian Mir, and passing through Leh, crossed the Takalung pass 18,060 feet in height, into the desolate region of Rukshu. He there swung the pendulums at a station he selected on the Moré plain 15,500 feet above the sea level. From Moré he made his way back to the Upper Indus, and, although suffering from a severe cold, he crossed the Marsimik pass and set up his tents and instruments on the Lanak plains, upwards of 17,000 feet above the sea. There, protected only by a tent, in a climate where the thermometer rises to 70° or 80° in the afternoon and falls below zero at daybreak, his illness increased. One morning, when gallantly striving to rise from his bed and commence work, he died, and by his untimely death the survey lost the services of one of its ablest officers.

Captain Heaviside was subsequently appointed to complete the operations After some preliminary observations at Dehra and at Massari he went to Kaliana, the base station in India for the pendulum experiments He there took observations with the invariable pendulums to determine whether they had undergone any change since they were last swung there He also swung and measured at Kaliana the Russian convertible pendulums He then started for England, and on his way to this country he swung the pendulums at Bombay, at Aden, and at Ismailia, in Egypt At the Kew Observatory he swung the invariable pendulums, to determine whether they had undergone any alteration since 1865, and he also carried out there a complete series of experiments with the Russian convertible pendulums for the determination of the length of the simple seconds pendulum

At the suggestion of General Sir E Sabine a further series of experiments was made with the convertible pendulum employed in 1818 by Captain Kater The bar of this pendulum, owing to some unknown cause, had become bent It was re straightened and the knife edges re ground and re-bedded In its altered condition this pendulum was swung at the Kew Observatory by Captain Heaviside Lieut Colonel A R Clarke, R E, undertook to measure the distance between the knife edges of the pendulum at Southampton From the values thus obtained a second determination of the length of the simple seconds pendulum at Kew was made Captain Heaviside then returned to India, where the final results of the whole series of experiments from 1865 were computed out and arranged for publication

One fact of great scientific importance has been ascertained by these experiments, namely, that the density of the strata of the earth's crust under and near the Himalaya is less than that under the plains to the south It is also a noticeable feature of Captain Basevi's observations, and one already observed in comparing pendulum observations made in other parts of the world, that at inland stations gravity appears to be in defect of that observed at coast stations in similar latitudes The cause of this is still uncertain

The superintendence of work in the field only forms a part of Colonel Walker's anxious and absorbing duties The labours in the computing and drawing office also require his close attention, and here he has been ably assisted by Lieutenants Herschel and Mr Hennessey One matter for careful thought is the dispersion of unavoidable though minute errors in the observations of latitudes, longitudes, and azimuths, in such a manner as to obtain the closest approach to accuracy This is a consideration of great intricacy and difficulty, and the preliminaries for eventual calculations have been carefully elaborated in the Computing Office All the observations are reduced *de novo*, which involves an enormous amount of calculation In 1865 Mr Hennessey, who had studied at Cambridge and Southampton while he was in England, resumed charge of the Computing Office He commenced the printing of the observations of all the principal angles, which, except the Great Arc Series, published by Sir George Everest, had hitherto been only in manuscript[1] He also introduced photozincography, having learnt the process at Southampton, and the sheets of topographical surveys were rapidly re-produced Photographic apparatus had been in use in the Drawing Office some years before, for copying and reducing Here the Kashmir maps were compiled, one of Central Asia, by Mr Scott, in 1866, and many others

In 1866-67 Colonel Walker was engaged, with Mr Hennessey, in the verification of the standards of length At the measurement of each base the relative length of the standard bar A and the six compensation bars was found to be altering, and as all the bars told the same tale, it seemed probable that their lengths had remained constant, and that the standard had changed While Colonel Walker was in England, in 1864, two new standard bars, one of brass and the other of iron, were constructed for him They arrived at Dehra Dún in 1866, and were compared with A, having first been compared with B at Southampton The comparison showed that the relative length of A and B was nearly the same as in 1834, when they were last compared together Then B was 1 28 millionths longer than A Now B is 3 08 millionths longer Thus the old standards have not altered appreciably, and the changes must be due to the compensation bars

The tables to facilitate the calculations of the Survey Department

[1] One copy at the India Office and another at Calcutta

[2] See "Professional Papers on Indian Engineering," vol v, p 305

were also revised and extended under the direction of Colonel Walker in 1866, by Mr Hennessey [1]

In 1867 the Kashmir and Ladak maps were completed, together with a series of maps with lines of levels, and in 1868 a valuable new map of Central Asia, in four sheets, was compiled and published

An accurate knowledge of the factor of expansion of the standard was the one thing wanting to permit of the final reductions of the base lines being taken in hand In 1870 the whole of these reductions were completed The details of the operations form part of the first volume of Colonel Walker's "Account of the Operations "of the Great Trigonometrical Survey of India," which contains a very interesting "Introductory account of the early operations of "the Survey between the years 1800 and 1830," and of the "Standards of Measure and the Base Lines" This great work will be completed in 20 volumes

Meanwhile 200 copies of the first volume were received in England in 1871, and upwards of 90 were distributed to various scientific institutions and men of learning at home and abroad In a letter to Colonel Walker, dated December 1st, 1871, the Under Secretary of State for India acknowledged the receipt of the copies of this volume in the following words "The Duke of Argyll "desires me to convey to you his congratulations on the completion "of this first volume of a great work which, as a record of accurate "geodetical measurement and of arduous services well performed, "will yield to none that has hitherto been published by any "European nation, either in interest or in scientific importance "His Grace is impressed with the amount of labour and of con-"centrated thought which must have been devoted to the pre-"paration of this volume, and I am to express to you his sense of "the value of your services as its author In a despatch to the "Governor General in Council, the Duke of Argyll has requested "that his Grace's appreciation of the assistance afforded to you by "Mr Hennessey and other officers of the Survey may be conveyed "to those gentlemen"

In 1874 the Computing Office, besides the usual duties of examining and reducing the observations, aided in the completion of the 3rd and 4th volumes of the "Account of the Operations of

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[1] "Auxiliary Tables to Facilitate the Calculations of the Survey Department" (Dehra Dun, 1868)

"the Great Trigonometrical Survey of India" The second volume contains an historical account of the triangulation, with description of the methods and procedure, and of the instruments which have been employed, and its preparation fell mainly upon Colonel Walker himself, as well as the portion of the 5th volume dealing with pendulum observations For the South East Quadrilateral there will be six synoptical volumes, one for each series, and much progress has been made not only with these, but also with the volumes of the North-East and North West Quadrilaterals and the Pendulum volume, by Major Herschel during Mr Hennessey's absence on leave, and since 1876 by Mr Hennessey himself

Preliminary charts of triangulation and charts of levels are prepared in the drawing branch of the Computing Office, and in 1872 a map of the country round Delhi was compiled for the camp of exercise As regards the latter map, experiments were tried as to the most convenient form of issuing it for use with troops in the field Copies were printed on waterproof india-rubber cloth, on white cloth, and on several kinds of paper, and it was found that white cloth promised to be most useful in the climate of India In 1875, Colonel Walker issued a third edition of his valuable map of Central Asia, each of the four sheets being entirely redrawn, and much new material being inserted The regular duties of the drawing and photozincographing branches of the Computing Office are to examine all maps and charts drawn by the field establishments, to photozincograph them, and to undertake original compilations The number of maps, charts, and diagrams that were photozincographed in 1875–76 was 25,425 The library of the Computing Office now consists of 2,121 volumes, all kept in good order in one room The work of the Computing Office of the Great Trigonometrical Survey is done under the immediate supervision of the Superintendent at his head quarters, and has hitherto been quite independent of the more voluminous labours of the Surveyor General at Calcutta, whose operations will be the subject of another section

The magnificent work, so ably commenced by Colonel Lambton in the first year of the century, is now nearly completed The topographical surveying of the present day is so much more accurate than it was in Lambton's, or even in Everest's time, that a smaller amount of triangulation suffices as its basis When the Eastern Sind series and the work in Assam and in the extreme south of the peninsula are finished, there will be nothing more left to do in India proper In Burmah there will be further triangulation, and probably two bases to measure, and, in some future day, the great arc will doubtless be carried northward over the mountain barriers to the shores of the Arctic Ocean A preliminary approximate series would extend our geographical knowledge of Central Asia, while it would establish the practicability of a final measurement Sir George Everest looked forward to an arc of the meridian extending from Cape Comorin to the northern shore of Siberia, as the final achievement by which his successors would complete his labours [1]

Colonel Walker, the fourth in succession of the great surveyors who have superintended this most difficult and important work, will, in all human probability, have the high honour and satisfaction of being at his post when it is completed It is, and has been, a very noble band, that body of surveyors who have been trained and have worked under Lambton, Everest, Waugh, and Walker It is no small honour to be at their head These men must combine the knowledge and habits of thought of a Cambridge wrangler with the energy, resource, and presence of mind of an explorer or a backwoodsman, and they must add to this the gallantry and devotion which inspire the leader of a forlorn hope The danger of service in the jungles and swamps of India, with the attendant anxiety and incessant work, is greater than that encountered on a battle field, the per centage of deaths is larger, while the sort of courage that is required is of a far higher order The story of the Great Trigonometrical Survey, when fitly told, will form one of the proudest pages in the history of English domination in the East

Since Sir Andrew Waugh's time, the manuscript volumes containing the Superintendent's reports and the triangulations for each series have not been forwarded to the India Office Preliminary charts containing all requisite data for Topographical Surveyors and Geographers are published by photozincography annually, but the reports are kept back until the whole of the results can be printed in a final and complete form A considerable portion of the original observations is already in the press

Colonel Walker has completed the first volume of this series, being a history of the Great Trigonometrical Survey of India, which includes an introductory account of the early operations

[1] See the preface to "An Account of the Measurement of Two Sections of the Meridional Arc of India," p 7

of the Survey during the period 1800–30, and sections on the standards of measure and on the measurement of base lines The complete work will consist of about twenty volumes[1] Accounts of Colonel Walker's work are to be found in his annual printed Reports, and in the abstracts of them which he has from time to time communicated to the "Journal of the Asiatic Society" (Bengal)[2] The progress of the Survey is noticed in the anniversary addresses of the President of the Royal Geographical Society, and there are articles on the Survey in the "Calcutta Review" for 1863,[3] and in the "Quarterly Journal of Science" for October 1870

The annual reports by Colonel Walker, or by the officer acting for him when on leave, in the Geographical Department of the India Office, are fourteen in number, from 1862–63 to 1875–76 inclusive

An abstract of that for 1862–63 is given in vol i, p 180, of the "Professional Papers on Indian Engineering" (Rurki) 1863

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[1] "Account of the Operations of the Great Trigonometrical Survey of India," vol i By Colonel J T Walker, R E, F R S, Superintendent of the Survey (Dehra Dun, 1870)

[2] Vol xxxii, (1863,) p 111 Vol xxxi (1862,) p 32

[3] Vol xxxviii, No 75

# X

# ROUTE SURVEYS BEYOND THE FRONTIER OF BRITISH INDIA BY NATIVE EXPLORERS

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THE employment of native explorers to make discoveries in the unknown regions beyond the Northern frontiers of British India has led to most important geographical results. The idea was originated by Colonel Montgomerie while he was carrying on the survey of Kashmir and Ladak, and he hoped that by this means the whole country between British and Russian territories might be explored. Natives would be permitted to travel without molestation, as traders or in other capacities, through countries where Europeans would certainly be regarded with suspicion and exposed to ill treatment, and most probably would be murdered.

The plan is to employ Pathans to explore the northern and southern valleys of the Hindu Kush, the valley of the Oxus, and Eastern Turkistan, while for exploration of Great Tibet, and the regions which are subject to the Chinese Government, and mostly inhabited by a Buddhist population, it is necessary to employ Bhutiyas or Tibetans, (the inhabitants of the upper valleys of the Himalaya within British territory.

The explorers are taught to make a route survey by taking bearings with a compass and pacing the distances, they are also taught to take meridian altitudes with a sextant to determine latitudes, but they are purposely not taught how to reduce their observations, nor supplied with astronomical tables, in order that they may not be able to fabricate fictitious work. Observations for determining absolute or differential longitudes are beyond their capacities. The resulting latitudes and the co-ordinates of the routes are computed in the office of the Superintendent of the Great Trigonometrical Survey on the explorer's return. With all its deficiencies this plan furnishes materials for defining the positions of chief towns with some accuracy, and results in the acquisition of a large amount of new geographical information.

The trigonometrical surveyors experienced very great difficulty in training these agents, and met with many disappointments. Out of six or eight men that they had spent years in training, only two or three turned out first class explorers The first man sent out was a native named Muhammad i-Hamid, who went to Yarkand by way of the Karakoram Pass, and determined the position of Yarkand [1]

Muhammad i Hamid died at Leh, on his return home, under very suspicious circumstances The next explorer sent out was a Pathan of the native sappers and miners, a very intelligent man, who promised exceedingly well He was sent into the country north of Peshawur, to explore in the direction of Chitral, but he had a blood feud in his family, and the avenger of blood went after him and murdered him His papers were collected and sent back by no less a person than the Akhund of Swat [2]

In 1864 Colonel Walker engaged two Pundits from one of the upper valleys of the Himalaya, who were recommended by Major Smyth of the Education Department as likely to have great facilities in travelling through various parts of Tibet They were placed under Colonel Montgomerie, who completed their training, and then ordered them to make a route survey from the Mansarowar Lake to Lhasa, with a view to defining the course of the great river Sanpu in Tibet One of these Pundits (A) was Nain Sing, a Bhutiya subject of the British Government, born at Milan in Kumaun He was in the service of Messrs Schlagintweit during 1856 and 1857, and then joined the Education Department, being head master of a Government vernacular school in his native district of Milan from 1858 to 1863 In the latter year he was trained as an explorer, and continued to serve in the Department of the Great Trigonometrical Survey for the next 13 years

The two Pundits (A and B) made a first attempt from Kumaun, but did not find this route practicable They, however, met some Bisahiris, British subjects, who had been robbed whilst trading in Chinese territory, near Gartokh, and who asked the Pundits to be their *vakíls*, in order to obtain redress from the Lhasa Government This furnished a plausible reason for the journey, and it was then decided that the best chance of reaching Lhasa would be through

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[1] Lat 38° 20′ N, Long 77° 30′ E The values adopted by Klaproth, Humboldt, and Ritter are 38° 19 N, and 76° 18′ E The Schlagintweits adopted 38° 10′ N, and 74° 10′ E

[2] See Colonel Walker's speech "Proceedings R G S" xv, p 203 (1871)

Nepal They accordingly set out,[1] and reached Kathmandu on the 7th of March 1865

The Pundits heard that the route by the Kirong pass was clear of snow earlier than that by Kuti (Nilam), and they, therefore, selected that route, leaving Kathmandu on the 20th of March , but the Chinese Governor of Kirong refused to allow them to pass, and they returned to Kathmandu on the 10th of April

One of the Pundits, B, then gave up the attempt, and contented himself with making a long journey in the upper parts of Western Nepal, including an examination of the Muktinath pass[2] The other, A, set out, disguised as a native of Ladak, as a companion of a Tibetan merchant, named Dawa Nangul, on the 20th of June, and made his way to Kirong

The post of Kirong is very important in connexion with the question of intercourse between India and Tibet It commands what is probably the best of the Nepalese passes The Pundit describes it as a place with a fort, a good sized temple, about 20 shops, and a population of 3,000 to 4,000 Wheat and barley are raised round the town, and there is a trade in salt from Tibet and in rice from Nepal

The road through Kirong leads past the important Chinese post of Jonkajong, on the Central Chain, which is probably the Ari-jong of D'Anville's map But the Pundit was again refused leave to proceed, and with very great difficulty he eventually got permission to take another route, to the westward, over the No la pass of the Central Chain, 16,600 feet above the sea His route was through forest on the outer slopes of the Southern Chain as far as a village called Lue, where the mountain sides become bare and rocky, and then across the Southern Chain by the Ga-la pass, which is the boundary between Tibet and Nepal, and 16,700 feet high The No la pass was crossed next day, so that here the two chains approach very closely, the intermediate plain sinking to 14,000 feet

On the 2nd of September the Pundit reached the banks of the Sanpu, and crossed to the Tadum monastery, on the north shore, 14,200 feet above the sea Here he learnt that once in two years the Maharajah of Kashmir sent a merchant to Lhasa with a great

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[1] They had a large sextant, two box sextants, prismatic and pocket compasses, pocket chronometer, boiling point thermometers, and a common watch

[2] No account has ever been published of the journey of this Pundit in Western Nepal, and of his visit to the Muktinath pass

quantity of goods, who is called "Lopchak," and that once a year the Government of Lhasa sent a merchant, called "Jang Chong-pon," to Ladak Another account of this exchange of *kafilas* between Kashmir and Tibet is given by a writer in the "Calcutta Review" He says, that every third year a *kafila*, consisting of 270 horse or yak loads leaves Ladak for Lhasa, carriage being supplied by the Tibetan Government while within its territory The goods from Ladak are dried apricots, saffron, oriss root, currants, chintz, and piece goods, and the articles brought back are shawl, wool, and tea The leader of the kafila, called "Lopchak," must be a Tibetan of Ladak, and is always chosen from a family of rank The profits of the undertaking are shared between the Kashmir Government and the leader's family The Tibetan Government sends a yearly venture of the same number of loads to Kashmir, the Maharajah conveying it at his own expense when within his own border [1] The Pundit joined the Kashmiri merchant's head man, named Chiring Nurpal, who passed through Tadum with 70 laden yaks, and they set out together for Lhasa on the 3rd of October

The party travelled along the northern side of the Sanpu, crossing a large tributary called the Charta-Sanpu, flowing from the Northern Chain, and then passing over a range into the valley of the Raka-Sanpu, a river which has a long course parallel to the Sanpu, into which it falls below Janglaché From Tadum to a place called Ralung there were no signs of cultivation, and the population was very scanty, but from Ralung onwards there were clumps of willow trees and cultivated patches Ralung is just below the Ka-la pass, over a spur from the range between the rivers Raka-Sanpu and Sanpu, which separates the Tsang province from those of Western or Little Tibet

On the 22nd of October the party crossed the Sanpu by a ferry, 190 miles below Tadum, and arrived at the town of Janglaché, where there is a strongly built fort on the top of a hill, a fine monastery, and a number of shops kept by Nepalese From Janglaché to the town of Shigatzé goods and men are transported on the river, which is wide and navigable, in boats covered with hides Here they were joined by the second part of the Kashmiri merchant's caravan, consisting of 105 laden yaks, and on the 29th they reached Shigatzé,[2] 11,800 feet above the sea At a place called

[1] "Calcutta Review," January 1877, No cxxvii, p 144

[2] The Pundit calls it Digarcha Here he took a number of observations for latitude

Phuncholing, between Janglache and Shigatzé, the river is spanned by an iron chain bridge

On the 1st of November 1865, the Pundit went from Shigatzé to Teshu Lumbo, to do homage to the Teshu Lama or Panchen Rimboché,[1] a boy eleven years old, who was seated on a high throne covered with rich silk The Pundit reports that there are 3,300 monks in the monastery of Teshu Lumbo, and that the town of Shigatzé has a population of 9,000, exclusive of the monks, but including a garrison of 100 Chinese soldiers, and 400 Tibetan militia A market is daily held on the space between Shigatzé and Teshu Lumbo, and good crops are raised in the neighbourhood

At Shigatzé the caravan was joined by the Kashmiri merchant himself, and setting out again on the 22nd of December, they passed through Painám,[2] and reached Giansu[3] on the 25th, a distance of 46 miles [4]

Giansu was visited by Bogle and Turner, and Mr Manning resided there for some time The Pundit describes it as a city about the size of Shigatzé, with a fort on a low hill in the centre of the town, and a large gilded temple It is ruled by a *Depon*,[5] assisted by two Jongpens, and has a garrison of 50 Chinese soldiers and 200 Tibetan militia The surrounding plain produces wheat, barley, radishes, peas, and ghee, while rice is imported from Bhutan Woollen cloths are manufactured in the town, and also small bells with which horses are adorned in Tibet

From Giansu the Pundit followed the route taken by Mr Manning to the Palti or Yamdok cho lake, crossing a spur of the Central Chain by the pass of Khoro-la, 17,000 feet above the sea He describes the lake as 45 miles in circumference, two to three miles broad, with a hilly island in the centre, the water very deep and good to drink, though the lake has no outlet He found the lake to be 13,700 feet above the sea

On the 4th of January 1866, the Pundit left the shores of this famous ring shaped lake, crossed the Khamba la mountain separating the provinces of U and Tsang, and reached the left bank of the Sanpu, at the village of Khamba barchi, where it is 11,400 feet above

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[1] He calls him the "Panjan Ringbo Che"

[2] Penajong

[3] Gyangze

[4] According to the Pundit 39 according to Turner

[5] The *Chechep Depen* of Edgar

the sea level. Here the party took a boat, and rowed down the stream to Chusul jong. Crossing the river at Chusul, they followed Mr. Manning's route up the valley of the Ki chu, and arrived at Lhasa on the 10th.

The Pundit describes the Lhasa valley as full of large and populous monasteries. He visited that of Sara (Sera of Huc), three miles from the city, where there are 5,500 monks, and the famous monastery of Galdan, founded by Tsong-khapa, which is three quarters of a mile in circumference, and peopled by 3,300 monks. The city of Lhasa has a circumference of 2½ miles, and in the centre stands a large temple containing images richly inlaid with gold and precious stones, and surrounded by bazaars with shops kept by Tibetan, Kashmiri, Ladaki, and Nepalese merchants, many of whom are Muhammadans. Chinese tradesmen are also numerous. The plain of Lhasa is about 12 miles long by 7 broad, and is surrounded by mountains. Around the town are the monasteries of Muru, Ramoché, Chumuling, Tankyaling, Kontyaling, and the palace-monastery of Potala, the residence of the Dalai Lama, or Gur (Gewan) Rimboché, called also the Lama Guru. It is a mile and a half in circumference, and stands on an eminence 300 feet above the plain. Four miles west of it is the Debang monastery, with 7,700 monks, and to the south, on the other side of the Ki chu, is the Chochuling monastery.[1]

The Pundit went with the Kashmiri merchant (Lopchak), to pay his respects to the Dalai Lama, who was a fair and handsome boy about 13 years old, seated on a throne six feet high, with the Gesub Rimboché,[2] or Regent Minister, on his right hand. The Pundit relates the popular belief to be that the Dalai Lama will transmigrate 13 times, and that he is now in his 13th transmigration. But he is only in the 12th according to the list of Desgodins. Below the Regent there are four ministers, called

1 According to another authority, the principal *Gonpas* or monasteries round Lhasa with the numbers of monks in each, are as follows:

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|---|---|---|---|
| Gandan monastery - | 3,500 | Kontyaling monastery | 200 |
| Sera ,, | 5,500 | Tankyaling ,, | 200 |
| Depong ,, | 7,500 | Chochuling ,, | 300 |
| Gentu ,, | 500 | Chumuling ,, | 1,000 |
| Grume ,, - | 500 | | |
| Chenamgé ,, - | 1,000 | | 20,400 |
| Chemchung ,, - | 200 | | |

2 Nomen khan of Huc, ii. p. 156. The Pundit calls him Gyalpo Khuro Gyago.

Khalons,[1] who conduct all public business, and the Amba, or Chinese political agent, has special, but apparently undefined, powers As a rule, he does not interfere in the internal affairs of Tibet The Pundit also heard that 36 miles east of Lhasa, on the north shore of the Sanpu, there is a town called Sáwe, where the Tibetan treasury is kept, that 40 miles farther east there is a town, on the south bank, called Shotang, as large as Shigatzé, that the river flows thence eastward for 120 miles, and then turns due south

The hills round Lhasa are barren, except for one thorny bush called *sia*, but there are trees of two kinds in the gardens, though not indigenous, called *changma* and *jawar* The crops of the Lhasa plains consist of barley, wheat, peas, mustard, radishes, carrots, onions, potatoes,[2] beans, and other garden produce There are cows, sheep, goats, yaks, ponies, asses, and pigs, and fowls, pigeons, and ducks are plentiful The manufactures at Lhasa are chiefly woollen cloths and felt

The population of Lhasa, according to a census taken in 1854, was 15,000, and owing to the number of celibates there is a large preponderance of women, 9,000 women to 6,000 men The garrison consists of 500 Chinese soldiers, and 1,000 Tibetans, armed with flint guns, and seven small pieces of ordnance

The Pundit left Lhasa on the 21st of April 1866, and, returning by the same route, reached Tadum on the 1st of June Journeying up the Sanpu valley, he crossed the Mariam la pass, and returned to India, reporting himself to Colonel Montgomerie at the head-quarters of the Great Trigonometrical Survey[3]

In May 1867, the same Pundit who was at Lhasa, A, with a third man who had been trained in the interval, C, as B had proved to be somewhat wanting in nerve, set out to explore the gold mines of Thok Jalung, on the lofty plateau in rear of the great Northern Range After a most trying journey, these hardy and persevering explorers crossed the Chomorong-la pass, 18,760 feet above the sea, and after a long march through snow, reached the chief gold field,[4] on a large desolate plain, 16,330 feet above the sea, where the camp of the Tibetan gold diggers was pitched The master of the

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[1] *Kaskaks*, of the Pundit

[2] Probably due to the benevolent forethought of Warren Hastings, and introduced through Bhutan

[3] See "General Report on the Operations of the Great Trigonometrical Survey of India during 1866-67," by Colonel J T Walker, R E, F R S, ix pp i to xxix

[4] In 32° 24′ 26″ N, 81° 37′ 38″ E

gold diggings was a native of Lhasa, a shrewd and well informed man The Pundit describes the method of working the gold, and the habits of the diggers The explorers left Thok-jalung in August, and returned to head quarters in November 1867 [1]

Some very important journeys were made by an explorer whom Colonel Montgomerie calls No 9, and whose results he reported upon in 1872 No 9 went up the valley of the Tambur, in Eastern Nepal, in the footsteps of Dr Hooker, as far as the Wallanchún pass, which No 9 calls Tipta la, and then succeeded in gaining permission to enter Tibet by his successful medical treatment of the wife of a chief official, at Tashirak, a large standing camp on a feeder of the Arun, 15,000 feet above the sea He then crossed a mountain spur by the Ni-la pass, and entered the district of Tinki-jong Advancing southward, he first came to patches of cultivation at a place called Lamadong, on the banks of the Khantongiri, another tributary of the Arun Crossing over another spur, by the pass of Tinki-la, he reached the banks of the Chomto-dong lake, 20 miles long by 16 miles wide, and 14,700 feet above the sea He then crossed the Central Range by the Lagulung la pass, 16,200 feet above the sea, with glacier ice close down to it, which forms the boundary between Sikkim and Tibet The explorer journeyed thence to Shigatzé, and duly paid his respects to the Teshu Lama

No 9 returned by the Sakia monastery of the Red Cap sect, crossed the Central Chain by the Dong-la pass, on the 3rd of October 1871, and proceeded by Sakar jong, Tingri, and Nilam to the gorge of the Bhotia Kosi into Nepal Nilam, or Kuti, is the last Tibetan town in this direction, and the pass thence into Nepal, according to the account given by No 9, is one of the most dangerous in the whole Himálayan range [2]

In 1868–69 an explorer, known as the Mirza, was employed to undertake a journey beyond the Hindu Kush He had had a partial English education, his father having been a Turk of Mash had engaged in trade, and his mother a native of Persia, where the Mirza was born He had spent a good deal of his life in Kabul, and could speak Persian and Turkish After much delay he reached

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1 "General Report on the Operations of the Great Trigonometrical Survey of India, 1867-68,' by Lieut Colonel J T Walker, R E, F R S, xi pp 1 to x

2 "General Report on the Operations of the Great Trigonometrical Survey of India during 1871-72," by Major T G Montgomerie R E, F R S

Kabul, and succeeded in starting thence for Badakshan in October 1868. Crossing the Hindu Kush by the ordinary route to Bamian, he made his way into Badakshan, following the course of the Kokcha river. The Mirza reached the Oxus at Ishkasim, and, marching up the stream nearly due east, he arrived at the Punja fort, in Wakhan. Up to this point he followed in the footsteps of Lieutenant Wood, so that his work could be tested, and his positions of the chief places differ but little from those of Wood.[1] From Punja onwards the Mirza's route diverged from that of Wood, who took the northern branch of the Oxus, while the Mirza followed the southern branch. On January 14th, 1869, the latter started from Punja and suffered severely from cold in crossing the Pamir Steppe, snow falling every day. After the fourth day the party reached the water parting between Wakhan and Eastern Turkistan, where the rivers were all frozen. The source of this southern branch of the Oxus was found to be a small frozen lake called Pamir-kul 13,300 feet above the sea.[2] After four more long marches the Mirza found himself at Tashkurgan, the capital of Sirikul, 10,986 feet above the sea, the stream he had followed down being a tributary of the Yarkand. He was now in the territory of the Atalik Ghazi, and was sent with an escort to Kashgar, where he arrived on February 3rd, 1869. Observations for latitude were taken at the chief places on the route, by meridian altitudes of the sun and stars, and a route survey was made by taking bearings with a prismatic compass, and measuring distances by pacing. The Mirza's work placed Kashgar in 39° 29′ N. and 76° 12′ W. He returned by Yarkand and the Karakorum pass, after executing a route survey of 2,179 miles, fixing the height of 28 points by boiling point observations, and taking 48 latitude observations at 14 places.[3]

In 1870 Colonel Montgomerie sent an explorer into the triangular space lying between the Indus and its great Kabul tributary, which is bounded on the north by the Hindu Kush and Mustagh ranges

[1] The position of Punja, according to Wood, is 37° 2′ N., and 72° 41′ E., and according to the Mirza 37° 5′ N. and 72° 39′ E.

[2] 13,200 according to Captain Trotter.

[3] See "G. T. S. Survey Report for 1869–70." In 1871 the Mirza was sent on a second journey, with his son-in-law as an assistant. He had traversed the road from Herat to Maimana, and was proceeding northwards when he and his companion were murdered during the night while asleep, by their guides. The Mirza was a most zealous, faithful, and intelligent explorer.

The man selected was a Havildar of one of the Pathan companies of sappers, who was regularly trained for the work, and then started from Peshawur, crossing from Yusufzai into Swat, and thence into Bajaur. From Bajaur he made his way into Dir, on the Punjkora river, and onwards through a part of Kafiristan to Chitral. From this point he crossed by the lofty and difficult pass of Nuksan to Faizabad in Badakshan. The Havildar returned to Chitral by the Dora pass, after completing the survey of the head waters of the Kokcha river, a large tributary of the Oxus, and made his way thence to Peshawur. He was constantly in great peril from robbers, and it was much to his credit that he was able to pass through so dangerous a country without a mishap of any kind. He took latitudes at five points, determined heights at four, and made a route survey of 286 miles, mostly over new ground.

In 1871, Colonel Montgomerie organized a party to explore some portion of the unknown region north of the Tibetan watershed of the Upper Brahmaputra, or Sanpu, led by a young semi-Tibetan, who is neither distinguished by name or number, so we will call him D. He had with him four assistants from the border districts. Crossing the Mariam la, they arrived at Shigatzé on the 24th of November, where D prepared for a journey across the great Northern Chain to the unvisited lake of Tengri-nor, which was only known from the Lama's Survey of 1716. Sheep were the only animals that could stand the journey, as the road was too stony for yaks and the climate too cold for donkeys. D therefore purchased fifty sheep to carry the baggage, and setting out on the 6th of December, the party crossed the Sanpu, and travelled up the valley of the Shiang chu, in the footsteps of Mr Bogle. The villages the explorers passed through were Peting, on the Tsanpu, Chu, Dongdot la, and Chom, and on the 14th they reached Namling, the Chamnamring of Mr Bogle, where there are a monastery with five hundred monks, a fort, and about two hundred houses surrounded by gardens, with an iron bridge over the river. This route is frequented by traders in salt and borax.

Following up the valley they next came to Kholam, and then to Gonkiang, where there is a monastery. On the 20th they halted at another monastery, called Rabdan Chuling Gonpa, the residence of a high Lama, called the Shaptung Rimboché, who was said to be about one hundred years old, and who had built the monastery eighty years before. Beyond this point the cold became very intense, and at the village of Gunje the explorers were told that white bears, called *tik-dumba*, abound, which commit great havoc amongst the cattle They next came to some very remarkable hot springs and geysers in the mountains, and on the 8th of January 1872, they crossed the Khalamba la pass over the great Northern Range, in a heavy snowstorm, which is 17,200 feet above the sea On the other side they came to an encampment of Dokpa shepherds, and a little farther on the first view was obtained of the great Tengri-nor lake, called on the spot Jang Namcho[1] Chidmo, and they crossed the large river Ghaika chu, flowing into it from the west They reached the monastery, on the banks of the lake, called Dorkia-lugu-dong,[2] whence there is a magnificent view of the wide expanse of water D resolved to execute a complete survey of the lake, making this monastery his head quarters, but there were constant heavy falls of snow, which impeded his work The principal peak in this part of the Northern Range is called *Ninjinthangla*, 25,000 feet high, and the lamas say it is a god surrounded by three hundred and sixty smaller snowy peaks as its servants The range was traced for 150 miles, running in a north-easterly direction

The lake is quite frozen over in November, though the water is too salt to be used for drinking The level is 15,200 feet above the sea It is 60 miles long by from 16 to 25 miles broad, and has some large islands To the north there is another smaller lake, called Bul-cho, about 6 miles long by 5 miles wide, whence a kind of borax is obtained

On their return, D and his companions were attacked by robbers, and stripped of nearly all they possessed, with difficulty making their way round the east side of the lake, and across the Central Chain, by the Damniargan-la pass, to Lhasa On the 2nd of March the weary travellers arrived at the Jangtalung monastery, where there are a thousand monks, and on the 9th they reached Lhasa, whence, after a long and difficult return journey, they made their way to the head quarters of the Great Trigonometrical Survey in safety[3]

Another explorer, whose journey is described in the same report, made his way through the upper part of Western Nepal, from

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[1] *Nam*, sky and *cho*, lake

[2] *Dor*, a rock, *lugu*, a sheep, and *dong*, face

[3] "General Report on the Operations of the Great Trigonometrical Survey of India during 1873–74,' by Colonel J T Walker, R E, F R S, pp i to x

Kumaun, across the Kali and Karnali, to Muktinath, and then, by Mantang, over the Photu-la pass of the Central Chain, 15,080 feet above the sea, to Tadum, in Tibet[1]

The training and despatch of these native explorers have added very materially to our knowledge, not only of the geography, but also of the condition of the people, and the state of trade in Nepal and Tibet Colonel Walker and Colonel Montgomerie have rendered most important service in having conceived and ably carried out so useful a project, and the Pundits themselves deserve the highest praise for their painstaking accuracy, perseverance, and gallant adventurous spirit

The Havildar, who made the remarkable journey into Badakshan in 1870, was employed in 1872 to make a route survey from Kabul to Bokhara He left Peshawur on the 19th of September 1873, with two companions, and as far as Jalalabad he was accompanied by the Mullah, who was to explore the Kunar valley The Havildar travelled as a merchant, with about 300*l* worth of muslins and cloths He left Kabul on the 3rd of November, and crossed into Badakshan by the Sar-ulang pass, about 12,000 feet above the sea, and on the 19th he arrived at Faizabad, the modern capital of Badakshan, where he passed the winter On the 19th of April 1874 he set out from Faizabad with a stock of *churrus* (an intoxicating drug from the hemp flower) for sale, and reached the left bank of the Oxus, where he crossed the river on a raft made of inflated skins, the stream being 600 paces wide and the current very swift The Oxus here separates the dominions of the Amir of Bokhara from those of the Amir of Afghanistan, and from this point upwards it is generally known as the Punjah Next day the Havildar arrived at Kolab, a city of 600 houses, where he remained until the 25th of May He then travelled along the right bank of the river into Darwaz, and arrived at Kila Yaz Ghulam, the frontier village of that little State, on the 9th of July He was told that, from this point, one long day's journey would have brought him into Shighnan, but he was recalled by the ruler of Darwaz, and detained at its chief town of Wanz for three weeks He was then told that he would not be allowed to continue his journey but must

[1] Also in the Report of 1873–74 following the above p x, with map The Himalayas have not yet been crossed at any point between the Muktinath pass and Kumaun, and except in one instance, the peaks, in this interval, have not been measured

return to Kolab He went back to Faizabad, and went thence, by Balkh and Bamian, back to Kabul, reaching Peshawur on the 11th of January 1875

The Mullah, who accompanied the Havildar as far as Jalalabad, was a native of Peshawur, and a brother of the sapper who was murdered in Swat in 1869 He is a well-educated man, skilled in Arabic, and in his capacity of Mullah can travel unquestioned about Swat The Mullah left Jalalabad on the 28th of September 1873, crossed the Kabul river, and proceeded up the valley of the Kunar, of which he has given a very valuable description He reached Chitral on the 31st of October, passing the winter there On the 22nd of March he set out for the Baroghil pass, which is believed to be the lowest depression in the chain that separates India and Afghanistan from northern Asia This pass forms the water parting between the Sarhadd and Chitral rivers, and the Mullah crossed it and reached Sarhadd in Wakhan on the 8th of May 1874 He then proceeded over the Little Pamir to Tashkurghan and Yarkand, and so by the Karakorum pass to Leh He merely made a route survey with compass, without attempting observations for latitude or height above the sea, as detection would have been a most serious matter

The journeys of the Havildar and the Mullah were complements of the work achieved by Captain Henry Trotter, R E, of the Great Trigonometrical Survey, who was selected to accompany the mission of Sir Douglas Forsyth to Kashgar, as geographer Two of the Pundits accompanied him, and he was well supplied with necessary instruments Captain Trotter's first useful piece of geographical work during this service was a boat expedition on the Pangong lake in October 1873, when he obtained some soundings He has given detailed descriptions of the routes between Ladak and Turkistan, and very interesting accounts of excursions in the neighbourhood of Kashgar, as far as the Artysh districts He then proceeded on his important journey, by way of Tashkurghan, to the Pamir Steppe, where he obtained a complete set of astronomical observations, and was thus enabled to fix the principal positions along the line of march with considerable accuracy

Captain Trotter started from Kashgar on the 17th March 1874, accompanied by Dr Stoliczka, the geologist, passed through Tash kurghan, and reached Punjah in Wakhan Here he despatched his assistant, Abdul Subhan, to explore the course of the Oxus from this point in the direction of Kulab He followed the river for 63 miles to Ishkashim, thence turning northwards he continued his journey along the river bank for nearly a hundred miles, passing through the districts of Gharan, Shighnan, and Roshan, countries which have hitherto been known to us hardly ever by name. He describes the famous ruby mines, and gives many particulars respecting the countries of Shighnan and Roshan. The Munshi Abdul Subhan succeeded in reaching a point very near to that at which the Havildar, coming from another direction, was obliged to turn back. Captain Trotter left Punjah on the 26th of April 1876, and marched up the northern branch on the Great Pamir, reaching the west end of Wood's Victoria Lake, the source of the Oxus. Captain Trotter's valuable report has thrown a flood of light on the geography of the Pamir, and of Eastern Turkistan. It is gratifying to find that his determination of the position of the Victoria Lake is practically identical with that of Lieutenant Wood. He has also succeeded in connecting the Indian surveys with those of Russia. In 1872 Colonel Scharnhorst, attached to the staff of Baron Kaulbars, the Russian Envoy, fixed the position of Kashgar, and that of Captain Trotter differed one mile in longitude, while the latitudes were practically identical.[1]

The reductions of the astronomical observations and the computations of heights were all made in the office of the Superintendent of the Great Trigonometrical Survey, and among other results a series of most valuable maps has been prepared.[2] For Captain Trotter has not only worked out his own observations, but has also reduced those of the Havildar and Mullah, as well as those of the Pundit, whose very remarkable journey across Tibet remains to be recorded.[3] These native explorers did good service in the field, but they were quite unable to utilize their work, and for the resulting narratives and maps geographers are indebted to Captain Trotter, as they were for the results of former journeys by native explorers, to Colonel Montgomerie.

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[1] 37° 24′ N. 76° 6′ E.

[2] For Captain Trotter's account of his own work see "Report of a Mission to Yarkund in 1873, under the Command of Sir T. D. Forsyth, K.C.S.I., C.B." (Calcutta, 1875), chapter vii. "Narrative of Geographical Exploration by Captain Trotter, R.E.," pp. 223 to 295.

[3] "Report on the Trans Himalayan Explorations by Employés of the Great Trigonometrical Survey during 1873–74–75,' drawn up from the original records by Captain Henry Trotter, R.E." (Calcutta, 1876), pp. 91. This Report, illustrated by maps, contains the narratives of the journeys of the Havildar, the Mullah, and the Pundit Nain Sing.

The journey performed between July 1874 and March 1875 by the Pundit Nain Sing, of the Great Trigonometrical Survey Department, is the most important, as regards geographical discovery, that has been made by any native explorer For the first time the vast lacustrine plateau of Tibet has been traversed by an educated traveller, who was able to take observations and describe what he saw, and thus a great increase has been made to our scanty knowledge of Tibet

In 1873 the Pundit Nain Sing accompanied the mission of Sir Douglas Forsyth to Yarkand, and in July 1874, under instructions from Captain Trotter, he set out from Leh on his final and most important journey, to cross the vast lacustrine plateau of Tibet to Lhasa, and thence to make his way down into Assam

Nain Sing reached Tankse, near the frontier, on the 21st of July, and entered Tibet, at Chagra, as a Lama professing to be going on a pilgrimage to a temple near Rudok At first he followed the Chang-chenmo road to Yarkand, crossing the Marsemik la at a height of 18,420 feet above the sea, and then turned to the east by a route over the Kin-la, which is still higher than the Marsemik, reaching Noh, a small village of the Rudok district The progress was slow, as all baggage is carried by sheep, 20 to 25 lbs each, which are never fed, and live on the pasturage by the roadside Yet, out of the twenty six which originally started from Tankse, four arrived at Lhasa, having carried their loads over a distance of a thousand miles

The region travelled over from Tankse to Noh is the northern portion of Nari, or Western Tibet At this western corner of the plateau the road to Khotan rises to 15,500 feet in 40 miles, and then descends rather abruptly to the plains of Eastern Turkistan Seven miles east of Noh is the eastern termination of the Pangong series of lakes, which is a hundred miles long The Pundit determined this eastern limit for the first time, and it is remarkable that the Pangong consists of sweet drinkable water at the east extremity, while the west end is very brackish The Pangong is the most westerly of the system of inland lakes to which the drainage of the vast river plateau of Tibet converges for a distance of 800 miles

From Noh the road eastward over the plateau passes along a wide grassy valley, with occasional shepherd's huts, and large herds of wild asses, antelopes, and gigantic sheep (*Ovis ammon*) Large sheets of water were frequently met with, generally salt, but occasionally fed by fresh-water streams The plateau is at an elevation of from 13,700 to 15,000 feet above the sea This western portion is inhabited by Kampas, the tribe which emigrated from eastern Tibet about a quarter of a century ago The Pundit describes them as fine broad shouldered men, well armed, and dressed in sheep skin coats, felt hats, and leather boots with curved pointed toes They are great sportsmen, and both men and women are constantly in the saddle Their black tents are made of yaks' hair, they manufacture a very coarse kind of woollen cloth, and live on meat, butter, cheese, milk, and a little flour to thicken their soup

On the 17th of September, the Pundit reached the gold-fields of Thok Daurakpa, which are not so important as those of Thok-Jalung, which he visited in 1867 There are also two smaller diggings, called Tang-jong, and Sarka-Shyar, further east, the whole under the superintendence of an officer from Lhasa, with the title of Sarpon The whole yield of gold, about 8,000*l* a year, is sent to Gartokh, whence it finds its way to sea

Continuing his journey over the plateau, the Pundit traversed elevated plains for many marches, covered with velvet turf, and frequented by countless herds of antelopes To the south were the snowy peaks of the northern Himalayan range (Gangdis ri), which the Pundit traced for a distance of 180 miles The highest, called Targot yap, is 25,000 feet above the sea Our traveller was informed that to the south of the range there was a river called Hota-Sangpo, which ultimately turned north into the Kyaring Lake At the foot of the northern slope of Targot yap there is a lake called Dangra-yum, and on its banks is the district of Nakchang Ombo, surrounded by snowy mountains Here there are several villages of stone houses, and barley is extensively cultivated It is remarkable that, although this district of Ombo is at nearly as great an elevation as the rest of the plateau, it is the only place where there is any cultivation from Chabuk Zinga, at a distance of 35 marches on one side, to Lhasa, a distance of 39 marches on the other The elevation of Ombo is 15,240 feet The inhabitants have a tradition that many centuries ago a great and powerful Gyalpo or king lived at Ombo and reigned over the whole of the Hor country He was overcome by the Gyalpo of Lhasa

Thence to the great Lake of Tengri-nor or Namchu the country is 15,000 to 16,000 feet above the sea, the drainage being from the mountains separating the plateau from the valley of the Brahmaputra to the north, into a vast system of inland lakes discovered by the

Pundit All these lakes are new to geographers, with the exception of Tengri nor The largest is the Dangra yum cho, which is 45 miles long by 25 broad, and the Kyaring cho is 40 miles by 8 to 12 These lakes are well stocked with fish, and frequented by myriads of wild fowl

The Pundit passed along the northern shore of Tengri-nor, and thence followed the track of the former Pundit of 1872 to Lhasa, which city he reached on the 18th of November[1] Nain Sing, owing to well-grounded fear of detection, only remained two days at Lhasa on this occasion, and went thence to the ancient monastery of Sama-yé gonpa where the images of the temple are of pure gold, and which contains a large Buddhistic library This is probably the Sáwe mentioned in his former account He continued his journey for two days down the course of the Brahmaputra, and crossed it at the lowest known point on its upper course, where it is 500 yards wide and 20 feet deep, with a very sluggish current He arrived at a large town called Chetang on the right bank, where there are two monasteries and 700 lamas, and here he made out that the Brahmaputra continued its eastward course for 30 miles, and then turned south east

At Chetang the route ascended the valley of the Yelung, a tributary of the Brahmaputra, on its right bank, which flows through a rich and fertile valley where there are fruit trees and large patches of wheat and barley After 36 miles the Dalatang plain is reached, a grassy expanse stretching for 15 miles to the Karkang-la, a pass over the central chain of the Himalaya, 16,210 feet above the sea Seventy miles to the south, over a lofty region, brought the traveller to the Kya kya pass, leading down into the Tawang valley, on the southern slopes of the southern chain Here, at Chona-jong, in the Chukhang valley, there is a great exchange mart, where the Tibetan merchants meet those from Assam The market, at its height, contains several hundred shops The Pundit was detained in Tawang for some months, and eventually reached Odálgiri in Assam on the 1st, and Calcutta on the 11th of March 1875

This really magnificent exploring achievement has yielded rich and valuable geographical results The distance from the Pangong Lake, by Lhasa, to Odálgiri, is 1,319 miles of previously unknown

[1] His latitude of Lhasa was 29° 39′ 23′ N In 1866 he made it 29° 39′ 17″ N, the mean of the two observations being 29° 39′ 20″ N, longitude 91° 5′ 30″ E

country, except for a very short distance traversed by the Pundit of 1872,[1] 1,200 miles were entirely unknown, and the whole extent was traversed with bearings and facings, 276 astronomical observations were taken for latitude, and 497 for elevation above the sea. The eastern extremity of the Pangong Lake was settled, a system of numerous lakes and rivers was discovered, the existence of the vast snowy range of the northern Himalaya (Gangdis ri) was clearly demonstrated, several peaks were fixed, 30 miles of the Brahmaputra was discovered, and the Tawang route from Tibet to India was surveyed.

On his return the Pundit Nain Sing retired from the public service on a well earned pension. He has displayed qualities which place him high in the rank of geographical explorers, combining extraordinary hardihood, endurance, and perseverance, with prudence and skilful diplomacy; while his observations are remarkable for accuracy and precision. It is not often that such splendid services have been performed for geography by the efforts of one man, and the greatest scientific traveller that India has produced was not to be allowed to retire from the service without some special recognition by geographers of the value of his achievements.

He received from the Government of India the grant of a village in addition to his pension, and in 1877 he was awarded one of the royal gold medals by the Council of the Geographical Society, for his distinguished services as an explorer and a surveyor.

[1] See page 159.

# XI
# FOURTH PERIOD OF THE TOPOGRAPHICAL SURVEYS
# (1861—77)

## Colonel Thuillier as Surveyor General

Colonel Thuillier succeeded Sir Andrew Waugh as Surveyor General of India, on the 13th of March 1861 Henry E Landor Thuillier entered the Bengal Artillery in 1832, and joined the surveying service in 1836 He had been Sir Andrew's Deputy in charge of the office at Calcutta since 1847, and during those fifteen years the general usefulness of the surveying operations had been increased a hundredfold Thuillier's energy and talent for organization had been devoted alike to improving the system of surveying in the field, and making its results more readily accessible to the public In all this he was well supported by his chief In one of his early reports Colonel Thuillier "records his sense of the "valuable and hearty support always rendered by Sir Andrew "Waugh's method of conducting the great triangulation to meet "the necessities and requiremements of the Revenue Survey, and of "his forethought and great consideration for the important objects "of the extension of the geographical knowledge of India"

The revival of the Revenue and Topographical Surveys may be dated from the appointment of Colonel Thuillier, at the end of the first Punjáb war in 1847 Since that date they have been conducted with ever increasing efficiency, and with annually improving arrangements for extending the sphere of their usefulness The previous history of the surveys will have shown that the great triangulation has, as a rule, been prosecuted by a distinct staff, and separate from the operations of filling in details for the maps Men trained for the strictly scientific work of the great triangulation are not always adapted for the detail surveys, or *vice versâ*, while the two classes of operations must be conducted on distinct principles The Revenue and Topographical Surveys must be undertaken with reference to the public requirements, while the triangulation is regularly proceeded with on a fixed plan But it has always been Colonel Thuillier's care to follow in the track of the different trigono metrical series, and thus have the advantage of fixed stations on which to base his detail surveys

The Topographical Surveys, usually on the scale of one inch to the mile, are simply intended for Native States or non regulation British districts of a wild rugged character and small value, as regards revenue, where only a military map on a smaller scale is required They are carefully connected with the great triangulation, by breaking up the large triangles into minor triangulations with sides sufficiently short to give bases for plane table sketching The chain is not generally used by the Topographical Surveyor, because it is politically obnoxious to independent tribes, and is looked upon as the sure harbinger of loss of territory The number of points used by the surveyor with the plane table in delineating the ground is the criterion of the value of his survey,[1] and lines are run across the ground, either with chain or perambulator, to test the accuracy of the work, by traverse

The Topographical Surveys, when Colonel Thuillier took charge, in 1861, consisted of four parties in Central India, the Nizam's Territory, Ganjam, and Chota Nagpur, comprising a total area of 43,316 square miles When this was completed there still remained 319,338 square miles to be done in the Native States, and 21,134 in the wild hills of Eastern Bengal In 1862 a fifth party was organized to survey Rewah

In 1864, after 18 years of uninterrupted and arduous service in charge of the Surveyor General's Office at Calcutta, Colonel Thuillier went home for 20 months on sick leave, Colonel Walker officiating for him as Surveyor General and Superintendent of the Topographical Surveys, and Colonel Gastrell as Superintendent of the Revenue Survey

During the two seasons, 1864–66, Captain Melville was surveying in Central India Mr Mulheran was at work in the upper Godavari district, in the midst of heavy forest and tangled underwood He fell a victim to his own unceasing exertions in the survey of the

1 The work is divided into sections, 15 minutes in latitude and longitude containing 270 square miles The surveyor fills in the details round the trigonometrical points already projected on his plane table, and at each trigonometrical station he draws a series of rays to neighbouring objects, the positions of which are determined by intersection The points of intersection are then visited, and a similar process is gone through The position of each detail need not be more than $\frac{1}{50}$ of an inch in error on the maps, but there is often great difficulty when the points are concealed from each other by jungle

Nirmul jungles, a most pestilential tract on the Wurda and Godavari rivers, and added one more to the long list of zealous and devoted surveyors who have laid down their lives in the service of their country

Colonel Saxton continued his severe work in Ganjam and Orissa, regions of a uniformly deadly and malarious nature, where the majority of the officers who were associated with him had perished The survey in Chota Nagpur was conducted by Captain Depree, and that in Rewah and Bandalkhand was under Captain Murray Godwin Austen, the topographer of the lofty region of the Pangong lake, had accompanied Mr Eden's Bhotan mission, and had served with the Duar field force He next headed a sixth topographical party, to survey the forest covered and pestilential Garoox, the Khasia and Jayanta hills, Naugong, and North Cachar

The Pegu Survey was distinct from these, and is on a scale of four miles to the inch The survey was commenced in about 1851, but when Captain Fitzroy took charge, in 1860, he rejected the work executed by his predecessors, and commenced *de novo*, which gave rise to considerable delay In 1865, Captain Edgcome, the Principal of the Madras College of Civil Engineering, took charge of the Pegu Survey He completed the field work, constructed *ten* or district maps on a one inch scale, besides the quarter-inch geographical map, and prepared a memoir containing much valuable statistical information

Colonel Thuillier returned to India, and resumed charge on the 12th of December 1866, but he was again in England from the 10th of May 1868 to the 7th of January 1869, when his duties were shared by Colonel Walker, Colonel Gastrell, and Captain Montgomerie On the latter occasion Colonel Thuillier was on duty, maturing arrangements for the transfer of the engraving of the sheets of the Indian Atlas from London to his own office at Calcutta

During the seasons of 1867–68 and 1868–69 there were seven parties of topographical surveyors in the field in Rajputana, the Central Provinces, and the wild region on the N E frontier The country under survey embraced every variety of ground, from the arid and sandy tracks of Bikanir to the mountains of Khasia and Jayanta, which are deluged with a rainfall of 600 inches in the year The surveyors penetrated into the wildest and most secluded spots In the Central Provinces they came upon a tract utterly devastated by a tigress which had killed 50 people, and driven the inhabitants from 13 villages In many parts they traversed regions hitherto not only unmapped but unknown Their system of work is suited to native states, their operations with the theodolite and plane table, and no chain, excite little jealousy, and they usually succeed in establishing friendly relations with the wildest hill tribes

Colonel Johnstone, of the Punjab Frontier Survey, accompanied the Hazara Field Force in October 1868 and following months, with his staff of surveyors, and completed a sketch map of 400 square miles of hitherto unexplored and unknown country during the expedition, resuming his regular duties on its return The work was amongst glaciers and mountains of perpetual snow Johnstone fixed stations on peaks that had hitherto been pronounced impracticable, and made an important geographical discovery respecting the true course of the Indus, between Astor and the Black Mountain

Six parties were at work during 1868–69 in the Lower Provinces, chiefly in Kuch Bahar, and in the Kamrup and Lakhimpur districts of Assam In Lakhimpur Lieutenant Barron had most severe work, cutting his way through dense jungles with imported labour, and his health has suffered much by it His services have been specially recognised in a despatch from the Secretary of State s

During 1871–72 seven Topographical Survey parties made systematic progress in filling up the blank country in the respective divisions, so as to provide for each sheet of the Indian Atlas in due order As the surveys progress, the ground to be taken up becomes more insalubrious and difficult of access The first party, under Lieutenant Holdich, was at work in Gwalior and Tonk in 1872, an unusually difficult country, where scarcity of water and constantly recurring famines have reduced the population, and where cities are now hamlets standing in the midst of ruins In 1873 Lieutenant Holdich was surveying a wild country in the valley of the Chumbral, and in 1874 the same party, under Captain Strahan, was at work to the eastward of Nimach Mr Scanlan, the assistant surveyor of the party, has written several very interesting reports on the antiquities, productions industries, and scenery of the region in which he served In 1875 the work of the first party was extended to the city of Udaipur, and in 1876 further progress was made in the same region, with Nimach in the centre The first party will also complete large-scale plans of the fortress of Gwalior, and of the cantonments of Morar and Nimach

The second party is commanded by Mr Girdlestone, who has also done good service in the Indian navy, and subsequently as a marine surveyor In 1872 he was at work in the north east corner of Khandesh, and in parts of Holkar's territory In 1873 he continued his work in the Narbada valley, and his management was marked by great success and energy In 1874 he was engaged along the great range of the Vindhyas, in portions of Nimar and Malwa, and wrote a most interesting report on the ruins of Mandó As soon as the Satpura hill tracts and native states on either side of the Narbada are surveyed on the one-inch scale, the whole strength of the second party will be brought to bear on the two inch scale survey of the revenue paying districts of Khandesh

The third party, under Colonel Saxton, was employed, in 1872, in a very wild and mountainous country in the Bustar and Jaipur State, the latter in the Vizagapatam Agency, working southward from the parallel of Vizianagram In 1873 Captain Holdich took charge of this party and carried on the survey over the broken, rugged hills which continue the mountain system of the Eastern Ghâts, extending across the Godavari river, a densely forest clad tract, and almost uninhabited In 1874–75, starting from Damagudiam on the Godavari, Captain Holdich proceeded along the valley to Sironcha, and then into Chanda, a district of the Central Provinces He has given, in his report of 1876, a most interesting account of this almost inaccessible region, and of the wild Gonds who inhabit it Owing to the orders for the reduction of the department, this party, which was doing such efficient service, is to be broken up

The fourth party, under Major Depree, was prosecuting a survey in the Rewah State and Bilâspur district in 1872, including the high plateau, from which rises, at Amarkantak, the Narbada, the Mahanadi, and the Son The highest part of this plateau is 3,860 feet above the sea, where the valleys are bare of forest and covered with long grass, and the inhabitants are wild Gonds, who live in wretched mud huts In 1873 the Amarkantak plateau was very carefully mapped in 1874, and in the following year the survey was continued through the Rewah State In 1876 the operations lay in the western portion of the Mandla, and the northern part of the Bilâspur district in the Central Provinces, and the Surveyor General recorded his appreciation of the efficient state in which it is maintained under Colonel Depree's energetic and able management Since the party broke ground in 1870 it has completed 14,929 square miles of topography over very difficult ground There remains about 1,200 square miles to be completed Owing to the stringent orders to reduce the department, this admirable organized party will be absorbed to No 7 party, and thus an excellent and well trained native establishment will be lost through a policy which is as short sighted in a financial point of view as it is injurious to the public service

The fifth party, under Captain Riddell, was engaged in the survey of Bhopal and Málwa, in the valley of the Narbada and its tributaries during 1872 and 1873, and in the Vindhya hills, and a plan of the city and fort of Bhopal was made on a scale of 12 inches to the mile In 1874 and 1875 good progress was made, but in 1876 the work was retarded owing to the extremely difficult forest clad nature of the ground in the Vindhya range north of the Narbada Captain Wilmer and Lieutenant Gore, in 1876, rendered very efficient service to Captain Riddell, the leader of the party In 1877 Captain Riddell was transferred to head-quarters, as an Assistant Surveyor General in charge of the mathematical instrument workshop

In 1871, the sixth party, under Captain Strahan, was at work along the eastern flank of the Araváli range in Rajputana, but in the following year the pressing demands of the Bengal Government necessitated its removal to the hill tracts of Assam and Munipur One division, under Captain Badgley, undertook the work in Tipperah and the Cachar and Lushai hills, Mr Cook was in northern Chittagong, and Lieutenant Woodthorpe in the Garo hills The object of the Bengal Government was the demarcation and survey of the portion of the Naga hills, contiguous with the Munipur native state boundary, and the exploration of the extreme frontier along the Patkoi range as far eastward as could be reached In 1871, the party was employed with the expeditionary force in the Lushai and North Chittagong hills Major Macdonald with Captain Tanner, Mr Clifford Barrett, and Mr Gordon Cooke, accompanied the southern column from Chittagong This party succeeded in establishing a series of 27 secondary triangles emanating from a base of the Eastern Frontier Series of the Great Trigonometrical Survey, and 76 minor triangles It established 40 well defined points, and its work covers an area of 2,300 square miles of country, never before laid down, or even attempted to be painted The mountain ranges and water system were sketched in from the Kurnafuli river to the valley of the Koladin in the extreme east Unfortunately, although the two columns of the Lushai expedition approached each other very closely, a junction was not actually formed It is hoped that improved relations with the hill tribes will hereafter enable the department to fill up this and other gaps which still disfigure the map of India The northern column, starting from Cachar, was accompanied by Captain Badgley in charge of the surveying party, assisted by Lieut Woodthorpe, Mr E V Leach, Mr Ogle Mr Robert, and Mr McCay The triangulation of this party emanates from a side of the Cachar Secondary Series of the Great Trigonometrical Survey, and extends for 25 miles, in a S E direction, into the Lushai country Thence a route survey of 191 miles formed, with the triangulation, a connected basis for the delineation of 4,800 miles of entirely new topography The party was within 40 miles of Major Macdonald's party which accompanied the southern column The officers of both parties have given very interesting descriptions of this new country, and of the manners and customs of the wild tribes which inhabit it Lieut Woodthorpe published a narrative of the proceedings of the left column of the Lushai expedition [1] His opening chapters contain a summary of the events which led to the expedition, and some particulars respecting the physical and intellectual characteristics of the Lushais, their villages, customs, and wasteful method of cultivation by jungle clearances The rest of the work consists of a narrative of the march, with various incidents and adventures, and accounts of the skirmishes with the hill men The book is illustrated by two sketches and a map, showing only the route of the left column, and not covering sufficient ground to give a notion of the general plan of the campaign Captain Tanner also wrote an account of the work of the right column, containing graphic descriptions of scenery, and interesting ethnological details A new general map of the entire frontier, showing all these recent additions, is in course of preparation In 1873 the work was under the superintendence of Captain Godwin Austen, and the reports of the officers comprising this party, threw much light on previously unexplored and unknown regions, and are extremely interesting In 1874–75 three detachments of No 6 Party were formed with the objects of continuing the exploration of the eastern Naga hills, of completing the central portion of those hills, and of filling up the blank (western) part of the Manipur Native State All these objects were attained, a considerable portion of the country visited and mapped being entirely unknown All the detachments had many and great

[1] "The Lushai Expedition, 1871–1872," by R G Woodthorpe, Lieutenant Royal Engineers (Hurst and Blackett, 1873)

privations to undergo from bad and insufficient food, fever, and exposure in low pestiferous valleys and the snow-covered eastern Nagas.

In 1875 Major Godwin Austen accompanied the Duffla military expedition against the tribes on the northern frontier of Assam. Narainpur, on the Dikrung Nullah, was reached on the 2nd December 1874, and from a base on the banks of the Brahmaputra a short series of triangles was extended northward into the Duffla hills. Owing to the brief period during which the military were in the country, the survey party were unable to remain beyond two and a half months. The out-turn of work amounted to 1,705 square miles of entirely new topography, on the scales of two and four inches to the mile. A map on the latter scale, showing the results of the season's work in the Duffla hills, has been compiled by Major Godwin Austen, and is a valuable addition to our geographical knowledge of the region beyond the northern frontier of Assam. Lieut. Harman, R.E., rendered assistance by surveying the course of the Ranga river, and Mr. Lister, of the Royal Botanical Gardens, Calcutta, was assiduous in making a collection of plants, seeds, and dried botanical specimens. The Surveyor-General expresses a hope that these explorations on the Northern Assam frontier will be continued, and is of opinion that with tact and precaution all difficulties in the way of visiting and exploring the narrow strip of hills between the Assam valley and Tibet may be overcome.

Meanwhile, Captain Badgley and Lieut. Woodthorpe were employed in the eastern Nagas, south of the Sibsagar district.

Captain Badgley was enabled to carry his triangulation from a side of the Assam Valley Series of the Great Trigonometrical Survey, to work into the hills immediately to the south and east, with a view to obtain a good basis for the topography, and to establish a connexion with the work executed by Captain Samuells of the Revenue Survey during a previous season in the South Lakhimpur hills east of the Dihing river. This he succeeded in doing, and had secured 792 square miles of triangulation and 657 square miles of topography up to February 2nd, 1875, when the party was suddenly attacked by Nagas from the villages of Sanna and Ninn, assisted by others from the village of Noka, who entered the camp very early in the morning under the pretence of furnishing supplies, and treacherously murdered Lieut. Holcombe, Political Officer, and 80 natives, besides severely wounding, in the space of a few minutes, Captain Badgley and 51 men, of whom some died afterwards It was entirely due to Captain Badgley's fortitude and presence of mind under very trying circumstances, and while suffering from serious flesh wounds received in personal combat with several Nagas, two of whom he killed, that the remnant of the party, carrying the dying and the wounded, were extricated from these hills and brought safely to the station of Jaipur, where medical aid was obtained on the 7th of February Captain Badgley, though unable to take any further part in the field, recovered sufficiently to resume his duties at Shillong by the time the party went there for the recess

The detachment under Lieut Woodthorpe entered the Naga hills, south of Golaghat, and proceeded into the interior, accompanied by Captain Butler, Political Agent They had barely begun work when they were attacked by natives from the large Naga village of Wokha These, however, they defeated, and by this stroke an excellent moral effect was produced on the surrounding Naga villagers, most of whom then sent in friendly deputations After this, work was continued in a north easterly direction along the outer ranges of the Naga hills, so as to join Captain Badgley's work, and complete what remained further south up to the Patkoi range Owing, however, to the disaster which had befallen Captain Badgley's party, survey work was closed on this side, and Lieut Woodthorpe and Mr McCay joined the punitive expedition against the Eastern Nagas, and, besides accomplishing a fair amount of topography, a good junction was established with Captain Samuell's work on the east, and the whole length of the outer and middle ranges south of district Sibsagar and part of Lakhimpur, or about 150 miles in length by 25 to 30 miles in breadth, was surveyed The area surveyed by the detachment was 1,507 square miles on ½-inch and 1,075 square miles on the ¼ inch scales The season's total out turn amounts to 792 square miles of triangulation and 3,239 square miles of topography, or, omitting overlaps and margins, 2,164 square miles of actually new area surveyed

A very interesting account of the Naga hills and the inhabitants is given in the narratives by Captain Badgley and Lieut Woodthorpe, which are inserted in the appendices to Colonel Thuillier's report

In 1875–76 Captain Badgley undertook the boundary surveys between the Gáro and Khásia hill districts and the plains of Assam, on a scale of two inches to the mile, while Lieut Woodthorpe continued the exploration of the eastern Nagas south of Sibságar, and established a good junction with the work of the previous season In 1877 the boundaries between the Khásia hill and the Kamrup district, and between the Khásia and Garo hills were taken in hand, and Lieut Woodthorpe has explored as much of the country as he could reach, to the east and south of Saduja, working in concert with Lieut Harman of the Great Trigonometrical Survey

The seventh party was under Captain Strahan in 1872–73, and was at work in Rajpútana, executing a topographical survey of the States of Marwar and Shahpura, and the southern portion of Mairwara In 1874 the party extended its triangulation through portions of Ajmir, Jodhpur, and Jaipur, a region consisting of plains studded with sand hills In 1876 the work was entirely in the Jodhpur or Marwar State, and the party was under Lieut Leach During 1875, before taking the field, the party completed a survey of the environs of Simla on the east side, for the use of the Water Supply Committee The rest of the Rajputana Survey, being mostly over a desert, will be on a reduced scale of two miles to the inch

In 1874 the Government of India ordered that immediate steps should be taken to commence a professional topographical survey of the Mysor State, estimated to contain 27,004 square miles Arrangements were at once made with the object of starting the necessary skeleton triangulation as a basis for the topography Two small parties were organized under Captain George Strahan, R E, and Captain J R McCullagh, to be paid for out of the revenues of Mysor, and were deputed to Bangalore fully equipped The scale of 1 mile to the inch has been adopted for this survey, being the same as that of other Native States Captain G Strahan has taken the Nundydrug and Ashtagram divisions, and made good progress in the first season, but he was much retarded in 1876 and 1877 by the famine which prevailed in Mysor The Nagar division of Mysor was allotted to Captain MacCullagh, who was also sadly hindered in his work by the distress of the country

A large office establishment is required for the reduction, compilation, and publication of such a mass of geographical materials, and in its efficient management the great talent for organization which distinguishes Colonel Thuillier has perhaps been most conspicuously displayed Certainly it is in the system by which he year by year extends and increases the general usefulness of the surveys, by making their results rapidly and easily accessible, that his services have borne most fruit.

In the Surveyor General's Office at Calcutta there is a drawing and compiling, a lithographic, and a photographic branch. The publishing branch may be said to have been completely formed by Colonel Thuillier. Originally there was only one small lithographic press, but during the term of Colonel Thuillier's tenure of office the establishment has been gradually increased, until now the printing branch has 20 presses continually at work, besides three small type presses for departmental forms. In addition to the map printing, all kinds of work are executed, as the different Government departments indent on the Surveyor General's Office to print any diagrams, sketches, or illustrations that they may require to accompany reports. It is worthy of remark that the first postage stamps ever used in India were lithographed at the Surveyor General's Office. Until within the last few years all the maps of the Indian Survey (with the exception of the Atlas sheets) were put on to stone by hand drawing on transfer paper, a very laborious process, and very liable to error, particularly when executed by natives who cannot read English, and who simply copy what they do not understand. The climate of Calcutta also militates very much against the successful transfer from paper to stone. Latterly natives, who have acquired a small knowledge of English, have been easily attainable, and apprentices have been carefully trained to write on stone, and thus better and more certain results are obtained.

The greatest advance of all was the introduction of photo zincography into the office. The credit of having first introduced the process into India is due to Mr Hennessey of the Great Trigonometrical Survey, and the first photo zincograph was executed by himself in the office of the Superintendent at Dehra Dun. Before Mr Hennessey's return to India in 1865 maps had been copied by photography both in the office at Calcutta and in that at Dehra Dun. Colonel Thuillier had two serjeants employed in his office, who were sent out, after receiving instruction in photo zincography at the Ordnance Survey office at Southampton, but their attempts were not very satisfactory. Photo zincography cannot be said to have been fairly introduced into Calcutta until 1866, when survey officers, who had been trained in the process under Mr Hennessey, were available to take charge of this branch. Since that year progress has been steadily made, the establishment has been enlarged, and the out turn of work, already enormous, is yearly increasing It must be remembered that the great demand in India is not for highly finished, but for rough accurate maps, published as soon after survey as possible By means of photo zincography the results of the surveys are immediately made available for general use Captain Melville and Lieutenant Waterhouse ably superintended this department,[1] and during the year 1868–69 as many as 44,092 copies of maps were struck off In the same year 97,647 were lithographed, so that the total out turn amounted to 141,739 maps The demand, both from official[2] and general sources, is in proportion to the supply, and these branches are not only self-paying but remunerative The value of the work turned out by the litho and photo zincographic branches very considerably exceeds the cost of the working expenses In 1875 as many as 1,856 original subjects were reproduced by photography, and transferred to zinc or stone, and 142,371 copies of maps and plans were struck off, and in 1876 the number of copies produced was 156,969 This great increase was chiefly due to the cadastral survey plans of the North-West Provinces There is also much work of all kinds done by the lithographic branch, including colour and tint printings for cholera, forest, and geological maps

In 1869 the engraving of most of the remaining sheets of the Indian Atlas was transferred to Calcutta, Colonel Thuillier having engaged a staff of engravers while he was in England, with Mr Coard, an experienced engraver, as superintendent of this branch In 1870 the first quarter sheets of the Indian Atlas engraved in India (No 87 S W Lucknow, and No 125 S E Sylhet) were issued The style of the work was all that could be desired, and reflected great credit on Mr Coard and his staff Mr Coard devoted much attention to the training of native apprentices in the art of copper engraving, and with much success The progress of the engraving has since been very satisfactory, and in 1876 no less than 123 plates were in the hands of the engravers, comprising sheets of the Atlas and miscellaneous maps The great difficulty is to obtain competent hill etchers, but native apprentices at this work are steadily improving under the able tuition of Mr Coard The European staff of engravers is 10 in number, under whom there are 25 native

[1] See "Report on the Cartographic Applications of Photography, and notes on the European and Indian Surveys," by Lieutenant J Waterhouse, R A (Calcutta, 1870)
[2] 21,848 maps supplied

apprentices, many of whom are already able to complete outlines and letterings in a creditable manner

The Surveyor General also issues valuable maps which are compiled and executed at the head-quarter s office Among these is a useful and valuable map of India on a scale of 64 miles to the inch in two sheets engraved on copper and transferred to stone, which was completed in 1877, and which will also be utilized for the geological map of India Colonel Thuillier is also preparing a general map of India in six sheets, on a scale of 32 miles to the inch engraved on copper, with which good progress is being made , and a new edition of a hand map of India on a scale of 128 miles to an inch, with the hills etched on copper, is issued periodically Among other maps are one of Bengal, Bahar, and Orissa, and another of Assam on a scale of 16 miles to the inch , a new map of Sind , another of Oudh complete with hills , one of Baluchistan , divisional maps, and a complete series of provincial maps to illustrate Aitchison's treaties The department, during 1875–76, issued 25,294 maps for official purposes, 2,870 were sent home to the Geographical Department of the India Office, and 5,278 were supplied to the public

The topographical surveys under Colonel Thuillier's superintendence have very materially helped towards the completion of our knowledge of the physical geography of vast tracts of India, the work being chiefly over mountainous and forest-clad regions, or over sandy deserts, frequently in parts never before visited by Europeans Colonel Thuillier truly says, that for frontier expeditions and wild tract of country, the Indian Topographical Survey method of surveying by theodolite and plane table based on the great and minor triangulations cannot be excelled for general accuracy, rapidity, and cheapness, if the agency employed is well trained and trustworthy The cost of the Topographical Surveys for one year (1875–76) was 38,633*l* , or 2*l* per square mile These surveys, on a scale of one inch to a mile, are urgently required for engineering, military, administrative, and geographical purposes, and there is at least ten years' work remaining for seven complete parties

There is also a vast field for future work in India, in the North West Provinces, in Madras, and in Bombay , besides that of parties still progressing in Central India and Assam Yet year by year a good out turn of work is produced , the system is admirable, and ere many decades have passed the whole structure of accurate triangulation will be clothed with useful and reliable topographical detail

The history of Colonel Thuillier's work is to be found in his own annual reports from 1854–55 to 1875–76 inclusive [1]

Colonel Thuillier retired from the office of Surveyor General at the end of the year 1877

[1] *See also* "Selections from the Records of the Government of India (Home Department)," No LXXIV (1869)

## XII

## THE REVENUE SURVEYS OF INDIA

THE Revenue Surveys of India are one of the bases on which the whole fiscal administration of the country rests. By their means the wealth of the various provinces is ascertained, as well as their food producing capabilities, and their power to bear taxation. The surveys furnish the information comprised in agricultural statistics, without which the statesman is deprived of the knowledge enabling him to improve the condition of the people, to increase their means of subsistence, to avert famines, to add to the wealth of the country, and to adjust taxation.

Revenue Surveys have, unfortunately, been conducted on different principles in various parts of India. The idéal survey, while furnishing complete information for settlement purposes, should be executed throughout on accurate principles, and supply materials for compiling maps for general use. Such a system has always been advocated by Colonel Thuillier; but in the Madras Presidency alone has any approach to a compliance with all the demands been effected. The Madras Revenue Survey must therefore be considered as, on the whole, the best in India. The Bombay Survey is admirable, and perhaps the best for fiscal purposes; but it is of less use, so far as the supply of materials for general maps is concerned. In the North West Provinces the surveys for the first settlement were very roughly executed, but there has since been a great improvement. In the Punjab, although there is a professional survey for the boundaries of villages and topographical features, a less accurate native system is in force for field measurements, which also unnecessarily goes over work done by the professional surveyor.

Since the appointment of Colonel Thuillier in 1847 the Revenue Surveys under his charge have been thoroughly well done, and there are excellent surveys of the Punjáb, Oudh, Sind, the Lower Provinces, and of all the districts included in the operations of his parties. But unfortunately the surveys of the North West Provinces were executed before his time. It will be remembered that, at the conference of surveyors held at Allahabad in 1834,[1] it was resolved to sacrifice everything to cheapness and rapidity of execution. The consequences of this resolution have been most disastrous. The surveys of the North West Provinces were made at a galloping rate each season, owing to the pressure of the revenue officers, who wanted to complete the settlement. The result was, that the maps were the merest and most inaccurate skeletons, while topographical details were altogether omitted. The surveys were confined to the actual definition of village boundaries, and the work on opposite sides of a river was never even connected. As geographical material they are perfectly useless. These were the materials from which the geographical maps on a scale of four miles to the inch were lithographed at Allahabad, after having been reduced by native draftsmen. They have no trigonometrical points, and no basis of any kind; yet from these maps the sheets of the Indian Atlas have been filled up.

Most of the original village plans, bound up in folio volumes, were destroyed in the mutinies; but those of twelve districts were saved, and deposited in the Surveyor General's Office at Calcutta.

When the time arrived for a second settlement of the North West Provinces the local Government proposed to dispense with a proper survey, because they thought that the *khusra* or measurement of fields by a native *amin* was so accurate that nothing more was required; and that if anything further was wanted for geographical purposes, a bare survey like that made in the native states would suffice. Thus we were threatened with a repetition of the lamentable and short sighted mistake that was made 30 years ago.

In reality the *khusra* measurements, however carefully made, having no basis or fixed points, must necessarily have an ever accumulating error. In the Revenue Survey the maximum error allowed is half an acre per cent, and that is considered bad work; while the *khusra* error, when unchecked, is from 3 to 7 per cent. The regular surveys check the gross village areas, and furnish reliable village maps on a scale of four inches, and district and pergunnah maps of one inch to the mile. Is is most surprising that such a proposal as to dispense with accurate surveys should have been made in these days, when it is well known that it would be ridiculous to attempt to use the old revenue skeleton maps of the North West Provinces as a basis on which to work for preparing any engineering project, or indeed for any useful purpose.

[1] See pages 97 and 98.

The year 1871–72 inaugurated the system of cadastral field surveys on accurate principles[1] They were commenced in the districts of Mattra and Muradabad, in the North West Provinces The work is most intricate, and Colonel Gastrell, the Superintendent of the Revenue Surveys (Upper Circle), reported that great credit was due to Colonel Anderson and Major Vanrenen, who commenced the operations in the Mattra and Muradabad districts, for the completeness of the work in every respect More permanent survey marks were needed to make this cadastral survey complete and efficient in every respect There were masonry marks erected at triple

[1] In a letter from the Secretary to the Government of the North West Provinces to the Secretary to the Government of India (No 2272 A, Dec 23, 1872) attention is invited to a passage at page 28 of my "Abstract of the Reports of the Surveys, &c (for 1870–71), which is said to contain erroneous statements "not in accordance with facts"

The remarks in question are —

1 That the first Revenue Survey of the North West Provinces was executed by professional surveyors

2 That this vital principle has since been set aside

3 That the return to the old and more accurate system is quite in accordance with the views of Mr Thomason

There is nothing in the Secretary's letter which contradicts the two first of these remarks, the correctness of which can scarcely be disputed The first survey was undoubtedly executed by professional surveyors, although it is true that, owing to the extraordinary haste with which the work was pushed forward (3,000 square miles each season), the topography was omitted, and the resulting maps were all but useless for any purpose but the settlement They were used for the Atlas of India, but the sheets which were constructed from such materials are incorrect and require revision

The second remark, that the vital principle of making the Surveys by professional agency has been set aside, is strictly accurate, although a correct system has recently been adopted in Mattra, Murádabad, Agra, and Humirpur

The third remark is based on several passages in Mr Thomason's directions for settlement officers In paragraph 30 he says, "The scientific survey is of great value as a check upon the Ameens,' although he adds that the giving of topographical information is a secondary consideration He also refers to the Scientific Survey at paragraphs 25 and 27, and to the principle laid down by him of "simultaneous procedure between the professional survey and khusreh" These passages prove that an accurate system was in accordance with the views of Mr Thomason, and a reference to paragraph 30 of Mr Thomason's directions, as well as to paragraph 29, will show that the remark at page 28 of the "Abstract" for 1870–71 is quite in accordance with facts Mr Thomason's views are also referred to by Colonel Thuillier, in a letter dated Feb 12th, 1870, No 229, paragraph 9

Mr Thomason did not put so high a value upon a correct survey, and upon the importance of combining settlement work with the preparation of maps for general administrative purposes as is done at the present day Thirty years ago such maps were not so urgently needed in every department of the government But he considered the Scientific Survey to be of great value as a check, and its operations are, therefore, quite in accordance with his views

junctions of villages, which were used as theodolite stations, and plotted down on the village maps But these alone are not sufficient to enable additions to be made to maps hereafter, without unnecessary labour and expense, and it was proposed to have the nearest survey station, right or left of the triple junction, permanently marked, so as to give a good and reliable base line, from which any new measurement can at once be laid off The Cadastral Surveys are on a scale of 16 inches to a mile, and Colonel Thuillier anticipates the very best results from these operations, both financially and professionally, as regards systematic and accurate measurement, with permanent recordings of the maps of "fields" and ascertainment of true areas "Eventually," he continues, "I believe they will prove not only invaluable as a correct
" permanent record of the landed tenures for all purposes of revenue
" assessment, but an immense saving of expense will be effected
" in the end, by doing away with the constant necessity for partial
" remeasurements for irrigation, canals, railways, roads, and other
" purposes, which are now perpetually being made in an irregular,
" unsatisfactory, and expensive manner, for emergent engineering
" objects" Besides Mattra and Murádabad, Revenue Surveys on
" accurate principles, on the scale of 16 inches to the mile, were
" commenced in Agra and Hamirpur

So that in 1873 there were four cadastral surveys at work in the North-West Provinces, in Murádabad, Mattra, Agra, and Hamirpur The size of the fields is very small, averaging 0 94 of an acre, and the enormous number of 1,269,882 fields were surveyed and computed in area by the four parties during one year Colonel Gastrell introduced several processes by which the labour of mapping was reduced to a minimum, and Government will be supplied with copies of the cadastral field maps for from $3\frac{1}{4}$ to $4\frac{1}{2}$ annas per imperial sheet, containing 1,250 acres The cost per acre, which averaged five annas in 1871–72, has been brought down to three annas one pie The working of the cadastral system has been placed on a thoroughly durable and satisfactory basis, and the immense advantage of accurate cadastral surveys is not confined to the questions relating to the settlement of the land revenue They are also useful for railway purposes The officers in charge of the cadastral surveys of Murádabad and Mattra supplied working ground plans for the extension of the Rohilkand railways towards Rani Khet and Naini Tal This is a great saving in time and expense of special survey, enabling the engineers to mark out their lines at once, and the civil officers to settle compensation due to proprietors for land to be taken up for the railways

The cadastral survey of Murádabad was commenced under Major Vanrenen in November 1872, the area comprising 731 villages, 376,191 acres and 348,523 fields The field survey of every village was carefully checked by lines run across each, and a certain percentage of villages was further tested by the Deputy Superintendent himself The work is connected with the stations of the Great Trigonometrical Survey

In 1876 the Murádabad Survey was in charge of Captain Barron During 1875–76 he surveyed (on a scale of 16 inches to the mile) 385 villages and 160,269 fields covering an area of 329 8 square miles, and laid down 19,987 government marks, including masonry platforms at the triple junctions of villages The Murádabad Survey was completed in 1877, and the party commenced the Badaon district Colonel Anderson, in charge of the Mattra and Banda Surveys, completed 732 square miles in 1875–76, and Mr E T S Johnson completed the survey of the Agra district The Hamirpur district was also completed in 1876

The first revenue survey of the Punjab was organized soon after the annexation of the country, and was conducted by the settlement officers with the aid of native village officers The *hudbust* is the outline sketch of the village boundaries The Pátwari, who in the Punjáb took the place of the Hindustani Amin, was in 1852 supplied with instruments with a view to his making a native *hudbust* map, which was to be nearly equal to that of the professional surveyors [1] Mr Barnes thus describes these instruments The first and principal instrument was a horizontal board screwed to a shaft, shod with an iron point The board was about 18 inches square, and over it was stretched a piece of paper, on which the village outlines were delineated To this board was fixed a *quiblanumah*, or rough compass, used by the Muhammadans to denote the west, which would cost one rupee in the bazars The surface of the board was adjusted by this *quiblanumah*, and the entire periphery of the board was graduated like the card of a compass This board and the *quiblanumah*, together with an iron ruler, formed the surveying equipment of the Pátwari The ruler was graduated, each division representing 10 *kurrums*, or 50 feet, and it was fitted with a per

[1] "Selections,' Punjab, Vol i, p 128 Letter from George C Barnes, Esq, 13th December 1852

pendicular sight at each end, through which the position of an object was observed [1]

The Patwari began work at a *trihudda*,[2] or triple junction pillar, by adjusting his board by the compass, "at some assumed and con-
"venient portion of the paper" He then "takes the bearing of the
"next pillar, through the perpendicular sights attached to the ruler,
"and measuring the distance with the chain, reduces the measure-
"ment according to the graduated scale on the same ruler, and
"draws a straight line to correspond, both in distance and bearing,
"on the paper In this manner he goes round the area of the
"whole village, correcting his measurements and angles by the
"scale and compass Moreover, from each *trihudda* he takes the
"bearing and draws a line in the direction of the village site, and
"wherever these various lines intersect each other, the village
"site is duly marked upon the sketch The total cost of the
"instruments is 1 rupee 12 annas"[3]

Such was the Patwari system of surveying in the Punjáb There was no actual observation of bearings, as all directions were laid off by the ruler The compass bearings were not corrected for variation, while the iron rulers must have made a farther large correction necessary, which was not applied The compasses must really have been utterly useless Moreover, no record of the distances appears to have been entered, so that it was impossible to check the work, by plotting the true bearings and distances independently An error of 8 to 10 per cent was allowed before any revision was ordered [4] Such a survey would furnish but a very rough and unreliable measurement for fiscal purposes

A professional survey, working independently of the Patwaris, fixed the boundaries of villages and inserted interior details, thus furnishing a partial check, but did not measure the fields

Since the revised settlements were taken up in the Punjáb in 1863, a great advance is reported to have been made in the native system of conducting a cadastral survey of fields, and more accurate results have been attained, both in the measurements and in the maps The *quiblanumah* is no longer used, but simply the plane table Triangulation is often adopted to form the skeleton map, and

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1 "Selections," Punjab, Vol i, p 129–130

2 Where the boundaries of three villages unite

3 "Selections," Punjab, Vol i, p 180

4 Ibid, p 139 Letter from Mr Temple to Mr Barnes, September 25th, 1852

within it small sections of country are marked off, and field by field measurement carried on, the work being tested as it proceeds The positions of the chief physical features are fixed by running lines to the boundary, so as to form triangles, with which the fields are plotted Dimensions of the fields are put on the map round each field, and are again checked by the chain and plane table These are certainly great improvements The assessment is based upon the aggregate areas, after checking each village with the results of the professional survey

The arguments for continuing the native survey in the Punjáb, side by side with the professional survey, instead of combining them in one accurate system, are, that "all the local aspects must be "brought to book, as well as the professional work, that the survey "must be based on a careful understanding of local requirements, "tenures, and modes of dividing land, and that physical features "must not only serve to indicate what is seen with the eye, but also "what the settlement officer knows to be wanted for administrative "purposes"

These considerations only show the necessity for the revenue and survey officers being in perfect accord and working together, but, this being the case they supply no argument for a professional survey side by side with a native and less accurate system If, for example, the village boundaries are accurately laid down by professional surveyors, there can be no good reason for the same work being also done less accurately by natives It is admitted that if professional officers supervised the field surveys they would make them more perfect, and that those surveys are not now as correct as they might be It must, therefore, also be admitted that a system by which the survey and revenue officers work together, and which is conducted on correct principles in every detail, in the field measurements as well as in the village boundaries, with a complete series of tests, is superior to a mixed native and professional system Revision was not enforced in the Punjáb Patwaris system until the error had reached to 8 or 10 per cent, now, an error of 5 per cent is allowed

The professional surveyors, in the Punjáb, fix the boundaries of villages, and insert topographical details

The survey of the Peshawur District was commenced in 1863–64, and was resumed by Colonel Johnstone in 1870 Some work was done beyond the British frontier, the Kohat pass was explored, and errors were discovered in the old maps, notably one in the course of the Kabul river. Colonel Johnstone got on very well with the wild robber tribes, and he tells rather a good story of one of them who chanced to see his crest, the "flying spur." The Afridi asked its meaning, and was told that, in former days, men in Scotland were as lawless as the Afridis, and that when the larder was empty, a dish was put before the chief, containing only a spur with a pair of feathers fastened to it, being a signal to him and his followers to boot and spur, and be off to raid the cattle over the border, and that the "flying spur" then became the badge worn by the clan. The hearts of the frontier Afridis warmed to the Colonel, when they found he was the descendant of the British Afridi.

In 1875 Colonel H. C. Johnstone was in charge of a party in the Dera Ismail Khan district and Bannu, where, as a rule, the settlement maps (*thakbust*) agreed well with the professionally surveyed boundaries. Captain Wilkins was at work in the Delhi, Rohtak, and Gurgaon districts, and Captain D. C. Andrew, completed the survey of the native state of Bhawalpur, which covers an area of 17,285 square miles, 5,082 being cultivable, and 12,203 desert.

The Revenue Surveys, under the Government of India, are divided into the Upper and Lower Circles. The Upper Circle comprises the Punjáb, the North West Provinces, Oudh and Sind. The Lower Circle includes Bahar, Bengal, Orissa, Assam, and British Burmah.

In the Lower Circle the cadastral survey of the Shahabad district in Bahar, in connexion with the western Sone Irrigation Works, was placed under Colonel Oakes in 1875, who was relieved by Major Sconce in 1876. (It is on a scale of 32 inches, the fields averaging only 0.273 of an acre.) Major Sconce had previously conducted the Midnapur survey, and has written a very interesting report on the rivers and embankments of that district. He was relieved by Mr. Kelly in March 1876, who was succeeded by Mr. W. Lane in the following year. The party, under Mr. Johnson, having completed the Agra district, was diverted to Bengal to undertake a cadastral survey of the district of Patna and Gaya, to meet the requirements of the Irrigation Department with reference to the Eastern Sone Works. The total area is 680 square miles, and

[1] Captain Andrew prepared a statistical and geographical report on the Bhawalpur State.

the scale 32 inches to a mile In 1876 revenue parties were also employed on the cadastral survey of the Government estates of Khurdwah in the Puri district, and of Dhanwar in Hazaribagh, on the survey of waste land grants and rent free lands in the districts of Darrang and Kamrup in Assam, and on that of the Oudh and Nepal boundary, besides two parties employed in the Bombay Presidency on topographical work in the Deccan

Thus there were 17 revenue survey parties employed in 1876 under the Government of India They completed 11,175 square miles of country, 599 on a scale of 32, 1,713 on a scale of 16, 5,245 on a scale of 4, and 3,618 on a scale of 2 miles to an inch In addition to this, much preliminary work was done in preparation for detail surveys in 1876–77, but, owing to orders from the Supreme Government, the number of parties has been reduced to 11 Good progress has been made by Colonel Vanrenen, who succeeded Colonel Gastrell as Superintendent of Revenue Surveys in 1875, in the publication of the cadastral maps 1,901 sheets have been published of the cadastral surveys in the North-West Provinces, and 12,061 remain to be published

The subject of a Revenue Survey of the Madras Presidency, with a new assessment of the land, had engaged the attention of the local Government for upwards of ten years, but it was not until the end of the year 1855 that they submitted the final result of their deliberations to the Court of Directors and the Government of India for approval At that time no regular survey had ever been made, and in many districts the land revenue demand was based merely on the unchecked statements of the curnums The object of the survey was to correct the measurements of superficial areas, and to ensure a fair and just assessment on each description of land, by a classification of the different fields in each village

But the Board of Revenue at Madras were at first disinclined or at least indifferent to the geographical aspect of the question, and objected to the survey being conducted in connexion with Colonel Lambton's triangulation They urged that they only required field maps for fiscal purposes, and that geodesical operations would cause extra expense and delay, which they strongly deprecated Major Thuillier, on the other hand, in a letter dated May 6th, 1857, represented that no general survey of the Madras Presidency ought to be commenced without full and ample precautions being taken for making the materials subservient to the general purposes of geography At the same time he showed that the utmost facilities existed for connecting the Revenue Survey operations with the trigonometrical points of Colonel Lambton

Fortunately, Colonel Thuillier's opinion prevailed, the Court of Directors approved of the arrangements on December 17th, 1856, and on August 18th, 1857, Captain Priestley, of the 74th Highlanders, was appointed Superintendent of the Madras Revenue Survey This officer had entered the service in 1838, and became a captain in 1853 He had already acquired considerable experience, and had been conducting an experimental survey in South Arcot since 1854

The area to be surveyed was assumed at 60,000 square miles or 38 million acres, and it was originally expected that the survey would cost Rs 38,40,000, and be completed in 14 years The survey is conducted on an English and not on an inaccurate native method, such as the *khusra* of Bengal, and it is designed to show all the principal variations in the surface of the soil, such as hills, jungles, woods, channels, tanks, topes, houses, cultivated and cultivable land, whether *nanjai* (irrigated) or *punjai* (unirrigated), and the area of each field The village maps are on a scale of 16 inches to the mile, the taluk maps one inch to the mile, and it was intended that, from these materials, district maps should have been compiled on a scale of half an inch to the mile The work is connected with the Great Trigonometrical Survey by the following method The first operation is the identification of the Great Trigonometrical Survey stations From one of these the traverse work commences, and runs along a village or taluk boundary until it reaches a convenient point to connect it with another trigonometrical station These traverses embrace circuits of from 50 to 100 square miles The bearing of station lines is ascertained at intervals by astronomical observations, and the traverses are corrected by comparison with the sides of the Great Trigonometrical Survey triangles, the errors being proportionately distributed Thus corrected, the work of the Madras Revenue Survey adapts itself exactly to Lambton's triangulation At every tri junction point the boundaries of villages are marked by masonry pillars, two feet square and three feet high

Captain Priestley commenced work with an establishment consisting of 18 surveyors and deputy surveyors, 30 survey amins, 30 gomastahs, 20 draftsmen and computers, 77 peons and measurers, and 19 station markers, at an annual cost of Rs 31,338 Mr Newill was appointed superintendent of the new assessment, and the two officers worked in concert In 1857 two taluks, one in South

Arcot and the other in Trichinápalli, were surveyed In 1858 the survey was commenced in the Rájmahendri district, in 1859 Masulipatam was taken up, and in 1860 there were parties in Nellor, Trichinápalli, and Salem

In 1859 a survey was undertaken of the important coffee-growing district of Wynaad, under Lieutenant Hessey, who had been working with Captain Priestley since 1855, and had, by his untiring exertions, contributed much to the success of the experimental survey in South Arcot The main object of the Wynaad Survey was to define the boundaries of the coffee estates, and Lieutenant Hessey began it in the Nellurnaad Umshum near Manantawaddy, the principal station The district had been surveyed as a part of Malabar by Captain Ward in 1826,[1] who fixed 16 stations from those of Lambton's Triangulation, but the sites of villages and pagodas are said to have been very loosely laid down in Ward's survey Hessey commenced work in 1860, forming a system of secondary triangulation from Ward's points, and filling in the detail by the plane table.

A lithographic press, with a suitable staff, was established at Madras, under Mr Paczensky, for the publication of the taluk and village maps, and during 1859 the number printed was 145, comprising 4,495 copies The work of the Madras Revenue Survey, which has been conducted under the superintendence of Colonel Priestley from the first, is still progressing [2]

In 1851 and 1852 the Nilgiri and Kundah hills were surveyed, under the superintendence of Colonel Ouchterlony The map is in 16 sheets, on a scale of 1,000 feet to an inch, and is accompanied by a geographical and statistical memoir [3]

Up to the end of 1873–74 the revenue survey of * eight districts had been completed and the survey of †eight was in progress The completed area amounted to square miles 38,290 surveyed and plotted in fields on the scale of 5 chains = 1 inch The extent completed in the districts under survey was square miles 8,818 There were also square miles 4,296 of partly

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|---|---|
| * Tinnevelli | Nellor |
| Trichinapalli | Kurnul |
| Salem | Kistna |
| Chingalpat | Godavari |

| | |
|---|---|
| † Madura | North Arcot |
| Coimbator | Cuddapah |
| Nilgiris | Ballári |
| Malabar | Ganjam |

[1] See page 76

[2] For an account of the Madras Revenue Survey, see the voluminuous correspondence published in the Selections from the Records of the Madras Government, No LIII (1858) and No LXXIV (1863)

[3] Published in the "Madras Journal of Literature and Science,' XV. p 1 Also presented to Parliament

completed work in these eight districts. The extent of country topographically surveyed and mapped reached square miles 51,996 in 1874.

Deducting 360 square miles of special surveys, the cost of the 51,636 square miles of completed work, including the items only on which the original estimate was based, was Rs. 5,324,406 or (532,440*l.* 12*s.*) or $3\frac{3}{4}d.$ per acre. Including the various items which have from time to time been debited to survey by changes in the mode of preparing accounts, the cost came to Rs. 6,486,120 (648,612*l.*), or $4\frac{3}{4}d.$ per acre.

Nilgiri Hills
Shevaroy do.
Wynaad
Teak plantation in the Nellambur Valley
Madras Town

The excess of assessable area brought to light by the survey ranges from 2 to 23 per cent., the average being about 12 per cent. Of the 38,290 square miles, deducting 25 per cent. (an extremely liberal margin) for waste and unprofitable land, there remain 28,700 square miles which have been hitherto counted as only 25,600 for assessment purposes. Taking the average assessment of the Presidency at Rs. 1–14–0 or 3*s.* 9*d.* per acre, the addition of square miles 3,100 or 1,984,000 acres to the taxable area would represent an annual gain to the State of Rs. 37,20,000 or 372,000*l.*, supposing that it were taxed at the existing average rate.

The average size of survey fields is about two acres, and the approximate number measured and plotted in the eight completed districts is 7,000,000.

The reduction of the results of the Madras Survey to maps of convenient size has made some progress. But the truth is that Colonel Priestley and his staff have as much to do as they can possibly get through, and there is no machinery for utilizing their work for geographical purposes. There can now be no doubt that the abolition of the office of Deputy Surveyor General at Madras, in 1834, was a great mistake. The beautiful old Military Institute Maps of the early part of the century remain in manuscript. They were used for the sheets of the Indian Atlas, but have never been published on their own most useful scale of an inch to a mile. Since those maps were drawn, geographical interests have somewhat languished in the Madras Presidency. Yet a good deal has been done at various times. Colonel Scott, the Quartermaster General of the Madras army, compiled an excellent map of the Presidency on two sheets, on a scale of 24 miles to the inch, in 1863. Large maps of the Presidency on a scale of 8 miles to the inch, showing all the works of irrigation, finished and in progress, have been compiled for the Secretary of State, from information supplied by the superintending engineers, in 1860, 63, 64, and 69 In 1862 a map showing the extent of cotton cultivation, on a scale of 24 miles to the inch, was published to illustrate the official cotton hand-book Maps of the taluks have also been compiled from the old surveys on a scale of two miles to an inch, and published, but they are meagre, and contain few of the names given on the original maps A map of the Tanjor irrigation channels, of the Denkanikota range, showing the Salem forests, some road maps, and a few others, have also been engraved But much remains to be done

From the commencement of operations to 1874 the Madras Survey was connected with 264 Great Trigonometrical Survey stations The average error per mile shown by the test of comparing the distance obtained by the Madras Survey of a side of the G T S Triangulation with the G T S records is 7 61 feet

Photo-lithography has been employed for reduction and reproduction of maps since the beginning of 1873

Colonel Priestley has deposited a most interesting series of documents with the Geographical Department of the India Office, to illustrate all the different stages of the Madras Revenue Survey work For this purpose one village is taken, that of Vellappakkam, in the Ponneri taluk of the Chingalpat district, and the whole of its survey and demarcation records are given in regular order, from the original field books to the lithographed copy of the village map Then follow a specimen of a taluk map, of a topographical map, the demarcation and survey rules, and other documents They are deposited in a separate case, so that anyone can obtain a clear idea of the system by one or two hours study [1]

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[1] Village Map Records —

Land Register
Boundary and Khandam Circuit Field Book
Minor Circuit Field Book
Ameen s Sketches
Ameen s Field Book
Boundary Traverse
Khandam Traverses
Minor Circuit Traverses
Computation Papers
Area Lists
Manuscript Map showing process of plotting fields
Taluk Maps
Maps of Madras Town
Specimen Plane Table Square
Topographical Maps
Demarcation Rules
Survey Rules

Extract from Main and Village Traverses for Distances between G T Stations
Comparative Statement of Distances between G T and Revenue Surveys
Average cost of survey measurements per square mile
There is also an excellent Index Map of the Madras Revenue Survey, showing the areas completed, the areas in progress, the intermediate spaces topographically surveyed, and those not yet taken up

The Survey Department in the Madras Presidency was only brought to its present strength in 1865–66 It is composed of 3,377 persons, made up of 24 officers, half military, half civilians, 30 upper subordinates, 1,805 surveyors, clerks, and draughtsmen, and 1,518 servants (*i e*, chain and offsetmen, &c &c )

In 1875–6 out of 125,886 square miles in the Madras Presidency 40,407 had been completed as village maps on the 16 inch scale, and 3,655 were in progress Of the Zemindary and hilly tracts 17,393 square miles had been completed on scales of 4, 2, and 1 inch, and 1,480 were in progress, besides 3,000 topographically surveyed by a party from Bengal The total surveyed was thus 65,935 square miles, leaving 15,553 square miles of the Revenue, and 44,398 of the Topographical Survey to be completed As regards publication, 13,420 village maps, 75 taluk maps, and 7 district maps are already available The total expenditure in Madras, on surveys, was 71,824*l*

Colonel Priestley, who had conducted the Madras Revenue Survey since it was commenced in 1857, retired in July 1876 He was succeeded by his assistant, Major W H Hessey, who went home on sick leave in February 1877, when Major De Courcy Scott, R E, who had formerly been on the Ordnance Survey of England, took acting charge of the Department

The Bombay Revenue Survey is, perhaps, the best and most perfect for revenue purposes, and it has undoubtedly conferred enormous benefits on the people But it is not so useful for general purposes of mapping and geography, as the village maps are mere rough plans, and can with difficulty be made use of in the compilation of maps on convenient scales The careful elaboration of the original design of the Bombay system is due to Sir George Wingate, and his labours, extending from 1836 until he received the well earned recognition of his great services in 1866, resulted in the admirable system of administration which has proved so efficacious in promoting the revival of agriculture in the Presidency The operations of the Survey form the basis of the revenue administration The system is *ryotwar*, and the first object was to determine the size of the fields, and thus to form the unit or basis of the Survey, on which the cess should be placed The smallest amount of stock with which cultivation can be carried on is one pair of bullocks, the *minimum* area to be measured separately and to be constituted a "*number*," as it is called, was therefore fixed at what two bullocks could plough The *maximum* area to be measured and constituted a separate "*number*" must not exceed the means of the generality of ryots to cultivate, so that it may easily be made the subject of sale or transfer The *maximum* area was fixed at what four bullocks can plough Thus the Survey "*numbers*" were fixed at what one pair of bullocks could plough up to double that size This varies from 20 to 40 acres for dry crops to from 4 to 8 acres for rice cultivation

The first operation is for the settlement officer to settle disputes, and finally fix the village boundaries, which are marked by stone pillars A series of detached earthen mounds are raised to demarcate the limits of "*numbers*," and these plots of land are defined on the map by continuous black lines In order to facilitate the settlement of disputes, topographical features and permanent marks are noted, such as watersheds, nullahs, roads, temples, tanks, wells, fruit trees, and boundary pillars

The field operations of the village surveys are conducted by a European assistant and 20 native measurers The European makes no original survey himself, his duty being to supervise and test the work, which he does by going over 10 per cent of it, the errors allowed being 1 per cent for survey numbers of above 6 acres, 2 per cent when they are under 6 acres, and 3 per cent for small garden or rice numbers The instruments of the native measurer consist of a chain 33 feet long, in 16 links, a square chain being called a *goonta*, 40 of which go to an acre The areas are calculated in acres and *goontas* He also has a pair of compasses, and a diagonal scale showing chains and links (called *avnas*) A base line is measured from the boundary on one side of a village to the opposite one, and all the first numbers are measured along this base The plotting of the map on the base line is effected by the principle of the triangle, each number being broken up into internal triangles and trapezoids by chaining, and the scale is 8 or 16 inches to the mile, according to the average size of the survey numbers All the work in the field is finally entered and abstracted in a fair field book As soon as the surveying work is finished, the registers and documents embodying the results are sent to the classing branch, in which the relative value of the soil and water in each number has to be determined, with a view to fixing the assessment

The classing is a very complicated and elaborate system, and shows with what extreme care the true value of each field is ascertained Numerous considerations are brought into account, which are classed under three heads, namely, the distance from the village site, natural productive capability, and the nature of the water supply As regards productive capability, not only are the soils divided into black, brown, and gravelly, but the depth of the soils is also taken into consideration, and the land is thus divided into nine classes, from pure black deep soil to the poorest and thinnest gravelly soil More over, the land is also rated with reference to eight other considera tions called faults [1] Thus the elements for settling the value of a Survey number are, 1, convenience of position, 2, colour of soil, 3, depth of soil, 4, faults, 5, water supply, which again is divided into six classes [2] When the classing is completed the amount of the assessment is fixed, and it is another very complicated question to decide what can safely be taken by the State and still leave a sufficient surplus for the ryot, to render him capable of improving his circumstances and extending his cultivation This is done by examining the averages of former settlements, but many other con siderations come into the account, and the final result was generally a considerable reduction A new era of prosperity and progress was inaugurated by this admirable Survey, which, so far as the adminis trative results are concerned, is the best in India But the import ance of making the Survey available for general use in the compilation of maps was lost sight of, and the topographical sur veyors in Gujrât have found great difficulty in making use of the revenue village maps

A "Revenue Survey and Assessment Atlas of the Khandesh Collectorate" was published at Bombay in 1876, and it is much to be desired that a similar Atlas should be prepared for the other Collectorates of the Presidency The Khandesh Atlas consists of

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[1] The faults, which are noted by certain signs in the classer's field book, are—

1 Mixture of minute nodules of limestone
2 Mixture of sand
3 Sloping surface
4 Want of cohesion in the soil
5 Mixture impervious to water
6 Liability to be swept over by running water
7 Surface springs causing excess of water
8 Large limestone nodules

[2] The classes of water are—

1st From a good tank or river, with supply until April
2d Similar to the above, but land more elevated
3d Dependent partly on rains
4th Still more elevated land irrigated from a canal
5th The same as the 4th, but on which no after crop can be raised
6th Dependent wholly on rain

a general map of the Collectorate showing each taluk, accompanied by statistical tables giving the details of the surveyed area, of the settlement, of cultivation, of occupation and population, and of houses, wells, live stock, and agricultural implements Then follow maps of each taluk with similar tables

The Survey and Settlement of the Haidarabad Assigned Districts was commenced in 1860, and has been conducted on the Bombay system of measuring and classing The whole survey is now completed with the exception of the classification of the soil in 29 villages, and the assessment of 712 The Bombay system has also been adopted for the Mysor Revenue Survey

It will have been seen that the work of surveyors and that of settlement officers are very closely connected The first operation of all brings the settlement officer on the scene to arrange disputes and fix the village boundaries Then the surveyors step in and measure the ground, and afterwards the settlement officers again take up the work and classify and assess the fields or villages, as the case may be Hence it is essential that there should be complete agreement between the revenue and surveying officers, and that the latter should thoroughly understand the requirements of the settlement and all the details that should be recorded for fiscal purposes But there is no reason why this understanding should not exist, and why the excellent revenue system of classing and assessing, such as prevails in Bombay, should not co exist with a survey on rigorously exact principles, turning out village maps which would form materials for those geographical and general purposes, attention to which is also important and, indeed, essential to efficient administration

Colonel Laughton has now completed the survey of the town and island of Bombay It was commenced on the 1st of October 1865, and completed on the 23rd of November 1872, at a cost of 31,306*l* towards which the municipality contributed 5,000*l* , but allowing for the sale of maps, the actual outlay will only be 20,000*l*. The area surveyed is 22 square miles, 149 acres

The first regular survey of Bombay, for defining not only the boundaries of the Company's property, but also those of the holdings of the inhabitants and for specifying the nature of the tenures, was undertaken in 1811, and completed in 1827, under Captain Tate and Colonel Dickinson [1] The fort and old town were on a scale of 40 feet to an inch, and the remainder of the island partly on 100 and partly on 300 feet to an inch The cost was 16,300*l* The great changes in

[1] See page 82

the features of landed property since 1827, and the additions to the area of the island by reclamations of foreshores, necessitated new maps, and another survey of the island, in much greater detail, was consequently found to be urgently required The scales sanctioned were 100 feet to an inch for the fields and open country, and 40 feet to an inch for the fort and native town Captain Nasmyth, of the great Trigonometrical Survey of India, triangulated the island, and fixed a series of points as a basis for chain measurements, and Colonel Laughton undertook the detailed work of surveying each separate property The corners of properties were fixed by cast-iron marks The outlines of high water mark at spring tides and high-water mark at ordinary or neap tides have been carefully laid down all round the island Levels have been taken at every 300 feet along the principal roads, and all the hills have been carefully and accurately contoured to every 10 feet All the 172 sheets are of one universal size (3 feet by 2 feet), and everything is plotted up to the marginal lines, which are actually projected parallel to the lines of meridian and latitude Besides these sheets, which are on a very large scale, there is a reduced map of the island in two sheets, which are extremely useful It is on a scale of 400 feet to an inch, and the sheets are 6½ feet long by 6 feet broad

The Government of Bombay have ordered measures to be taken for the maintenance of the boundary marks, and a law will be enacted to ensure a recognition of the record that has been made of the several properties Much credit is due to Colonel Laughton for the accuracy and skill with which this difficult and important survey has been executed

# XIII

## SUPPLY OF INSTRUMENTS FOR THE INDIAN SURVEYS

THE superiority of modern surveys rests mainly on the perfection to which the manufacture of instruments has attained Observers in the old days were as careful and thoughtful, but this availed them little without the needful appliances What could the most learned Hindu astronomer achieve with such instruments as Sir Robert Barker found on that terrace at Benares in 1777 ?—Quadrants with a 20 foot radius, and the arc carved on a stone wall, so that to take an angle a Brahman must have been slung in a bowline knot, and hoisted up and down with guys Rough approximations would be all that an observer with such an instrument could hope for [1]

When Englishmen became the rulers in India, the instruments they brought with them were certainly improvements on the wonderful structures in the observatories at Delhi and Benares, but at first the difference was not so very great Reuben Burrow,[2] in starting upon a Government survey, had to borrow his tools anyhow, and complained that among them he got a wretched quadrant from Captain Ritchie [3] It was probably such an instrument as Bruce took with him to Abyssinia, which it required four men to carry

Colonel Lambton was in constant difficulties with his instruments, for, though he was eventually provided with the best that the artists of that period could produce, he had no means of getting repairs done, and no trusty coadjutor in England to refer to, until Captain Kater went home It will be remembered how, when the guy carried away, and the great theodolite was violently bumped against the tower of the pagoda at Tanjor, Lambton shut himself up in a tent for weeks, and repaired the damage with his own hands When, in the evening of his days, difficulties arose respecting the measuring

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[1] "An account of the Bramin's Observatory at Benares,' by Sir Robert Barker (May 1777) *Philosophical Transactions*, vol lxix, pt 2 See also "Benares, Ancient and Modern,' by FitzEdward Hall

[2] See page 56

[3] See page 4

chains,[1] he felt the want of a proper system for the supply and testing of instruments In those days it was the custom of the service, until the first Burmese war, for officers to supply their own instruments Colonel Hodgson, when he was surveying, had instruments and books of his own to the value of Rs 13,000, and nothing belonging to Government As Surveyor General he considered this to be a better system than the supply by contract, and declared that the instruments sent out for the Revenue Survey of 1821, by contract, were not such as a good observer would consent to use

Everest saw these evils, and provided a remedy He personally superintended every detail in the construction of his instruments while he was in England, watching their progress day after day, and examining them at every stage When he returned to India with them in 1830, he took an accomplished maker, Mr Barrow, out with him, and established a mathematical instrument manufactory at Calcutta Yet even these precautions were insufficient, and when Colonel Everest began to observe with the large astronomical circle he found that it was top heavy from faults in the construction, and unreliable Again the Superintendent of the Survey was thrown upon his own resources, and, with the aid of Syud Mohsin, invented and applied the remedy with his own hands [2]

Mr Barrow was established at the head of a useful factory at Calcutta, where instruments of all kinds could be repaired, and much good work done Indeed the second great theodolite, known as Barrow's theodolite, which has measured the angles of several of the Trigonometrical Series, was made at the mathematical instrument manufactory, under Colonel Everest's direction The graduation of the circle was performed by Mr Barrow, and the instrument was built out of old musket barrels, and parts of Colonel Lambton's trusty old theodolite that was damaged by a blow against the pagoda at Tanjor Lambton's old zenith sector is laid up in ordinary at Calcutta When Mr Barrow retired he was succeeded by Syud Mohsin, a native of Arcot, possessed of great mechanical talent Colonel Everest, like most men of genius, had a sort of intuitive perception in selecting the right man, and at once singled out Syud Mohsin as an able mechanician He was right This native of

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1 The first bases were measured with wooden rods Colonel Roy, after a careful series of experiments on the dilatation of various bodies, adopted glass tubes 20 feet long Then the 100 foot steel chains came into use, and finally the compensation bars

2 See page 89

India, though he could not read English, would have taken a leading place even among European instrument makers When he died his place was taken by a mechanician from Mr Cooke's establishment at York, and the factory continues to turn out plenty of useful work

But all important instruments, and all that require nicety and accuracy in their construction, must still be made in Europe, and, moreover, they must have the benefit of scientific supervision of the highest order if they are to prove efficient in such a service as the Indian Survey It was obvious that the Superintendent of the Survey could only occasionally be in England, at intervals of several years, while the supervision of instruments was a constant requirement

In 1862 the supply of a complete new set of instruments was sanctioned for the Great Trigonometrical Survey, and in the following year the importance of having all instruments for India subjected to special scientific examination became apparent

It would be impossible to find half a dozen men in England who combine the experience of India, knowledge of the highest branches of mechanical science, fertility of resource, and inventive genius, which are required in the officer to whom the superintendence of the manufactory of instruments for the Indian Surveys can be properly entrusted Most fortunately the services of Colonel Strange were secured, an officer who possessed all these qualifications Colonel Strange was a member of the Great Trigonometrical Survey from 1847 to 1860 It will be remembered that he conducted the Western Longitudinal Series, superintended the measurement of the Karáchi base, and for a short time was in charge of the Coast Series [1] He thus had had considerable practical experience in trigonometrical surveying, while his mechanical genius, and knowledge of mathematical, geodetical, and astronomical instruments, was not surpassed by any man in England

In 1862 the Secretary of State for India entrusted Colonel Strange with the task of designing and superintending the construction of a set of geodetical and astronomical instruments of the first order, for the Great Trigonometrical Survey, and in 1863 he was appointed to examine and test all instruments ordered for India

A set of instruments was required for the efficient discharge of his duties, and a special observatory for testing was an absolute necessity The provision of these requisites was sanctioned in 1864

[1] See pages 108 and 114

and 1865, and the observatory was erected at the warehouse of the Store Department of the India Office in Belvidere Road (Lambeth), where Colonel Strange's office was established.

The site of the observatory at Lambeth is on the banks of the Thames, close to a railway, and is exposed to much vibratory motion, while it is essential to secure rest and complete isolation for the proper examination of astronomical and geodetical instruments. Colonel Strange found it necessary to pierce right through the London clay, and established a basis on the underlying gravel, in order to ensure stability for his instruments during the process of testing.

For this purpose twelve screw piles were wormed into the gravel, which here lies 24 feet below the surface of the London clay. Broad heads of cast iron were keyed upon the top of the piles, and stone slabs were laid on the pile heads, the space beneath being filled in for a depth of three feet with concrete cement. A circular platform of brick work was built on the flag stones. A solid column of masonry was then erected in the centre, and two semi circular segments of wall were raised round the circumference. In order to secure complete isolation between the observer and the instruments resting on the piled foundation, the wooden flooring, between the central column and the circular wall, lies upon beams which are supported from beyond the brick work built over the piles. The observer thus walks on the floor, without shaking, or affecting in any way, the instruments on the wall or column. The floor is reached by a flight of stairs.

This arrangement is on the principle designed by Sir George Everest for the towers of observation in India, a central column for the instrument, with complete isolation for the observer.

For the examination of graduated circles for taking horizontal angles, the instrument is placed on the central column. Four collimators are fixed on different parts of the circular wall. These are horizontal telescopes containing marks for observation. In one there are diagonally crossing spider threads, in another horizontally and vertically crossing threads, in a third an artificial star or speck of light. The angular intervals between the collimators are 30°, 60°, 120°, and 150°, an arrangement which admits of twelve different angles being taken, by varying the sets of collimators. The positions of the collimators themselves also admit of alteration. The angles between them must have exactly the same values, whichever part of the circle is employed. This forms a severe and searching test

There are contrivances in the roof of the observatory for enabling observations of celestial bodies to be taken, and vertical circles are tested, when necessary, by observing stars as they pass the meridian

There are two clocks, built into the circular wall, one for mean, the other for sidereal time, the mean time clock being connected by electric wires with Greenwich

The methods for testing spirit levels and telescopes to small surveying instruments are equally complete and searching These operations are performed in the observatory

In another room, in the body of the building, are the standard barometer and thermometer They have been compared at the observatories at Kew and Greenwich, and it is an important fact that the two comparisons do not exactly agree So that there is no fixed standard in England to which observations can be referred, a deficiency which Colonel Strange brought to the notice of the Royal Society, but no steps have yet been taken to remedy this defect in physical science Colonel Strange, therefore, gave the error on both for every instrument that passed, and was sent out to India

Every kind of meteorological instrument is tested and examined There is a most ingenious contrivance for comparing the aneroids They are placed in a reservoir connected with the receiver of an air pump in such a way that the channel of communication is crossed by a diaphragm of porous porcelain When the receiver of the air pump is exhausted to a certain degree, the exhaustion of the reservoir containing the aneroids goes on very gradually through the porcelain Thus the action of the instrument is exactly the same as it would be in the pocket of a man slowly ascending a mountain At every half inch of change the aneroid is compared with an accurate mercurial barometer [1]

As many as 7,000 instruments of more than a hundred different kinds are examined yearly, and the number is largely on the increase [2] The system, ably and thoroughly worked out by its talented founder and inventor, is a complete success

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1 See an article by Dr Mann, in the *Quarterly Journal of Science*, entitled "The Lambeth Observatory," which gives an excellent popular account of Colonel Strange's operations The article is also printed in *Scientific Opinion* in the numbers for July 21st and 28th, and August 4th, 1869

2 It is curious to compare the return of instruments in store in the office of the Surveyor General and in use in the surveys, which was driven up by Colonel Hodgson in 1828, with Colonel Strange's Return, showing the number of instruments ordered in 1868 and 1869

The following system was adopted by Colonel Strange. All pattern instruments were abolished, for he considered patterns to be an obstacle to improvement, and no two batches of important instruments were sent out by him which were identical in construction. But the abolition of patterns added enormously to his labour, and kept the inventive faculty constantly on the stretch. A sufficient amount of competition, both in price and quality, was ensured by employing at least two makers for each separate class of instruments. At the same time competition in price was abolished. This was formerly the chief, if not the only competition relied on, and the consequence was that the prices became such as no really good conscientious maker could compete with. The supply thus fell into fifth rate hands. The selection of makers was made chiefly with reference to two points, character and general manufacturing power in the first place, and secondly special knowledge of particular branches of the profession. Thus makers of meteorological instruments were seldom distinguished for the excellence of their surveying instruments. All instruments were subjected to rigorous inspection, Colonel Strange's decision on them being accepted, in every contract, as final.

Colonel Strange's most absorbing work was the designing and superintendence of the construction of the grand new set of instruments for the Trigonometrical Survey. They consist of a great theodolite with a three-foot horizontal circle, and two zenith sectors, by Troughton and Simms, two five foot transit instruments, and two smaller ones by Cooke of York, two 12 inch vertical circles by Repsold of Hamburgh, two galvanic chronographs for registering transit observations, by MM. Secretan and Hardy of Paris, and three astronomical clocks by Frodsham. The five-foot transit instruments have very powerful telescopes of five inches clear aperture, with a hollow axis of aluminium bronze, cast in one piece. They are provided with four levels for rendering the axis horizontal, and there are peculiar methods for adjusting the axis vertically and azimuthally, the object sought being to exclude shake, obviate strain, and cause the expansions to take place from the centre outwards. These adjustments are exceedingly delicate in their action, and very stable.[1] These instruments have since arrived in India.

[1] "On a transit instrument and zenith sector, to be used on the Great Trigonometrical Survey of India, for the determination, respectively, of longitude and latitude," by Lieutenant Colonel A. Strange, F.R.S.—*Proceedings of the Royal Society*, *No.* 90. 1867.

On October 15th, 1866, Colonel Strange submitted a report, and on March 3rd, 1873, he sent in another interesting report, based on the results of 10 years' experience of the working of his system.

When Colonel Strange was first appointed there was no one kind of instrument supplied to India which was not faulty, either in respect of form, principle, workmanship, or material, and frequently in all these respects. Parallel rulers were not parallel, protractors indicated angles enormously in error, scales and level staves were incorrectly graduated, spirit levels were imperfect, barometers had enormous errors, and the more elaborate instruments, such as theodolites and levels, stood in need of thorough reform in every detail.

The great improvement effected by Colonel Strange has been attained by three measures, the abolition of patterns, the abolition of tenders, and a system of thorough inspection.

The pattern system is an encouragement to the trade to stand still, and the result is the perpetuation of forms which have long been condemned and superseded by the advance of knowledge. But there is no finality in science. In no branch of human knowledge is there more rapid and extensive change. At the same time, a system of supply without patterns entails invention and skilful superintendence, and could not have been adopted unless the services of such an officer as Colonel Strange had been available, who to unsurpassed knowledge of the use and construction of scientific instruments, added a practical acquaintance with Indian surveying acquired by many years of arduous service in the field. In December 1867, Mr Thomas Cushing, an accomplished mechanic, trained under the eye of Mr Thomas Cooke, of York, was appointed as Colonel Strange's assistant. Under the colonel's instructions he became qualified to inspect, adjust, and observe with every description of scientific instrument and apparatus furnished to the Indian services.

The system of employing makers of repute was substituted by Colonel Strange for that of tenders, but he gave orders to more than one for each class of instrument. This plan stimulated effort, and afforded the means of checking any augmentation of prices. Makers were called upon to give estimates, not tenders, for each class of instruments.

The instruments were subjected to rigorous inspection, and to actual trial before payment was made. This raised their price, but at the same time it greatly increased their accuracy. In 1865 there were 4,148 instruments inspected, which cost 10,609*l*. In 1872 the number inspected was 18,000, and the cost 20,845*l*. The number of different kinds of instruments ordered through Colonel Strange was about 150, several had to be individually carefully examined and tested, and some required to be taken to pieces. The following was the average annual number of the most important kinds:—

| | | | |
|---|---|---|---|
| Theodolites | 145 | Microscopes | 17 |
| Levelling instruments | 152 | Pentagraphs | 19 |
| Thermometers | 739 | Salinometers | 34 |
| Barometers | 25 | Hydrometers | 17 |
| Aneroids | 20 | Telescopes | 48 |
| Insts. Mathl. cases | 406 | Levelling staves | 212 |
| Chronometers | 45 | Prismatic compasses | 103 |

Colonel Strange remarked that the only just mode of viewing the cost of inspection, which he calculated at 3·57 per cent. of the cost of the instruments,[1] was by looking on it as a per centage of the cost of the departments using the instruments, and on this point he offered the following calculation:—

"My office is not kept up for its own sake, but for the sake of "maintaining the efficiency of certain departments, such as the "Public Works, the Surveys, and, to a certain extent, the Medical "and Educational Departments. It is as an integral part of these "departments that the cost of instruments, including their inspec"tion, is rendered necessary and is to be justified.

"Viewing it in this way, I take the expenditure of late years on "Public Works in India as between seven and eight millions "(8,000,000*l*.) per annum.

"The number of instruments which would be supplied if no "inspection existed would probably be the same as that supplied "at present with inspection, but one effect of efficient super"intendence must be, and has been, to raise the price of instru"ments. I held out no other expectation on being appointed, as "I conceived one of the main objects in appointing me was to put "a stop to the supply of low priced bad instruments by inferior "makers. It is difficult to arrive exactly at the amount of this "increase, which has affected different kinds of instruments very "unequally, but I am quite sure that if I take it at 10 per cent. on "the whole I shall be considerably over estimating it.

[1] Average yearly cost of instruments for the last five years, 16,343*l*. The cost of inspection is 584*l*., being 350*l* for the salary of Colonel Strange, 170*l* for that of Mr. Cushing, and 64*l* for the Observatory attendant, being 3·57 per cent. on the cost of the instruments. A commission agent would charge 5 per cent. for merely buying such instruments, without even pretending to submit them to any efficient examination.

"Taking the average cost of instruments for the last five years, " as before, at 16,343*l*, then 10 per cent of this will be 1,634*l* " We have then—

| | | |
|---|---|---|
| Increased cost of instruments consequent on inspection | | 1 634*l* |
| Colonel Strange s salary | - - - | 350*l* |
| " Mr Cushing s " | - - - - - | 170*l* |
| " Observatory attendant | - - | 64*l* |
| | Total | 2 218*l* |

" Comparing this with 8,000,000*l* we find that the superintending, " improving, and inspecting of the instrument supply adds at present " sixpence halfpenny per 100*l*, or about $\frac{1}{36}$th of 1 per cent to the " cost of the departments to whose efficiency such superintendence, " improvement, and inspection contributes I need make no " remarks on this result"

Colonel Strange died on the 9th of March 1876, and was succeeded in the duty of testing instruments by his assistant Mr Cushing, whom he had himself trained for the work

Captain Waterhouse is the Superintendent of the Mathematical Instrument Department in India In 1874–75 the number of instruments manufactured there was 3,999, repaired 2,391, and examined 2,067

## XIV

## THE GEOLOGICAL SURVEY OF INDIA

A Geological Survey of India, regularly organized and working systematically, has now reached the twenty second year of its existence. Ever since cultivated Englishmen have been at work in India, in the surveying, military, clerical, or medical services, there have been keen observers of everything worth observing, and the Indian rocks and minerals, viewed sometimes from a practical and at others from a purely scientific point of view, have had their due share of attention. Thus there have been many geological reports on various Indian districts in the years preceding the regular establishment of the Survey, but it will only be possible to enumerate those that are best known.

It will be remembered that when Sir George Everest first joined Colonel Lambton in 1818, he had with him, as a colleague, Dr Voysey, who was surgeon and geologist to the Survey. This was probably the first official appointment of a geologist in India,[1] when the science was in its infancy, and Doctor Voysey's papers refer to the Wernerian and Huttonian systems. He was sent by Colonel Lambton to reconnoitre the country in advance, as far as Agra. He accompanied Everest in his severe work on the Godavari, and was one of the earliest writers on the rocks of the Deccan. He explored the Nalla Malla mountains between Cummum and Cuddapa and Amrabad north of the Kistna, and wrote an interesting account of the diamond mines in Southern India. He also wrote papers on the building stones of Agra, and on petrified shells in the Tapti valley.[2] This able and zealous officer died of fever on his way to Calcutta in 1823.

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[1] A Mr Laidlaw was appointed as mineralogist and geologist to the Survey in Kumaun under Captain Webb (see page 81) in June 1817, but his allowances were stopped in 1818.—*Despatch from Lord Hastings*, Feb 15th 1821. Laidlaw was a very able man, and is said to have been badly treated.

[2] See "Asiatic Researches," xviii, p 187, and xv, p 429 and p 120. Dr Voysey's Private Journal during 1819 was published in the "Journal of the Asiatic Society of Bengal," xix, p 201. See also "Gleanings in Science," ii, p 27 (Calcutta 1830). Dr Voysey's 1st and 2nd Reports on the geology of Haidarabad are in the "Journal of the Asiatic Society, vol ii, pp 298 and 392. Dr J H Carter speaks of "the sagacity, ability, and truthfulness which characterize Dr Voysey's observations

Dr Voysey was followed by various other observers, who reported upon the rocks and minerals in different parts of India Captain Dangerfield wrote a notice of the geology of Malwa, the result of careful observation, previous to 1823,[1] and Captain Franklin, while executing the topographical survey of Bandalkhand in 1828, also reparted on its geology[2] Colonel Sleeman discovered fossils near Jabalpur in 1830,[3] Dr Spilsbury made further collections,[4] and the geological investigations of Sir Andrew Waugh and Major Renny Tailyour have already been mentioned Lieutenant Finnis wrote upon the rocks of the country between Hoshangabad and Nagpur in 1834,[5] and in 1842 Dr Adam described the rocks of Bandalkhand, north of Spilsbury's work[6] The Rev S Hislop also wrote various papers on the geology of the Nagpur country,[7] and in 1831 the Rev R Everest recorded his geological observations between Calcutta and Ghazipur He also criticised Captain Franklin's work in a paper entitled "The Sandstones of India"[8] James Prinsep wrote papers, in his Journal, on the fossil bones found in the Jamna and Narbada valleys[9] In 1854 Captain Nicolls made large and valuable collections of fossils from the inter-trappean lacustrine limestone deposits at Sagar, and from the Narbada valley, and Lieutenant Keatinge collected fossil ammonites and bivalves of what was supposed to be the Cretacean age, at Bagh, near the Narbada

There are some geological notices on the rocks of the Rewah table land, and other parts of India, in the valuable work of M Jacquemont[10]

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1 Published in 1823 in Sir John Malcolm's "Central India," ii p 320

2 Papers in the "Journal of the Asiatic Society of Bengal," and in the "Transactions of the Geological Society"

3 "Journal of the Asiatic Society of Bengal," i p 456

4 Ibid, ii p 549, and xiii pt ii p 765

5 Ibid, iii p 71, and xi p 20

6 Ibid, vol xi p 392

7 There is an account of the inter trappean freshwater and estuarine formations of the peninsula of India, by Mr Hislop, in the "Quarterly Journal of the Geological Society," xvi p 154, and Professor Owen described the fossil cranium of a labyrinthodont reptile, obtained by Mr Hislop from the sandstone of Mangoli, 60 miles south of Nagpur, in the "Quarterly Journal of the Geological Society," xi pt i p 37

8 "Gleanings in Science, iii p 129 and 207

9 "Journal of the Asiatic Society of Bengal," iii p 396

10 "Voyage dans les Indes Orientales"

Attention was early turned to the coal bearing rocks of Bengal and the Narbada valley Coal was known to exist in the Dámodar valley so long ago as 1774, and was actually worked in 1777 Mr Jones described the coal fields and opened mines in 1815,[1] and in 1830 there were several collieries in the Ránigany country Mr Hislop wrote a paper on the age of the coal strata in Western Bengal, and a description of the coal fields in the Dámodar valley by Mr Homfray was published in 1842[2] But the Ranigany coal field was first carefully examined and reported on by Mr Williams in 1845, who was appointed Geological Surveyor to the East India Company[3] Mr Williams died of jungle fever at Hazaribagh in 1849 The earliest explorer of the Narbada coal region was Colonel Ouseley, who tried a quantity of the coal in 1838[4]

In 1833 Mr Calder wrote a general review of the geology of India, which forms a sort of introduction to various geological papers in the 18th volume of "Asiatic Researches," by Franklin, Voysey, Hardie, Jones, and Coulthard

The most interesting geological work in India, before the commencement of the survey, was undoubtedly the examination of the Sawalakh hills by Dr Falconer and Sir Proby Cautley, and the famous discovery of their wonderful fossil fauna

Dr Falconer took charge of the government gardens at Saharanpur in 1832, and at once began to investigate the geology of the Sawalakh hills This is a ridge running parallel to the great chain of the Himálaya, and consisting of rocks of very late formation In strictness the Sawalakhs are the range of hills rising from the plains between the Ganges and Jamna, but the term is often applied to the outermost ridge along the whole length of the Himálaya[5]

Herbert had examined and reported on the Sawalakh rocks when engaged on the survey,[6] but Captain Webb is said to have been the first to prove the existence of fossil bones Yet they were

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1 "Description of the N W Coal District, stretching along the river Damoodah"—*Asiatic Researches*, xviii p 163

2 "Journal of the Asiatic Society of Bengal," vol xi pt ii p 723

3 "A Geological Report on the Damoodah Valley,' by D H Williams, Esq, late Geological Surveyor in the Service of the East India Company (London, 1850) The work was reprinted in Calcutta

4 "Journal of the Asiatic Society of Bengal," iv p 648

5 Rennell applied the name to the hills from Hardwar to the Sutlej—"Memoirs," p 233

6 "Journal of the Asiatic Society," vol xi (App)

known to Firoz III as long ago as 1360 Ferishta tells us that this monarch, while cutting through a hill with 50,000 workmen, to lead the waters of the Sursati into the Selıona, came upon bones of giants three yards long

Dr Falconer was led to expect the discovery from the nature of the rocks, and he had noted the above passage in Ferishta At that time three officers, who have since linked their names indissolubly with the history of Indian irrigation, Sir Proby Cautley, Sir William Baker, and Sir Henry Durand, were at work on those Jamna canals, the heads of which are close to Dr Falconer's abode at Saharanpur, and he had them as fellow labourers in the same field of research

Falconer and Cautley both found fossil bones in 1831, and Cautley energetically followed up the search by blasting operations in the Kalawala pass of the Sawalakh These discoveries were not fortuitous, but were results led up to by previous special study In 1834 Baker and Durand discovered the great ossiferous deposit near the valley of the Markunda, below Nahun Two days after they got their first specimens, Falconer was on the spot, and collected 300 specimens of fossil bones within six hours

Thus was a sub tropical mammalian fossil fauna brought to light, which was unexampled in richness and extent in any other region then known The history of the discovery is recorded in various papers published in scientific journals, and the whole was to have been embodied by Dr Falconer in a great work entitled "Fauna Antiqua Sevalensis" It was commenced, and 1,123 specimens were figured, but Dr Falconer was not spared to complete it He died in 1865, and all his papers bearing on this subject have been ably edited and published by Dr Murchison[1] Dr Royle, in his great work on the Himalayas, both figures and describes the Sawalakh fossils[2]

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[1] "Palæontological Memoirs and Notes," by Hugh Falconer, 2 vols 1868

His first account of the Sawalakh is in the "Journal of the Asiatic Society of Bengal,' i p 96 (1832) Cautley's first memoir is in the "Asiatic Researches," vol xvi In vol xix of the "Asiatic Researches' are seven papers by Falconer, Cautley, and Durand On the fossil camel at p 115, fossil tiger, p 135, fossil bear, p 193 See also Baker's papers in the "Journal of the Asiatic Society," iv p 506, 694, 706, v p 729 There is also a paper by Cautley in the "Geological Transactions (2nd Series)" v p 276 (1836) Cautley's paper on a fossil giraffe in the Sewalik is in the "Journal of the Asiatic Society," vii pt ii p 658, and Falconer's on the quadrumana of the Sewalik, ibid vi pt i p 354

[2] "Illustrations of the botany and other branches of the natural history of the Himalaya mountains," by J Forbes Royle (London, 1839 2 vols)

These important discoveries have thrown light upon the state of India in the most remote ages On their authority we may conceive an ancient sea to have occupied the valleys of the Indus and Ganges, washing the bases of the Himálaya on one side, and the Vindhya of the Deccan on the other, and receiving all the silt bearing rivers from both In course of time the sea was filled up, and the alluvial valleys teemed with the animals whose bones are now imbeddied in the Sawalakh Similar remains exist in Sindh They were also found by Mr Crawfurd on the banks of the Irawadi in 1826,[1] by Dr Spilsbury in the Narbada valley, and by Captain Fulljames on the island of Perim in the gulf of Cambay[2] These points indicate the vast area over which the Sawalakh animals of that remote tertiary age roamed There were mastodons, elephants, five species of hippopotami, rhinoceroses, giraffes, horses, pigs, camels, stags, antelopes, hyænas, dogs, and cats, monkeys, ostriches, and huge cranes There are also the sivatherium, a bull the size of an elephant with four horns and a roman nose, and the colossachelys atlas, a gigantic tortoise 6 feet high and 22 feet long

The upheaval of a narrow belt of the plains of India, at the foot of the Himálayas, into hills 3,500 feet high, seems to mark the time when the present epoch commenced in India, as these hills form the grave and monument of an earlier and distinct fauna

The investigation of the Sawalakhs was followed by Colonel Richard Strachey's examination of the lofty ranges in their rear,[3] and by reports on the fossils of the Spiti Valley by Dr Gerard[4] and Captain Hutton[5] Captain Henry Strachey also explored Western Tibet, including the remarkable alluvial plain of Gugé, which the

1 See the account of the rocks and animal remains collected by Mr Crawfurd in 1826–27, on the banks of the Irawadi, by Dr Buckland, in "Crawfurd's Embassy," ii, App p 143, and in the "Transactions of the Geological Society" The collection consisted of bones of mastodons rhinoceroses, hippotamuses, tapirs, oxen, deer, and land tortoises

2 Baron Hugel had a large collection of fossils from Perim Captain Fulljames reported on them in the "Bengal Asiatic Society's Journal, i p 233 See also "Notes on the Island of Perim, in the Gulf of Cambay, by Lieut Ethersey,' *Bombay Geographical Society's Journal*, vol ii Dr Falconer described the Perim fossils in the "Quarterly Journal of the Geological Society," i p 356

3 "Quarterly Journal of the Geological Society," vii p 292

4 "Asiatic Researches," xviii pt ii p 238

5 "Journal of the Asiatic Society of Bengal" (1841,) p 198

Sutlej has excavated to the depth of a full vertical mile,[1] and Dr Thomson, in his journey through Ladak to the Karakorum pass in 1848, made very careful geological notes[2]

The peninsula of India has been examined and reported upon by several ardent geologists Colonel Sykes has written upon the trap formation of the Deccan,[3] and Dr Malcolmson's paper on fossils of the eastern portion of the great basaltic region had for its object an endeavour to arrive at a conclusion respecting the age of the basalt which is spread over 200,000 square miles on the plateau of the Indian peninsula The fossils were collected in 1832, on the Sichel hills, which extend from the junction of the Wurda and Godavari towards Aurangabad[4]

But perhaps the most eminent of the Indian geological observers of those days was Captain Newbold, the Assistant Resident at Karnál, an officer who had entered the army in 1827 He made several careful sections across the peninsula, and reported upon the whole region south of a line drawn from Ganjam to Bombay No formation has attracted more attention than the laterite, a rock peculiar to India, which was first noticed and named by Dr Buchanan, in his work on Malabar Captain Newbold described it very fully as a reddish brown tubular and cellular clay, more or less indurated, and often impregnated with iron The air exposed surface of laterite is hard and glazed, but a few inches below the surface it becomes softer, and is cut out in blocks with a spade, hardening after exposure to the atmosphere It is used largely for building and for repairing roads, and, among other edifices, the arcaded Inquisition at Goa is built of laterite The laterite formation covers the western coast almost continuously from Bombay to Cape Comorin, and generally from the sea to the foot of

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1 "Physical Geography of Western Tibet,' in the *R G S Journal*, vol xxiii p 1 Henry Strachey is a Gold Medallist of the Royal Geographical Society

2 "Western Himalaya and Tibet A journey during the years 1847–48,' by Thomas Thomson, M D (1852)

3 "Colonel Sykes on the Geology of a portion of the Dukhun" (4to London, 1836) Re printed from the "Transactions of the Geological Society," vol iv (Second Series)

4 "Transactions of the Geological Society,' v p 537 Dr Malcolmson, who was Secretary to the Bombay Branch of the Asiatic Society, died at Dhulia in the Tapti valley, while engaged in the pursuit of his favourite science, in February 1844 See a notice of him in the "Bombay Times" of April 30th, 1844

the ghauts It is also found in detached beds in many other parts of India It is of late origin Some writers derive it from the weathering of trap rocks, but the laterite beds are sometimes conglomeritic, cover indiscriminately all kinds of formations, and rest undisturbed alike on the traps and on the cretaceous lime stones of Pondicherry, while they are never invaded by trap dykes [1]

General Cullen, an officer of high scientific attainments, who was for many years resident in Travancor, found beds of lignite in the laterite near Kollam (Quilon)

The régur or black cotton soil was also carefully studied by Captain Newbold,[2] and he formed a theory respecting the origin of those nodules of lime so well known in India by the name of kunkur, which are met with as irregular overlying beds, or filling up chinks and fissures of rocks of every age He referred their origin to the action of springs charged with carbonic acid, bringing up lime in solution, and either depositing it as the temperature lowered, or parting with the carbonic acid [3]

In 1840 Captain Newbold visited the fossiliferous limestones of South Arcot and Trichinápalli, which were afterwards carefully examined by Mr C Turton Kaye and Mr Brooke Cunliffe of the Madras Civil Service These gentlemen collected 178 fossils from the cretaceous formation near Pondicherry, described by Sir Philip Egerton and Professor Edward Forbes [4]

Captain John Warren, the assistant of Colonel Lambton, had examined the petrified drift wood at Trivikera near Pondicherry in

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1 See also a paper on laterite by Dr Cole, in the "Madras Journal of Literature and Science," iii p 100 , and another by Dr Clark, viii p 334

2 Paper read before the Royal Society, March 22nd, 1838

3 Captain Newbold's papers will be found in the "Transactions of the Geological Society,' in the "Journal of the Royal Asiatic Society,' vol vii , and in "Notes, chiefly Geological, in four parts, in the "Journal of the Asiatic Society of Bengal ' The papers in the "Journal of the Asiatic Society ... are, on the Mineral Resources of India, in eight numbers They contain accounts of the gold tracts, and of the mines of lead, manganese, rubies, garnets, diamonds, &c See also the "Calcutta Review, ' ix p 314 He also wrote papers on the geology of Egypt, and on the petrified forest near Cairo ("Quarterly Journal of the Geological Society, iv pp 324–49 )

Captain Newbold was an accomplished antiquary and Persian scholar, as well as a geologist He died at Mahabulashwur on June 2nd, 1850

4 "Madras Journal of Literature and Science,' No 28, xii p 37 'Transactions of the Geological Society," vii p 97 Mr Kaye died in October 1845

1808,[1] which, Captain Newbold tells us, closely resembles the petrified wood in the desert near Cairo

In the Western Presidency, Captain Grant examined the important plant bearing formation in Kach [2] Dr Christie gave an account of the geology in the Southern Mahratta country in 1836,[3] and Lieutenant Aytoun reported upon the geology of parts of Belgaum [4] Colonel Meadows Taylor has described the geology of the district of Shorapore in the Deccan, where the several formations of that region unite with those of the Carnatic, accompanied by evidence of much local disturbance His observations connect the work of Captain Newbold at Karnal with that of Dr Christie and Lieut Aytoun in the Southern Mahratta country [5] Dr Fleming described the nummulitic limestone in the Suliman range, above the Derajat [6] In Sindh, Sir Bartle Frere has written upon the geology,[7] and also contributed a most admirable paper on the Desert and the Ran of Kach The same region was described by Alexander Burnes and Mac Murdo, and Sir Charles Lyell has given an interesting account of the Allah Bund, and of the effects of the earthquake of 1819, in his "Principles of Geology" Dr Robert Thompson,[8] Dr Buist,[9] and Dr H J Carter,[10] have written upon the geology of the Island of Bombay

The nummulitic limestone formation in western India has attracted much attention, and has been carefully studied In 1844 Dr Malcolmson, just before his death, discovered a nummulitic bed in the Rajpipla hills, crossing the Nerbudda valley, and Major Fulljames, in 1852, reported upon the same formation More recently, in 1861, Mr Alexander Rogers, the Collector of Surat, who is an accomplished and enthusiastic geologist, discovered nummulitic limestone at Turkeysur, between Surat and Broach Thus

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1 "Asiatic Researches," xi p 1

2 "Transactions of the Geological Society (2nd Series)," v p 289

3 "Madras Journal of Literature and Science," iv p 452

4 "Journal of the Bombay Geographical Society," xi p 20

5 See the "Transactions of the Royal Geological Society of Ireland"

6 "Quarterly Journal of the Geological Society," ix p 346

7 Ibid, ix p 349

8 In 1836 "Madras Journal of Literature and Science," v p 129

9 "Journal of the Bombay Geographical Society," x p 167

10 "Bombay Branch of the Asiatic Society," iv p 161 Dr Carter made a final geological examination of Caranja, Elephanta, Trombay, Salsette, and the other islands round Bombay See "Journal of the Bombay Branch," Nov 1860

the existence of the nummulitic formation in the Rajpipla hills, which form the westernmost termination of the Satpura range, was fully established [1]

Dr Carter, then in the Indian Navy, was the most distinguished of the Pioneers of Indian geology While serving with Captain Sanders in the "Palinurus," he examined the rocks of the Arabian coast,[2] and he afterwards reported upon the geology of the Islands of Bombay and Salsette But his most valuable work consisted in the collection and classification of all the geological labours of his predecessors, to which is added a reprint of his Summary of the Geology of India between the Ganges, Indus, and Cape Comorin This work was undertaken at the instance of Lord Elphinstone [3] The plan is first to introduce the reader to the geology of the great trappean region of Western India, and then to carry him round its outskirts, in order that he may become acquainted with the geological formations of India generally His attention is then directed to the geology of Kach, afterwards to that of Sindh, and lastly to that of the Arabian coast For this purpose almost all the geological papers on India that had then been written were reprinted *in extenso*

In 1853 Mr Greenough carefully compiled his geological map of India, showing the state of our knowledge at that date,[4] copies of which were transmitted to the Local Governments, and elicited several reports from officers interested in the subject [5]

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1 A work on the nummulitic fossils of India was published in France in 1853 "Description des animaux fossiles de groupe nummulitique de l'Inde, precedée d'un "résumé geologique et d'une monographie des nummulites, par le Vicomte de Archiac "et Jules Haime' 4to 32 plates Paris, 1853

2 See note at page 22

3 "Geological Papers on Western India, including Kach, Sindh, and the South east "Coast of Arabia, to which is appended a Summary of the Geology of India generally, edited for the Government by Henry J Carter, Assistant Surgeon (Bombay, 1857) See a review of this valuable work in the "Bombay Quarterly Review," vol vii p 316

4 "General Sketch of the Physical and Geological Features of British India," by G B Greenough, Esq, engraved by A Petermann The map is 7 feet long by 5¾ It is described by Sir Roderick Murchison in one of his anniversary addresses as President of the Geographical Society "R G S Journal,' xxiii p cviii

5 "Correspondence on the subject of the Geological Map of India, compiled by Professor Greenough" (Madras, 1857) This pamphlet contains remarks by General Cullen on the laterite of Travancore, by Major Dallas and Dr Cole on the geological features of the Ceded Districts, and memoranda by Dr Ranking, Dr Balfour, Dr Hunter, and Rev C F Muzzy Mr Muzzy wrote a paper on the geological features of Madras, Trichinapalli and Tanjor, in the "Madras Journal of Literature and Science," i N S, p 90

Such were the principal labours in the field of Indian geologists previous to the establishment of the official survey They were results obtained by independent inquirers, and, such as were recorded when geology was in its infancy, are now to some extent out of date There was of course a great want of concentration in these labours, and the value of many observations was lost owing to the absence of an intelligible nomenclature Much has required revision, but at the same time the labours of those Indian geologists who were first in the field are valuable and important

Dr McClelland, who held the office of Geological Surveyor for two years after the death of Mr Williams, wrote a Report on the Geological Survey of India for the Session 1848–49, and described the coal strata of the Rajmahal hills [1] He also mapped the Kurhabari field

The work of Dr Oldham, the late Superintendent of the Geological Survey of India, extends over a period of upwards of 25 years Before commencing his service in India he had been on the Irish Survey, and Professor of Geology at Trinity College, Dublin He arrived in India in March 1851, and found that the establishment of the Geological Survey then consisted of one peon and one writer, with no European assistant, and no preparation of any field work The few existing records were kept in a box in a small room in the Surveyor General's Office Dr Oldham obtained sanction for the employment of Mr J G Medlicott, who had served with him for several years on the Survey of Ireland, as assistant, and in 1852 Mr St George was added The only idea the Government then had of the duties of a geological surveyor was that he should go about from place to place, and report upon real or fancied discoveries of minerals The difficulty of the position was increased by the small confidence that could be placed in much that had previously been done The beds represented by the former Coal Committee to be the very lowest of the carboniferous period are in reality eocene or miocene resting upon nummulitic limestone, and the coal measures of the Rajmahal hills, which had been stated to be newer than or to rest upon the trap flows of that district, are in reality

[1] Dr McClelland was secretary to a committee for the investigation of the coal resources of India See the Report printed at Calcutta in 1841 There is also a work on the Geology of the Province of Kumaon, by John McClelland (8vo Calcutta, 1835 )

exactly the opposite. Dr Oldham worked steadily on, in the face of many difficulties at the outset, to obtain a definite geological horizon from which to work up or down, and so obtain a true basis for future operations. This was, however, impracticable while he was expected to go first to the eastern boundary of Bengal, then to the southern extreme of Tenasserim, and next towards Bombay.

Lord Canning really took an enlightened interest in geology, and on his arrival Dr Oldham was able for the first time to commence a regular survey of the country. Lord Canning ordered that, unless under very special circumstances, the geological surveyors were to confine their labours to those parts of the country which had already been mapped, and steadily to proceed, as far as the maps existed, over the country from east to west. Before Lord Canning's arrival Dr Oldham had, in 1851, proceeded to Cháriápunji, with a view to examining the iron ores in the Khasia hills. He made a collection of fossils, chiefly from the nummulitic limestone of the Khasia hills, establishing the occurrence of rocks of the upper cretaceous age in Eastern Bengal.[1] In 1852–53 he examined the geological features of the Rajmahal hills,[2] and Mr Theobald, one of his assistants, made a detailed report upon the Punjab Salt Range in 1853.[3] In 1855 Dr Oldham accompanied Sir Arthur Phayre's mission to Ava and wrote a memoir on the geological features of the banks of the Irawadi, and of the country north of Amarapura.[4]

In 1856 Lord Canning placed the Geological Survey upon a proper footing. Dr Oldham's staff was increased, the labours of the survey were systematized, and the reports were ordered to be published in a uniform series. The operations have been directed to those districts where the Revenue and Topographical Surveyors have completed their maps, and where the most valuable practical or scientific

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1 "On the Geological Structure of part of the Khasia hills, with observations on the "meteorology and ethnology of that district," by Thomas Oldham, A.M., &c. (4to Calcutta, 1854, with geological maps). See also the "Quarterly Journal of the Geological Society," xix p 524. "Geological Memoirs," i p 94. Colonel Hannay and Captain Dalton reported upon the economic geology of Upper Assam at about the same time. "Journal of the Asiatic Society of Bengal," vii p 625, xxii p 511, xxv p 230. See also their report on auriferous deposits in Assam.—"Memoirs," i p 90. Dr Hooker described the structure of the Khasia hills, much as Dr Oldham did afterwards. This district is the Cossyah hills of other authors.

2 "Journal of the Asiatic Society of Bengal," xxiii p 268, and xxv p 249.

3 Ibid Nos 3, 4, 5, of 1853. In 1848 Dr A. Fleming, of the 7th N.I., had also written a paper on the Salt Range. Ibid, xvii pt 2, p 500.

4 "Yule's Mission to Ava," App. A, p 309.

results were to be obtained But the geologists have been constantly hindered in their work by the want of maps, and indeed this has been one of their chief difficulties The superintendent and his staff have also been frequently detached from their regular work to report upon some special point for the Government, which though useful service is sometimes performed in the interval) has delayed the progress of the survey

The best way to convey a tolerably clear idea of the geological work that has been done will perhaps be to take the history of the progress of the survey in each district, instead of reviewing the whole of the operations year by year, and, with this object, it will be as well to begin with the coal yielding region

The coal fields of India lie in a region bounded by the Ganges on the north, and extending beyond the Godavari on the south, while from the east to west they stretch from Assam to the Narbada valley Mr Hughes has calculated the area over which the coal rocks may be presumed to extend at 35,000 square miles Nearly all the coals come from one geological formation called "Dámodar" from the name of the river, in the valley of which the principal coal seams occur It is the same as that of the Australian beds, and differs very little from the carboniferous group of beds in Europe But the coal is very different both in quality and appearance Its most characteristic distinction is its excessive lamination, and it contains from 10 to 30 per cent of ash, while the proportion of fixed carbon rarely exceeds 60 per cent, and averages 52 per cent In average English coal the ash is 27 per cent, and fixed carbon 68 per cent Indian coal is only capable of doing one-half to three-quarters of the work performed by the same amount of English coal Mr Blanford divides the coal fields of India into four groups, 1st, those of the Rajmahal hills and Dámodar valley, 2nd, those in Rewah, Sirgújah, Chota, Nágpur, Talchir, 3rd, the coal of the Narbada valley and Satpura hills, and 4th, the new fields in the valleys of the Warda and Godavari

On the Rajmahal hills there are small coal basins in every large valley traversing the range, with seams 3 to 12 feet thick But Raniganj is far the most important of the Indian coal fields, and nearly the whole of the coal mined in India is obtained from it The others are Jherría, 10 miles west of the Raniganj coal bearing tract, where there are numerous seams of great thickness which have not yet been worked The Bokaro field is a long strip of coal bearing rocks commencing within a mile of the Jherria field, and extending for

40 miles Rangarh is a small field to the south of the Bokaro field Karampura consists of two basins of coal bearing rocks lying west of Rangarh, and due south of Hazaribagh All these are in the valley of the Dámodar, and form a belt of coal bearing rocks extending 150 miles, and occupying 1,500 square miles of country Where the Damodar formations attain their greatest thickness they consist of two groups, the upper one 5,000 and the lower 2,000 feet thick, each containing several seams of coal, but to the westward the upper group thins out and disappears, while the lower one gradually diminishes in thickness

The Karhabari coal field, in the valley of the Barakur, a tribu tary of the Dámodar, is to the north-west of the Raniganj collieries, and covers an area of 18 square miles Mr Hughes has calculated that there is a sufficient supply at Karhabari to supply 250,000 tons a year for 800 years The collieries belong to the East India Railway, and a branch line 28 miles long has been made to them There are two very small fields containing valuable coal near Deogarh in the Santhal Parganas, and a third at Itkuri to the west of Karhabari

The second group consists of a number of basins scattered thinly over an immense tract of the wildest country in India, the Palaman fields in Chota Nagpur, the South Rewah field, and seams in the Upper Son valley, and at Talchir on the Bramani river

The third group is included in the Narbada valley and Satpura hills, where the Mopani collieries belong to the Narbada Coal and Iron Company[1] Here the average thickness of the coal seam is 25 feet, and though there are numerous faults and dykes, it is believed that a large quantity exists

The fourth group lies on the edge of the great sandstone tract which occupies the valley of the Godavari, and its tributaries the Warda and Pranhita Outside these four groups of oval fields are those in the Khasia hills, and at the extreme end of the Assam valley

In 1856–57 Cattack was examined by three of the staff, Messrs W T and H F Blanford and Mr J G Medlicott, from the Chilka lake to Midnapur, and Mr Blanford reported upon the laterite of

[1] This Company was formed in March 1860 The site of their grant is twelve miles east of the main line of the G I P Railway, and 80 miles south of Jabalpur In 1872 a branch line was opened to the Company's colliery, and the demand for coal is now greater than the supply The quantity on the Company's ground is estimated at 214,500 tons

Orissa.[1] The Blanfords discovered and named the important Talchir group of rocks underlying the coal beds. The separation of the Talchir from the coal bearing rocks is applicable in all districts. During the two following years Mr. W. T. Blanford was zealously investigating the Raniganj coal field,[2] while Mr. Medlicott was engaged in the survey of the Karakpur hills and on the examination of the Karhabari coal district. The existence of a large supply of coal west of the river Barakur was established, and Dr. Oldham had himself explored the Cossyah hills in former years.[3] Mr. Blanford completed field maps of the Raniganj, works which are as useful to the practical worker as the geologist, and he also brought together returns of the coal raised from the several open works and pits. In 1859–60 there were 370,206 tons of coals raised. At the close of 1861 Mr. Blanford was transferred to Burmah.

The examination of the coal country was continued in 1863 by Mr. Hughes and Mr. Wilson, at Jherria[4] and Karhabari. In the following year Mr. Medlicott was on detached duty in Assam,[5] and came to satisfactory conclusions respecting the value of coal in that district. In 1865 Mr. Hughes continued his work in the coal region, exploring the Hazaribagh and Bokaro[6] fields; and in 1866 Mr. Blanford made his first examination of the Chanda coal field, and indicated the localities where borings should be made. The Palamow coal fields could not be proceeded with for want of maps. In 1868 Mr. Medlicott traversed a wide tract of country to investigate the extent and relations of the several series of sandstones associated with coal in Bengal, as compared with those in Central India; and proceeded, in the following year, to the Narbada valley, to work out the coal bearing rocks in that area, which had been first visited 12 years before, when there were no maps.[7] In 1869

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1 See "Memoirs," vol. i., "On the Coal and Iron of Talcheer in Cuttack." "Structure and Relations of the Talchir Coal Fields." "Geology of Midnapore and Orissa." "Laterite of Orissa." These labours are reviewed in the "Quarterly Journal of the Geological Society," xiii. p. cviii. The coal and iron of Talcheer had previously been written upon by Captain Kittoe. "Journal of the Asiatic Society of Bengal," viii. p. 137.

2 "Memoirs," vol. iii., "On the Raniganj coal field."

3 "Memoirs," vol. i., "Geology of the Khasia hills."

4 "Memoirs," vol. v., "On the Jherria coal field," by T. Hughes.

5 "Memoirs," vol. iv., "On the coal of Assam," by H. B. Medlicott.

6 "Memoirs," vol. vi., pt. 2, "On the Bokaro coal field." G. T. W. Hughes.

7 "On the Mohpani coal field in the Narbada valley," by H. B. Medlicott. "Records," iii. pt. 3, (1870.)

two geologists were sent to revise the maps of Bhagalpur and Bírbhum, the earliest coal region examined by the survey

These Indian coal fields are situated in the drainage basins of the rivers Dámodar, Son, Mahanadi, Godavari, and Narbada The oldest and best known, namely, the Raniganj, Jherria, Bokaro, Ramghur, and Karampura fields are in the Dámodar drainage basin [1] The Itkuri and Karhabari fields are in Chòta Nagpur province, on the Barakur, the chief effluent of the Dámodar, from which river it is separated, in the upper part of its course, by the lofty Parasnath hill and the wide plateau of Hazaribagh The whole of these may be considered to have been deposited in one great estuary In the Son valley are the Palamau, Singrauli, and South Rewah coal fields, the Talchir and Belaspur fields are in that of the Mahanadi, and the Chanda in the Godavari

The conclusions derived from the survey are, that the rocks associated with coal are separated into several distinct groups The lowest is the Talchir group, first established by the brothers Blanford, and not containing coal The Dámodar series contains most of the coal beds of Bengal and Central India It was separated from the overlying rocks by Dr Oldham There are also the Rajmahal group, and the tertiary series of the Khasia hills The data for this classification of the coal bearing rocks consist of the remains of plants

In the eastern coal fields there are five well marked sub divisions

1 The Talchir beds, the lowest, in which no coal is known, so called by the Blanfords, from the district in Cattack where they were first examined
2 The Barakur beds, formerly called Lower Dámodar
3 Ironstone shales
4 Raniganj beds
5 Panchet beds, or upper series First separated as a distinct sub division, and so-named by Mr Blanford They are of the triassic epoch, and contain bones of labyrinthodont and dicynodont amphibia Panchet is the name of a remarkable hill, and the title of a rajah

To the westward these become three

1 Talchir
2 Barakur
3 Panchet

[1] An affluent of the Hugli, rising in the province of Chota Nagpur, and flowing through the Bancurah, Burdwan, and Hugli districts of the Lower Provinces of Bengal

Dr Oldham's general conclusions, respecting these coal series, are that the drainage basins of India were marked out and existed at the enormously distant period when the deposition of the great plant bearing formations commenced All the successive beds represent an enormous lapse of time, and seem to be fresh water or estuarine deposits He also concludes that the present limits of the coal measures coincide with the original limits of deposition, and are not the results of faulting or even mainly of denudation,[1] The Dámodar system is believed to represent the Permian period of European geology, together with a portion of the upper carboniferous epoch

Since 1870 the coal bearing stata, in all parts of India, have been actively explored In 1871 Mr Medlicott was examining the Puchmari hills and the Mohpari coal fields in the south part of the Narbada valley, where he had a severe attack of fever, and in 1872 he was engaged upon the Satpura coal fields, and again in 1875 Mr Mallett at the same time explored the Kota coal field extending into Rewah and Chota Nagpur, and in 1876 he examined the coal fields of the Naga hills and Upper Assam In 1872, Mr Blanford mapped the coal bearing rocks of the Godavari series, and borings were carried on under Mr Vanstavern, the Executive Engineer But the beds in that district are thin and irregular, and the area small Mr Blanford further extended his investigations into the sandstone area to the east of the Nizam's dominions, and south towards Ellor, which appears to belong to true coal bearing rocks

The Chanda coal was first discovered by Major Lucie Smith, the Deputy Commissioner of the Central Provinces in 1866 Mr Blanford visited the localities in 1869 and recommended borings Mr Mark Fryar, a mining engineer, was sent to Chanda to explore the beds regularly in 1869, and two skilled borers with the necessary tools were sent out from England

Mr Hughes was at work in 1871 at the Warda coal fields, and two pits were sunk to the coal at Warora and Pisgaon Mr Whyte made similar researches in the adjacent part of the Nizam's dominions, proving the existence of coal 50 feet thick at Sastu During 1875 Mr Hughes was working up the geological maps of

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[1] See Dr Oldham's papers "On the Geological Relations and Probable Geological Age of the Several Systems of Rocks in Central India and Bengal," ("Memoirs," vol ii, p 299), and "Additional Remarks" in ("Memoirs," vol iii, p 198)

the Chanda country, with especial view to the coal fields of the Warda valley In 1871 Mr King took up the Godavari valley work in continuation of Mr Blanford's survey, and discovered the most southern Indian coal deposit at Singareni In 1876 Mr King made a traverse up the Godavari valley, to bring his work into connexion with that of Mr Hughes in the Warda and Pranhita valleys

Dr Oldham has, from time to time, prepared returns of the amount of coal raised In June 1859 he furnished one of the Raniganj fields; in 1861 returns were given in Mr Blanford's Report,[1] and in June 1861 the first general statement of the out-turn of Indian coal was given by Dr Oldham In March 1867 he prepared a Report on the coal resources of India, for the Secretary of State, with results from 1861 to 1866, and in June 1869 he sent in a Return for 1868, with statistics of the methods of working the coal, and statements tabulated for each year from 1858 to 1868

In 1868 the number of tons of coal extracted throughout India was 497,000, of which 493,000 came from Raniganj In 1872–73 the out-turn was 322,433 only

Iron producing minerals are widely scattered over India, and consist, 1st, of magnetic and specular iron ores and red hematite in beds and veins, 2nd, of clay iron ores from the coal bearing strata, and, 3rd, of surface deposits derived from the waste of metamorphic and sedimentary strata, and from laterite The latter formation contains from 20 to 30 per cent of iron Some of the most remarkable deposits of magnetic iron ores are in the Salem districts of the Madras Presidency, where they occur in immense beds At Lohara, in the Chanda district, there are two localities where hematite abounds, and in the Narbada valley there are large quantities of hematite ore The clay iron ores of the Dámodar coal fields yield 39 per cent of iron, and the Kumaun iron ores form an argillaceous band containing large quantities of red hematite Iron has been manufactured in India from time immemoral in a rude primitive way, but all attempts to manufacture iron, made by the English, have hitherto utterly failed

In 1825 Mr Heath of the Madras Civil Service formed a Company, aided by a Government advance, to establish iron works at Porto Novo, near Cuddabar, at Palemputi, near Salem, and at

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[1] "Memoirs," iii p 179

Beypur, where the iron was obtained from the laterite But, in spite of Government aid, there was nothing but failure attributed to the distance of the works from the source of supply, to scarcity of charcoal, and to other causes Company succeeded Company, and at last there was an utter collapse In 1857 Mr Sowerby, an engineer, reported on the iron ores in Kumaun, but the Company which attempted to work them was a failure, and operation ceased in 1863 [1] The Government erected works at Burwai in the Narbada valley under the auspices of Colonel Keatinge, and a Swedish metallurgist named Mitander took charge, but in 1864 the works were suddenly closed In 1872 Mr Bauerman was sent out to report the possibility of manufacturing iron profitably in India, and his conclusion was that the Raniganj coal field was the most promising place for a trial, an opinion which is concurred in by the officers of the Geological Survey Indeed, Mr Bauerman has simply restated the case as it has all along been expressed by the members of the survey

The next investigation is that respecting the alluvial deposits of the Ganges valley, which was commenced in the first year of the survey In 1859 the portion from the Bhagrati northwards to the foot of the hills was examined and mapped In 1860 Mr Theobald was fixing the boundaries and extent of recent alluvial deposits from Bardwán to Monghir In 1861 the investigation was continued over the plains south of the Ganges to Patna and Shahabad, and in 1862 the examination was completed

The geological survey of the important formations in Central India was also a great object [2] In 1855 Mr J G Medlicott passed from Jabalpur westward down the Narbada valley, while his brother crossed the Rewah country and the river Son to the Singrauli coal field Both considered that the sandstone rocks of Rewah and Bandalkhand should be entirely separated from the sandstones associated with coals in Bengal and in the Narbada valley Dr Oldham visited the same country in 1856, and gave the name of VINDHYAN to the entire group, because it is best seen in the scarped mountains of that name on the northern side of the Narbada valley [3] It includes the diamond yielding rocks of Central

[1] On the Iron Ores of Kamaun *See* "Geological Records," vol vii (1874)

[2] Mr J G Medlicott compiled the "Cotton Handbook" for Bengal in 1862, for the Government

[3] "Memoirs," vol ii, p 1, "On the Vindhyan Rocks and their Associates in Bandalkhand" "Geological Structure of the Central Portion of the Neerbudda

India, and is one of the most remarkable and interesting series in the country Hitherto no fossils have been found in it Its age cannot therefore be determined, but the Vindhyan rocks are older than the carboniferous series in India In 1863 Mr Mallet was engaged in tracing out the divisions and boundries of this formation in Rewah, while Mr Hackett worked out the limits of the trappean rocks in Sagar, and Mr H B Medlicott was closing up the gaps in the geological mapping between Central India and the Son valley In 1864 Mr Mallet revised the boundaries of the Vindhyan rocks north of the Narbada valley, covering 2,200 square miles of ground, while Mr Hackett examined the Gwalior country During this year Dr Oldham himself examined the rocks on the south bank of the Ganges, from Gaya to near Bhagalpur In 1867 Mr Medlicott undertook the investigation of a wild and difficult country from Raniganj and Hazaribagh in the Damudar basin to the basin of the Mahanadi He came again upon the old Vindhyan rocks, chiefly limestone, which cover 12,000 square miles, abutting against crystalline rocks to the north, and passing under the Deccan traps to the south and west In 1869 Mr Willson was at work in Jhansi, to connect with Mr Hackett in Gwalior,[1] and Mr Mallet was in the Son valley He explored a remarkable series of trappean dykes and quartz reefs in the north of Rewah, and in 1874 extended his work into Bandalkhand, continuing it in 1875 In 1875 Mr Hackett was at first engaged in Rajputana, and afterwards in Ulwar

A complete and connected history of the Vindhyan formations has been drawn up by Mr Mallet and still more recently Mr Blanford has re examined part of the Vindhyan series, but he could find no fossils to determine their age, which therefore still remains unsettled

Mr H B Medlicott, then Professor of Geology in the Rurki College, commenced the examination of the Sawalakhs, and upper

District,' p 95 "Tertiary and Alluvial Deposits of the Narbada Valley,' p 279 "The Vindhyan Series,' vol vii, pt 1 Dr Oldham proposed the name VINDHYAN in a paper in the "Journal of the Asiatic Society of Bengal,' xxv p 249 See also his paper on the "Geological Relations of the Rock Systems of Central India and Bengal —"Memoirs," ii, p 299 There is a useful list of all papers relating to the Narbada valley, published previously to the date of Vol ii of the "Geological Memoirs," at page 387

"Records," vol ii, pt 2, "Sketch of the Metamorphic Rocks of Bengal"

[1] "Records," vol iii, pt 2, "Geology of Gwalior and Vicinity"

and outer Himalaya, in 1859, during the intervals of time that his collegiate duties permitted of his taking the field. His studies were more directed to the orographical relations of these hills than to their fossils. In the following years he continued his examination to near Kangra, and the results of his labours are embodied in a valuable memoir. These are the hills in which Dr Falconer discovered numerous mammalian remains. They are of miocene and post miocene age. Nummulitic rocks occur north of the Sawalakhs, and appear to form a large proportion of the ranges in the Punjab. Representatives of these tertiary rocks extend to the east, are found at the base of the hills in Sikkim, and stretch far up the Assam valley. Dr Hooker also found nummulites in Tibet, north of Sikkim, at 16,000 feet above the sea. One important consequence of Mr Medlicott's survey of this region was the discovery of a good water supply at Ambála. He reported that water bearing beds must exist there, and the trial confirmed his expectations.[1] Mr Medlicott also reported upon the *reh* efflorescence which has given rise to so much anxiety, and on the waters of the rivers and canals in the N W Provinces.[2] In 1875 Mr Medlicott, in conjunction with Messrs Theobald and Lydekker, commenced a revision of the tertiary rocks of the Punjab and North-West Provinces, with the main object of seeing whether the marked stratigraphical separation of two distinct groups of rocks in the Nahun country was accompanied by a distinction further west in their fossils.

In 1862 Messrs Theobald and Mallet were sent in the footsteps of Colonel Richard Strachey, to collect fossils, and trace out the succession of sedimentary beds on the northern slopes of the western Himalaya and in the Chini and Spiti valleys, up to an elevation of 18,000 feet. They were found to be identical with known species from Europe occurring in the same association. Triassic and oolitic beds are especially abundant about Spiti. In 1864 Mr Mallet, in company with Dr Ferdinand Stoliczka, who was formerly in the Austrian Geological Survey, and a colleague of Dr Hochstetter, were depatched to the Himalaya to work out their structure, and revise the fossil fauna. Undoubted representatives were proved to occur of the European Silurian, carboniferous, triassic, lias, jurassic, and cretaceous periods, and, out of 200 varieties collected, only 32

1 "Memoirs," vol iii, "On the Southern Portions of the Himalayan Ranges"

2 "Journal of the Asiatic Society," xx, p 326

are new[1] In 1865, Dr Stoliczka extended his investigations in the Himalaya as far as Leh, but in 1867 he went home with Mr Oldham

The great mass of the Himalayan ranges consists of metamorphic rocks, in places highly granitoid, in others slatey or schistose

The operations of the Survey were extended to the Madras Presidency in 1857 The party was in charge of Mr H F Blanford, and consisted of Mr C Oldham, Mr King, and Mr Geoghegan The latter gentleman died suddenly of sun stroke early in 1858, and was succeeded by Mr R Bruce Foote They were instructed first to examine the important group of cretaceous rocks in South Arcot and Trichinápalli, the fossils of which had been collected in former years by Kaye and Cunliffe, and thence to work northward In the first year Mr Blanford reported upon the geology of the Nilgiri hills[2] The survey of the highly interesting cretaceous formations was completed in 1861,[3] and in the same year King and Foote examined the iron deposits of Salem Mr H F Blanford then retired from the Survey[4]

The other members of the party, in 1862, commenced an examination of the hill range which separates Cuddapa and Karnal from Nellor, a very difficult and almost roadless country In 1863 Mr King traced the boundaries of these Cuddapa rocks, chiefly quartzites and slates, into Ballári and Karnál Mr Foote was engaged during the same year in examining rocks near Madras[5] He met with beds of marine fossils intercalated with others holding abundance of vegetable remains of the same species as have been found in the Rajmahal hills and in Kach This discovery of the wide extension of the Rajmahal series is a fact of high interest

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1 "Memoirs," vol v, "Sections across N W Himalaya from Sutlej to Indus "On the gypsum of Spiti' "Summary of Geological Observations in S Ladak, Western Tibet, &c," by F Stoliczka

2 "Memoirs," vol i, p 211, "The Nilghiri Hills" Dr Benza wrote papers on the geology of the Nilgiris and Kundahs, on that of the country between the Nilgiris and Madras, and on the geology of the Northern Circars, in the "Madras Journal of Literature and Science,' in 1835–36, vols iii and v

3 "Memoirs," vol iv, "On the Cretaceous Rocks of the South Arcot and Trichinopoly Districts," by H F Blanford "On the Structure of the Districts of Trichinápalli and Salem" "On the Occurrence of Crystalline Limestone in the vicinity of Trichinápalli,' by W King —*Madras Journal*, iv N S, p 271

4 He wrote papers on the occurrence of crystalline limestone in Coimbatoi, and on the geological age of the Sandstones at Trivicari, near Pondicherry, in the "Madras Journal of Literature and Science, iii N S, p 60, and iv N S, p 47

5 "Records,' vol iii, pt 1, "Notes of the Geology of the Neighbourhood of Madras"

The Cuddapa formations appear to represent an older portion of the great Vindhyan series The diamond beds of Southern India occur in these formations, and they show very favourable traces of lead, copper, and iron The main object of the geologists was to work out the true succession and extent of these remarkable and interesting series of quartzite, slate, schist, and limestone beds in Cuddapa, Nellor, and Karnál In 1866 Mr Foote was working along their eastern and Mr C Oldham up their western boundaries, while Mr King was in the centre They completed the area in Cuddapa and Karnal during 1868, when the Superintendent took an opportunity of testing the accuracy of their mapping, and in 1869 Mr Foote began to work across the Raichur Doab towards the Bombay Presidency Mr King has drawn up a general report on the entire series[1] During the hot weather in each year the gentlemen of the Madras Survey were usefully employed in arranging and cataloguing the fossils and minerals of the Madras Central Museum, for Captain Mitchell, the curator, and Mr C Oldham, followed by Messrs King and Foote, have delivered a series of lectures on geology at the Madras Engineering College Mr Oldham went home on leave in 1868, and died from the effects of disease contracted in India in April 1869 An able and talented geologist, and a painstaking conscientious public servant, was thus lost to his country Mr King, in subsequent years, explored the Tungabadra valley up to the boundary of the great area of Deccan trap rocks as far as Julberga His main object was to carry out an investigation of the several rocks which occur between the vast thickness of the trappean rocks above, and the even more widely spread base of underlying gneiss and metamorphic rocks below in the valley of the Bhima, overlying the gneiss Mr Bruce Foote examined similar rocks to the south-westward, in the upper part of the Krishna valley, carrying on the boundary line between the Deccan trap rocks and the underlying beds He found the fossilized remains of a rhinoceros in the *regur* or black cotton soil, and reported on the Dambal gold field in Dharwar in 1874, and on the geology of the Southern Mahratta country in 1875

The Geological Survey of British Burma was commenced in 1860, under Mr W T Blanford, with the Henzada district in Pegu, where there are petroleum wells and salt springs This district was selected because it was the only one of which there

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[1] "Records," vol ii, pt 1, "On the Kuddapa and Karnál formations"

were reliable maps, and the future direction of geological researches had to depend on the publication of the results of the Topographical Survey Mr Blanford was transferred to Bombay in the following year, and Mr Theobald took charge in Burma, indeed he was single handed He was at work in the Yoma range and on the west coast, but was much hampered in his operations by the want of trustworthy maps The great Yoma range is composed of slightly altered sandstones and shales of unknown age, but expected to be in part at least cretaceous Upon them, in Pegu, rest nummulitic rocks Some peculiar serpentines are associated with the Yoma rocks In 1864 Mr Theobald took advantage of the publication of a sheet of the Survey by Captain Fitzroy to complete the geological examination of the country contained in it, including Rangoon, and in the two following years he and Mr Fedden were at work in the ground covered by the second sheet, east of the Irawadi and north of Prome In 1864–65 Mr Fedden accompanied an expedition through the Shan provinces of the kingdom of Burma to the Salwin river, and constructed a map of the route. In 1867 Mr Theobald went home, after a continuous service of 18 years But in 1868 he was again at work in the Prome district of Pegu, the east part of which he completed, taking up the western banks of the Irawadi, where there is a formation of mummulitic rocks, in 1869 [1] Mr Theobald completed the geological survey of Pegu in 1873, having been at work since 1864

Mr Blanford took charge of the party in the Bombay Presidency, with Mr Wilkinson and Mr Wynne as his assistants, in 1863 He commenced at Surat, and on the shores of the gulf of Cambay, with the view of connecting his work with that of Medlicott in the Narbada valley, and thus completing a band of geological survey across India from sea to sea, on that parallel In the following season the line from sea to sea, containing some of the most important formations in India, was completed The hill ranges north of Gujrát are partly metamorphic and partly trap, and not far from the coast nummulitic rocks are found resting on the trap Mr Wilkinson also examined the Western Ghats in the rocks of Mahabaleswar, Ratnagiri, and Sawant Wari, and Mr Wynne

1 "'Records,' vol ii, pt 4, "On the Beds containing Silicified Wood in Eastern Prome"

,, vol iii, pt 1, "On the Alluvial Deposits of the Irawadi"

,, vol iii, pt 3, "Note on Petroleum in Burmah" investigated the geology of the island of Bombay, and showed how erroneous the previous conclusions respecting its structure had been in some respects [1]

In 1863 Mr Blanford was detached to report upon a supposed discovery of coal near Kotri, in Sindh, for the Bombay Government [2] He found it to be lignite and of no commercial value, but on his return he took the opportunity of visiting the interesting formations in Kach [3] In 1865 the northern declivities of the Narbada valley were reached, and a tract of 5,000 square miles was examined, chiefly trap with bottom rocks of granite or gneiss In 1866 Mr Blanford was at work in the upper Tapti and the Purna and Wurda valleys,[4] and reported upon the Chanda coal fields He was usefully employed in Abyssinia, and in completing the publication of his results, during the greater part of the two following years, and in 1870 he returned to his old work in the Central Provinces, with Mr Hughes and Mr Fedden as assistants He has since reported on the coal and lead ores in Chatisgarh [5] Mr Blanford is an accomplished naturalist, as well as an able and experienced geologist, and during the period that he was employed on detached duty in Abyssinia he did work of the highest scientific value In 1872 Mr Blanford was employed in Persia, examining the geology and natural history, and accompanying Major St John on a journey to Makran The valuable results of his work are embodied in the two official volumes on Eastern Persia, and he returned to India, after being occupied for some months in preparing his portion of the work for the press in England, in December 1873 [6] He then proceeded to Sindh, with Mr Fedden, and by the end of 1875 these two geologists had completed a sketch of the geology of the province In 1876 Mr Blanford traversed the great desert

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1 "Memoirs," vol v, "On the Geology of Bombay"

2 Ibid, vol vi, pt 1, "On the Geology of the neighbourhood of Lynyan and Runneecote in Sind"

3 Ibid, vol vii, pt 2, "On the Geology of a Portion of Cutch"

4 Ibid, vol vi, pt 2, "The Traps of Western and Central India," by W T Blanford

" pt iii, "The Taptee and Lower Nerbudda valleys"

5 "Records," vol ii, pt 1, "The Valley of the Poorna River"

" vol ii, pt 4, "Lead in Raipur District"

" vol iii, pt 2, Ibid

6 "Eastern Persia," vol ii The Zoology and Geology, by W T Blanford, F R S, with numerous coloured illustrations, pp 516 (Macmillan 1876)

to Jasalmır and Jodhpar, while Mr Fedden made an excellent collection of fossils [1]

After Mr Blanford's visit to Kach in 1863, Mr Wynne was sent to make a fuller and more exhaustive examination of the rocks in that district There was an important question as to the relation of certain beds of fresh water origin containing imperfect layers of coal and plant remains, with others which yielded marine fossils of undoubted jurassic age in Kach Mr Blanford decided that the two groups were intercalated and not superimposed, and thus fixed the age of the plant beds He also ascertained the extension of the Deccan trap rocks into Kach Mr Wynne reported that the jurassic rocks occupied a large portion of the northern half of the province, and also formed the hilly parts of the islands in the Rann His complete report and map have not yet appeared [2]

In 1870 Mr Wynne proceeded to the Punjab, to take up the geology of that important province, and reported upon the geology of Mount Tilla [3] He completed the eastern portion of the Salt Range in 1870, and was at work on the western part in 1871, which he also completed In 1873, accompanied by Dr Warth, he surveyed the Trans Indus Salt Range, and Dr Waagen examined the relations and mode of occurrence of fossils in the Salt Range

In 1874 Dr Stoliczka, the Palæontologist of the Geological Survey accompanied the mission of Sir Douglas Forsyth to Kashgar, and he died on the 9th of June on the road from Yarkand to Leh, when returning to India His death was caused by too great physical exertion at an extreme elevation and in a rarefied atmo sphere He was buried at Leh on the 23rd Ferdinand Stoliczka had established for himself a sound reputation as naturalist and geologist in connexion with the Imperial Geological Survey of Austria He came to India in December 1862 and conducted the *Palæontologia Indica* The whole of the four volumes in which the cretaceous fauna of Southern India is described are his work He also devoted two summers to an examination of the fossils of the Himalaya, and in that time he laid the foundation of all future work

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1 See Mr Blanford's paper on the "Geology of Sind" *Records* 1876, Feb p 8

2 "Memoirs," vol ii, pt 3, "Preliminary Notes on the Geology of Cutch" See also a "Report on the Geological action on the south coast of Kattiwar and in the Runn of Cutch," by William Sowerby, C E —*Bombay G S Journal*, xviii, p 96

3 "Note on the Petroleum Locality near Rawal Pindi, by A B Wynne"—"Records," vol iii, pt 3, p 73 "Geology of Mount Tilla," by A B Wynne Ibid, pt 4 p 83

in those regions. A suitable monument is to be erected over his grave at Leh, and a memorial tablet in the Calcutta Museum, to which he bequeathed all his private collections. A record of the results of Dr. Stoliczka's scientific investigations as naturalist to the Kashgar mission will be published by the Government of India. Dr. Stoliczka was succeeded, as Palæontologist, by Dr. Waagen, who had previously written valuable papers on the jurassic fauna of Kach, and on the fossils, of the Salt Range; but he was obliged to retire from ill health in 1876. Meanwhile Mr. Lydekker and Dr. Feistmantel had been appointed to the Survey in 1875.

During the examination of Indian rocks, geologists have not failed to discover traces of a race of men belonging to that stone age, the history of which has been so carefully examined in Europe by Sir John Lubbock and other writers. In 1864 Messrs. King and Foote discovered chiselled stone implements spread widely over the country west and north of the town of Madras, all of the ruder type, and made of semi vitreous quartzites from the Cuddapa rocks. In 1864 Mr. Ball found a chipped implement in the Jheria coal field, and Mr. Theobald found others in Burma. A chipped stone weapon of hard, close grained quartzite was found near Nimach by Mr. Medlicott, and in 1868 the Madras implements were traced up to the banks of the Krishna. More recent observations have shown that these implements occur over a much larger extent of country to the north of the Krishna river, and close to the southern edge of the region examined by Mr. Blanford on the Godavari.

The superintendence and control of all the geological operations have devolved upon Dr. Oldham, the Superintendent of the Survey, besides the direction of the museum and the publications. He has, in addition to his ordinary duties, been constantly called upon to make special reports to the Government on such points as the propriety of sinking Artesian wells in particular localities, on the structure of rock to be cut through for engineering purposes, on the selection of lines of railroad with reference to the position of coal fields, and on proper sites for barracks. He must have travelled over many thousands of miles, sometimes to confirm the importance of useful discoveries, at others to expose mares' nests. A brief sketch of the extent and objects of these journeys will convey some idea of Dr. Oldham's labours.

In 1860, Mr. Oldham went to Kumaun to report upon the iron works, which he considered to be essentially a practical and not a geological question. In 1862 he went to England to seek for assistants, and brought five out with him. In 1863 he was engaged on the investigation of the modes of deposit of lignite in the Salt Range, in the northern part of the Punjab. The Salt Range contains an extensive series of carboniferous, triassic, oolitic, and tertiary rocks. In 1867 he was again in England for a few months. In 1868 he went to examine some alleged coal bearing rocks near the Krishna, but found that nothing of the kind existed in that region. Later in the year he went to Attock, to examine the rocks on the Indus through which the tunnel drift is carried. He saw nothing to prevent its being enlarged into a regular road way, so far as the nature of the rock is concerned. Afterwards he examined the Gurgaon and Dhurmsala districts in the North-West Provinces, with regard to the possibility of utilizing the kaolin clay; and in 1869 he visited the scenes of the earthquake in Cachar and Silhet. He has since prepared a list of earthquakes that have occurred in India.[1] In this year he was also engaged in important work at the Chanda coal field.

A small museum of economic geology was established at Calcutta in 1840, under the direction of Captain Piddington,[2] who was curator for some years before his death, and made many useful analyses. His careful experiments to ascertain the quantity of silt in the Hugli at different seasons were especially valuable. In 1856 the museum was placed in connexion with the Geological Survey, and under the superintendence of Dr. Oldham. As early as 1859 it contained 1,000 specimens of fossils, minerals, rocks, and ores. The various members of the Survey of course contributed; so that there are good series of cretaceous fossils from Madras, of fossil plants from the Rajmahal hills, of tertiary fossils from the Spiti valley, of minerals obtained by Mr. Blanford on the Bhore Ghat, of fossils from the Salt Range and the jurassic beds of Kach, and from other places. But the great boast of the museum is its collection of meteoric stones. It contains specimens from 247 falls, and in this branch its collection ranks among the first in the world. A very complete geological library has also been gradually formed.

The museum is of great practical use, as its officers are constantly

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[1] Colonel Baird Smith had previously compiled a memoir on Indian Earthquakes, in three parts.—*Journal of the Asiatic Society of Bengal*, vols. xii., p. 257 and 1227, and xiii., p. 964.

[2] Piddington's Memorandum on the establishment of the Geological Museum is printed in "Thuillier's Manual of Surveying." Appendix, p. xxxiii.

applied to for information, and to supply assays and analyses for companies and private individuals, as well as for the Government

The publications of the Geological Survey, under the direction of Dr Oldham, consist of "Memoirs," "Records," and the "Palæontologia Indica"

The "Memoirs," which have now reached to the twelfth volume, are the detailed and matured results of the survey of each district, written by the geologist who has conducted it The volumes are fully illustrated with maps, sections, and sketches

The "Palæontologia Indica," is a superb series, containing figures and descriptions of the organic remains procured during the progress of the Survey The volumes already issued contain the cephalopoda and gasteropoda of the cretaceous rocks of Southern India, the fossil flora of the Rajmahal series, the vertebrate fossils of the Panchet rocks and the fossils of Kach The Panchet fossils are described by Professor Huxley They are bones of fossil reptiles, hitherto only known in South Africa

The "Records" were commenced in 1868, and are published quarterly in rather small type and on thin paper, for ready transmission by post They contain the Superintendent's annual reports, brief abstracts of the labours of members of the Survey in the field during the quarter, and other papers of general interest [1]

There is a vast field still spread before the Geological Survey of India, a great work yet to be achieved, though much certainly has already been done They must be animated by a noble devotion to the cause of science—these Indian geologists, for theirs is neither a safe nor an easy task Out of the two dozen or so that have entered the Survey since it commenced, 34 per cent have been struck down by death or incapacitating disease The rest work on zealously and bravely, reflecting honour on English administration by the results of their labours, extending the sum of human knowledge, and doing much practically useful work [2]

In spite of all difficulties of climate, inaccessibility of districts, and slowness of means of travel, they have examined an area about five times as large as Great Britain

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[1] We have ten of Dr Oldham's Annual Reports, 1858 to 1868 in separate covers, and the rest to 1875, bound up in the "Records"

[2] There is a short notice of the operations of the Geological Survey of India, by H Woodward, Esq, in the "Quarterly Journal of Science," for Oct 1870, No xxviii, p 458

In February 1876 Dr Oldham resigned his appointment as Superintendent of the ~~Great Trigonometrical~~ Survey, which he had held since 1851, owing to ill health For a quarter of a century this distinguished geologist has presided over the labours of the geological surveyors He created the survey, and its present advanced position is due to his great ability, learning, and un wearied exertions He was succeeded by Mr H B Medlicott

# XV
# THE ARCHÆOLOGICAL SURVEY OF INDIA

A SURVEY of the archæological remains throughout India, which are as important as regards art, as they are indispensable to the study of history, has only of late years been considered to be a work which comes within the province of the Government to undertake. This is the more to be regretted because the loss of time is irreparable. All investigations connected with physical science are almost independent of delay, and can be made as well in one year as in another, but archæological remains are liable to deterioration, and delay causes absolute loss. Paintings fade from walls, sculptured edifices are destroyed by the vigorous growth of trees, and by ruthless modern builders in want of material, coins and inscriptions are mislaid or effaced, and all the works of man suffer more or less under the hand of time. In connexion with geography, the study of archæology forms a most important branch; for, through the identification of ancient sites, the physical changes that have taken place in a country are determined.

Yet it was not possible that a survey of this nature could have been entered upon with any useful result before the English occupation, or even until long after our power was established. Mere descriptions of ruins and other remains are of little use unless the observer has mastered their history and true significance, and this was impossible until the study of the languages and literature of India was well advanced. Thus the earliest accounts of Indian archæological remains were only useful in exciting an interest in the subject, and in stimulating later enquirers to labour at those studies which alone could qualify them, and others of later generations who benefited by their works, for the task of investigating the mysteries of Indian chronology and art.

Glowing descriptions of the architectural monuments of India are not wanting among the writings of early travellers.

The Hindu capital of Bijayanagar is described in the works of Varthema,[1] Nicolo di Conti, Abdu 'r-Razzak, Nikitin,[2] Barbosa,[3] and

[1] Hukluyt Society's Translation, p. 125.

[2] The narratives of Conti, Abdu r Razzak, and Nikitin will be found in the Hakluyt Society's volume, entitled "India in the 15th century."

[3] Hakluyt Society's volume, entitled "The Coasts of East Africa and Malabar," p. 85.

Cæsar Frederick,[1] the beauties of Bijapur were noticed by Tavernier,[2] and Finch, Thevenot, Bernier, and others, who visited the court of the Mogul, did not fail to recount the wonders of Agra and Delhi. The cave temples of Western India also received attention from early travellers. Thevenot[3] and Anquetil du Perron explored the caves of Ellora, Linschoten, Boon,[4] Anquetil, and Salt described Salsette, Salt was at Karli with Lord Valentia, and the famous cave of Elephanta was visited and described by Niebuhr, Fryer, Hamilton, Anquetil, Lord Valentia, and others.[5]

The perusal of some of these authors had filled the mind of Sir William Jones with a keen interest in the literature and antiquities of the East, and his arrival at Calcutta is the epoch from which any attempt at the systematic investigation of Indian antiquities dates. The Asiatic Society at Calcutta was instituted on the 22nd of January ~~1874~~, and a centre was thus formed to which individual 1784
inquirers might forward the results of their labours, and from which they might derive assistance and advice. In the absence of an exhaustive survey under the direction of the Government, such an institution as the Asiatic Society was invaluable. Warren Hastings was obliged to decline the post of President, which he was so admirably fitted to occupy, from want of leisure to perform the duties, and Sir William Jones presided over the proceedings of the society from its first institution until his death. A branch of the Asiatic Society was formed at Bombay by Sir James Mackintosh in 1804. The Madras Literary Society, under the auspices of Sir John Newbold, the Chief Justice, was established in 1818.

The results of the early labours of English antiquaries in India are recorded in the twenty volumes of the Asiatic Researches from 1788 to 1836, in the three volumes of the Transactions of the Literary Society of Bombay, 1819–21, and in the opening numbers of the Journal of the Madras Literary Society, which was commenced in 1827.

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1 Viaggio di M. Cesare Federici nell' India Orientale (Venetia 1587), p. 32.

2 In Pinkerton.

3 Travels, Part III., Chap. 45 (Eng. Trans.)

4 Governor of Bombay.

5 See the "Archæologia," vii., p. 323. Linschoten mentioned the cave of Elephanta in 1579. Dr. Fryer describes the Salsette caves in his travels published in 1698, J. Ovington, 1689. Hamilton in his Voyage, I., chap. xx., p. 338, Anquetil Zend Avesta, I., pp. 234, 249, 419, 394.

The earliest labourers in the fruitful and important field of Indian archæology were Sir William Jones, Charles Wilkins,[1] Henry Colebrooke,[2] Francis Gladwin,[3] William Chambers, and Colin Mackenzie,[4] followed by Buchanan Hamilton[5] and Horace Wilson.[6] These learned and accomplished scholars were zealously assisted and furnished with material for their researches by numerous younger explorers who forwarded to them the results of their investigations in all parts of India.

The description and delineation of architectural remains were of great importance, but the deciphering of inscriptions on pillars, metal plates, or coins was most essential to the student of Indian history, for by that means alone could dates be obtained, without which history would have no coherence. The learning and sagacity and the indefatigable industry that have been brought to bear upon

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[1] Charles Wilkins went to Bengal, in the Civil Service, in 1770. After studying Sanscrit for several years, he translated the Bhagavat Gita, to which Warren Hastings prefixed a learned dissertation. The Court of Directors published this work in 1785. Wilkins prepared the first types for Bengali and Persian that were ever used in India. He returned home in 1786, and in 1795 he published his translation of Sacontala. He became Librarian of the East India House in 1800, in 1808 he published his Sanscrit Grammar, and he took an active part in the promotion of the Oriental Translation Fund. He was knighted by William IV, and died in Baker Street on May 13th, 1836, aged 86.

[2] Henry T. Colebrooke, son of Sir George Colebrooke, Bart., the Chairman of the East India Company, was born in London in 1765. He went out to India as a writer 1782, and in 1794 undertook the translation of a digest of Hindu Law, compiled under the direction of Sir William Jones. In 1803 he was at work on a Sanscrit grammar, and published the first volume in 1805, but abandoned the rest, owing to the publication of the grammar by Wilkins. Colebrooke became a member of Council at Calcutta in 1805, returned home in 1815, and died in 1837. His works are the "Digest of Hindoo law" (4 vols., folio, 1798), the first volume of a Sanscrit grammar (1805), lexicon (1808), Sanscrit algebra (1817), and numerous essays in the *Asiatic Researches*, '*Transactions of the Royal Asiatic Society*,' &c.

[3] Translator of the Ayin Akbari.

[4] See page 73.

[5] Dr. Buchanan is well known for his explorations in Nepal, Mysor, and Malabar, and Burmah, and for his survey of Bengal.

[6] Horace H. Wilson went out to India as assistant surgeon in 1808, and was attached to the Calcutta mint. In 1813 he published Calidasa's "Cloud Messenger," and in 1819 the first edition of his Sanscrit dictionary appeared. In 1826 his "Hindu Theatre" was published. In 1812 he became Secretary to the Asiatic Society at Calcutta, and, after his return to England, he was elected Professor of Sanscrit at Oxford in 1833, and Librarian to the East India Company on the death of Sir Charles Wilkins in 1836. The last years of his life were devoted to the translation of the Rig Veda. He died on May 23rd, 1860, and his numerous works on Sanscrit literature and kindred subjects have been republished since his death.

the deciphering of inscriptions in India have never been surpassed, and have perhaps produced the most valuable results of archæological research in that country The importance of this branch of the investigation was felt from the very first Colonel Polier described the famous Buddhist pillar with its inscriptions, known as the Firuz Lat,[1] and a paper was contributed to the "Asiatic Researches" on the same subject by Colebrooke[2] Blunt[3] and Ewer[4] described the Katab Minar pillar at Delhi, and Harington and Buchanan contributed papers describing the remains at Budh Gaya[5] Charles Wilkins wrote six papers on the meaning of various inscriptions that had been forwarded to him,[6] and Colebrooke wrote an essay on inscriptions generally, especially on those found on ancient monuments[7] Several were also translated by Captain Fell from Hissar and Benares, containing genealogies of Indian dynasties[8], and Lieutenant Price translated a Sanscrit inscription on a stone found in Bandalkhand[9] Wilson contributed translations of three copper plates found in Chatisgarh[10] and of many Sanscrit inscriptions at Abu, which throw much light on the history of the Jain temples from 1189 to 1752[11] In the last volume of the Researches there are translations of various inscriptions found in the ruins of Bijayanagar by Mr Ravenshaw, with observations by Wilson They consist of genealogies of the kings and grants of land[12]

In the total absence of authentic materials for fixing dates in Indian written histories, very great importance attaches to all genuine monuments and inscriptions on stone or metal The principal discovery resulting from researches of this nature was made by Sir William Jones, and announced in his anniversary address

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1 "Asiatic Researches," i, p 379
2 ,, vii, p 175
3 ,, iv, p 313
4 ,, xiv, p 480
5 ,, i, p 276 "Description of the Ruins at Buddha Gaya," by Dr Buchanan Hamilton —*Transactions of the Royal Asiatic Society*, ii, p 40

6 On a copper plate found at Monghir, i, p 123 on a stone pillar near Buddal, i, p 131 on Budh Gaya, i, p 284, on an inscription near Gaya, ii, p 167 on Islamabad, ii, p 383, and another on Budh Gaya, i, p 276

7 ix, p 398
8 xv, p 387
9 xv, p 437
10 xv, p 499
11 xv, p 284
12 xx, p 1

delivered on the 28th of February 1793.[1] It had been a question where the city of Palibothra was situated, which was visited by the Greek ambassador Megasthenes. Sir William discovered in a Sanscrit book that Hiranyabahu or "the golden armed," which the Greeks changed into Erannaboas,[2] was only another name for the river Son. This discovery led to another of great moment, for King Chandragupta actually fixed the seat of his empire at Pataliputra at the mouth of the Son (the Palibothra of Strabo), and was no other than the very Sandracottus who concluded a treaty with Seleucus Nicator. Thus Sir William Jones fixed the first great landmark in the ancient history of India. He reserved his proofs for a future essay, but his interesting labours were cut short by a premature death.

Detailed descriptions of ruins and other architectural remains were also contributed to the "Asiatic Researches." William Chambers visited the famous ruins on the Coromandel coast known as the Seven Pagodas or Mavalipuram in 1772, and again in 1776, and described them,[3] and another more detailed account of the Mavalipuram sculptures was furnished by Mr. Goldingham, the astronomer at Madras,[4] who also wrote an account of the cave of Elephanta. Sir C. Malet contributed a paper on the Ellora caves in 1794, with drawings by Lieutenant Manby,[5] and Colin Mackenzie described the pagoda of Perwuttum in a wild tract near the south bank of the Krishna,[6] and wrote an account of the Jains.[7] A full description of the grand Muhammadan ruins at Bijapur was written by Captain Sydenham in 1811, who also made a careful survey.[8] They had been previously described by Major Moor in 1794,[9] and when Sir James Mackintosh visited them in 1808 he called Bijapur the "Palmyra of the Deccan."

The antiquaries on the Bombay side of India emulated the example of their brethren at Calcutta. Mr. Salt, Lord Valentia's

1 "Asiatic Researches," iv, p. 11.
2 Strabo XV, c. i and ii, 1, 9.
3 "Asiatic Researches," i, p. 123.
4 ,, iv, p. 69.
5 ,, vi, p. 389.
6 ,, iv, p. 303.
7 ,, vii, p. 175.
8 ,, xiii, p. 433.
9 Major Moor's "Narrative of the Operations of Captain Little's Detachment," p. 310.

secretary, wrote an account of the caves in Salsette in 1806, illustrated by drawings and copies of sculptures[1] Mr Erskine drew up his exhaustive essay on the cave of Elephanta,[2] the whole conception and plan of which he truly describes as extremely grand and magnificent His account, which is correct and minute without being tedious, and is by far the best description of the cave that has been published, is illustrated by plans and copies of sculpture[3] It was written in November 1813[4] In 1819 and 1820 Colonel Sykes wrote accounts of the ruined city of Bijapur and of the Ellora caves[5]

In Madras the leading antiquary of the earlier period was Colin Mackenzie, whose labours have already been noticed[6] His vast collections of *sassanums* or inscriptions on stone and copper, of manuscripts and coins, have alone enabled the early history of Southern India and its dynasties to be understood and written[7] To Mackenzie's researches we owe Wilson's history of the great Pandyan dynasty of Madura,[8] and Dowson's paper on the Chera dynasty[9]

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1 "Transactions of the Literary Society of Bombay," i, p 41 The Rev J Stevenson afterwards wrote a paper "On the Rock Inscriptions of the Island of Salsette —*Journal of Bombay Branch of Asiatic Society*, iv, p 132

2 "Transactions of the Literary Society of Bombay, i, p 198

3 See also "An Account of the Cave of Elephanta,' by Mr Goldingham —*Asiatic Researches*, iv, p 407

"On the Three faced Siva at Elephanta," by Colonel Sykes —*Journal of the Royal Asiatic Society*, v, p 81

"The Theory of the Great Elephanta Cave," by Dr Stevenson —*Journal of Bombay Branch of Asiatic Society*, iv, p 261

4 William Erskine came out to India with Sir James Mackintosh in 1804, and was for many years a magistrate at Bombay He returned to England in 1823 When the Literary Society of Bombay was instituted in 1804 he became its Secretary Besides his paper on the Cave of Elephanta, he wrote an essay on the sacred books of the Parsees in 1819, and his valuable translation of the Memoirs of Baber was published in 1823

5 "Transactions of the Literary Society of Bombay' iii, pp 55, 265

6 See p 73

7 "Mackenzie Collection of Oriental Manuscripts," by H H Wilson 2 vols (Calcutta, 1828)

"1st Report on the Mackenzie MSS," by Rev Wm Taylor —*Madras Journal of Literature and Science*, vol vii, p 1 2d, 3d, 4th, and 5th Reports in vols viii and ix

8 "Journal of the Royal Asiatic Society,' iii, p 199

9 " " viii, p 1

A correct estimate of the beauty and magnificence of Indian architectural art, and of the interest which attaches to it, was furnished to our fathers by Thomas Daniell, an artist who passed the greater part of the last decade of the last century in traversing all parts of India, and executing water-colour drawings of the highest merit, of all the principal monuments and edifices His labours were given to the world in six large folio volumes, containing 120 coloured views engraved by himself and his nephew between 1797 and 1809 Here will be found most accurate drawings of the temples and palaces at Madura and Tanjore, and of the ruins at Mavalipuram, to represent the architecture of Southern India, the Taj Mahal, Akbar's tomb, and mosques at Juanpur and Delhi, as specimens of Muhammadan art, and the rock hewn temples at Salsette and Elephanta This work also contains an elaborate series of views of the caves at Ellora, drawn by Mr Wales, but engraved by the Daniells, as well as numerous general views They are drawn with such care and accuracy that they bear the test of comparison with recent photographs

Such were the advances that were made in the investigation of Indian antiquities during what may be considered as the first period of the study of the subject The second period is that in which James Prinsep took the lead—a man whose equal has rarely been found in acute reasoning and unflagging industry, backed by an enthusiastic love of research He added to rare gifts of intellect an amiable and generous disposition, giving all credit to his fellow labourers and reserving none for himself, so that men worked as much to please James Prinsep as for the sake of Indian archæology The son of an East India agent and nephew of Mr Auriol, Warren Hastings's secretary, James Prinsep was one out of seven brothers who obtained employment in India He was born in 1799, and was appointed assistant assay master at the Calcutta mint in 1819, serving under Horace Wilson In 1820 he became assay master at Benares, where he executed a series of accurate drawings of streets and buildings which were published by the Asiatic Society, and in 1825 his "Views and Illustrations of Benares" appeared In 1830 Prinsep returned to Calcutta, where he joined heartily with Major Herbert in his project of publishing a periodical called "Gleanings in Science," of which he became editor and proprietor in 1831, when Herbert accepted the post of astronomer at Lucknow He succeeded Wilson as assay master of the Calcutta mint in 1832, and became secretary to the Asiatic Society, altering the title of his "Gleanings" to that of "The Journal of the Asiatic Society of Bengal," the first number of which appeared on March 7th, 1832 It has been published monthly ever since For the remaining 10 years of his life James Prinsep devoted his energies to the solution of a most difficult problem, and his marvellous success has thrown new light on ancient Indian history, while it has immortalized his name among oriental scholars

The Buddhist remains were known to be the most important and the most ancient in India, but the numerous inscriptions connected with them were still unreadable puzzles The inscriptions on the pillars at Delhi and Allahabad had been copied and published, but they had baffled the scholarship of Jones and Colebrooke to decipher In the years 1835 and 1836, notices of James Prinsep's success in deciphering the inscriptions were published In 1834 Lieutenant Burt had written a description, with drawings, of the Buddhist stone pillar at Allahabad,[1] which was said by the Hindus to be the club with which the hero Bhima ground his bhang There are four inscriptions engraven upon it in different characters Of these the first is the same as that on the Delhi pillar, and the second is the same as the Gaya inscription, the key to which was supplied by Wilkins's translation[2] The name of Chandragupta, the king whose identity with Sandracottus had been established by Sir William Jones, occurs on the second inscription But the clue was first obtained when, in June 1837, Prinsep received copies made by Captain E Smith, of sentences cut on the pillars round the famous Sanchi tope or mound, near Bhilsa, in Central India[3] Each sentence ended with the same two letters, and it occurred to Prinsep, by a sort of inspiration, that these two letters represented the verb "to give," or "a gift" It was thus that he finally obtained a clue to the alphabet, and the language turned out to resemble the Pali of Ceylon He applied this alphabet to the inscriptions on the *lats* or pillars at Delhi and Allahabad, and the great discovery was completed They all proved to be the same series of edicts by the famous Buddhist King Asoka[4] The name on the pillars was

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1 "Asiatic Researches," iii, p 106
2 " i, p 279
3 "J A S B" iii, p 488, vi, pt i, p 451
4 " " p 257 Restoration of No 2 inscription on the Allahabad Lat, by Dr Mill

Pryadası, which Mr Turnour, the Palı scholar,[1] identified with that of Asoka

Among the most indefatigable of Prinsep's coadjutors was Lieutenant Kittoe, who investigated the ruins in Orissa, and discovered an important series of inscriptions on a rock at Dhauli, in Cattack He was also employed by Government to make excavations at Sarnath, near Benares[2] At about the time that Kittoe found the Dhauli inscription, a copy of the rock inscription at Girnar, in Gujrát, was made by Captain Lang, and sent to Prinsep in 1837 by Mr Wathen, and a third series was discovered at Kapur di Giri, near Peshawar, in the far north of India Prinsep studied the first two of these rock inscriptions with the utmost care[3] Those discovered by Kittoe at Dhauli, in Cattack, proved to be identical with those received from Girnar, in Gujrát, being a series of inscriptions by King Asoka The names of Antiochus the Great,[4] of Antigonus, and of one of the Ptolemies[5] occur and fix their date while the prohibition of the sacrifice of animals either for food or ceremonies, the order that medical aid shall be supplied for animals

"J A S B" vi, p 1 Restoration and translation of the inscription on the Bhitari Lat in Ghazeepore, by Dr Mill
" vi, p 451 Note on fac similes of inscription from Sanchi, taken by Capt E Smith
" iii, p 488 Copy of the inscription on the iron pillar at Delhi
" vi, pt 2, p 566 Interpretation of the inscriptions on the Firoze Shah and Allahabad Lats
" vii, p 219, Edicts on Girnar and Dhauli rocks
" vii, pt 1, p 434 Edicts on the Dhauli rock
" " p 456 More *denams*, sent from the Sanchi Tope by Capt Burt, and translated by Prinsep

1 *See* an account of these investigations in the introduction to Turnour's Mahawanso

2 Lieut Markham Kittoe wrote many papers in the *Journal of the Asiatic Society of Bengal* —"Journal of his tour in Orissa" (vii, pt 2, p 679), "A journey through the forests of Orissa" (viii, pts 1 and 2) "On the viharas and chaityas round Gyah' (xvi, pt 1, 272), "On Sculptured images on the temple of Grameswara in Cuttack' (xvi, pt 2, p 660) "On pillars found in the Ganges" (viii, p 681), "Notes on the places visited by F A Hian" (xvi, p 953) "Inscriptions at Juanpore (xix, p 454) On antiquarian researches (xvii, p 536), "The temple of Durga at Badieswar (vii, p 828) These contributions range from 1838 to 1850 He was Curator and Librarian to the Asiatic Society at Calcutta until 1838, when he was appointed to survey the road to Bombay He died soon after returning to England in 1853

3 "J A S B" viii, pt 1, p 156

4 " vii, pt 1, p 156

5 " " p 334

as well as men, that for the planting of trees and digging of wells by the roadsides, and the publication of precepts, prove that the royal lawgiver was a follower of the creed of Bhudda.

Important researches were successfully conducted in the north of India during the time of James Prinsep's editorship, which engaged his attention. Generals Ventura and Court, officers in the service of Rangît Sing, opened a tope at Manikyala, in 1830, and others between Jhelum and the Indus in 1833 and 1834. They found a gold box containing coins and relics; while Masson, Honigberger, and Gerard examined some equally interesting topes near Jalalabad.[1] Captain William Brown, of the Revenue Survey, also gave an account of the ancient temple and famous ship model at Hissar, in Prinsep's Journal.[2]

The copy of the Girnar inscription was not quite satisfactory, and through Prinsep's influence, Lieutenant Postans was employed by the Bombay Government to take exact fac similes. But James Prinsep had worn himself out by intense and continuous study. He was obliged to return home in a hopeless condition, and died on April 22nd, 1840.[3] Meanwhile, Lieutenant Postans took infinite pains to secure exactitude in his fac similes of the Girnar inscription, which were sent to Calcutta. They arrived too late. The guiding spirit of these investigations—the heart and soul of Indian archæological research—had already passed away. Prinsep sailed for England just before the results of the labours of Lieutenant Postans arrived. The manuscripts and cloth copies were thrown carelessly aside, and rotted in a godown at Calcutta.[4]

Prinsep's genius discovered the first positive dates in early Indian history, and opened to European scholars a mine of knowledge

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1 "Asiatic Researches," vol. xvii. "J. A. S. B." iii., p. 313. "Remarks on the Relic in the Manikyala tope by Prinsep," iii., p. 436 and p. 556. Masson on "Cabul Coins," v., p. 537.

2 "J. A. S. B., vol. vii., pt. 1, p. 429.

3 The seven first volumes of the "Journal of the Asiatic Society of Bengal" were edited by Prinsep, 1832–38. See a notice of him, written by his brother, at the beginning of "Essays on Indian Antiquities, by the late James Prinsep, edited by E. Thomas (2 vols. Murray, 1858). In this work Prinsep's essays were reprinted, owing to an increased demand for the early copies of the "Journal of the Asiatic Society of Bengal," in which they first appeared.

4 "Journal of the Bombay Branch of the Asiatic Society," i., p. 257. The Girnar inscription was again copied by Le Grand Jacob and the Danish Zend scholar Westergaard, and a second copy was sent to Professor Lassen.

which has been ably followed up by his disciples His conclusions were closely criticised, and were more fully established by the ordeal Horace Wilson[1] expressed doubts of the correctness of Prinsep's identification of the Pryadarsi of the inscriptions with the great King Asoka, but he has been completely answered by General Cunningham,[2] and the soundness of Prinsep's interpretations are no longer impugned The history of these discoveries, and a very complete and interesting notice of Asoka, his religion and government, was published by Sir Erskine Perry[3]

The third and last period of Indian archæological research, extending from the death of Prinsep in 1840 to the present year, has been one of great activity, the zeal and scholarship of Prinsep having been inherited by numerous successors Cunningham and Maisey in the north, Meadows Taylor and Wilson in Bombay, Walter Elliot in Madras, have taken the lead, and they have had many followers; while photography has lately increased the means of illustrating and elucidating their researches But it is to Fergusson that European inquirers are most indebted for having brought a knowledge of Indian architecture within their reach, and for having systematized and rendered clear the chronology and history of eastern art, while he has explained and illustrated its rare beauty and excellence A brief notice of his labours will be a fitting prelude to the enumeration of the various archæological researches of the last thirty years

Mr James Fergusson, having, as far as he was able, qualified himself for the task of thoroughly investigating the architecture and antiquities of India, left England in 1829, with the intention of availing himself of any opportunities of pursuing his inquiries that might be offered him, and which his professional engagements would admit of During his residence in Jessor, from 1829 to 1833, he repeatedly visited Dacca, Rajghur, and the few other places in the Ganges Delta which contain any remains of architectural art In 1834 he went to Benares, and thence visited Agra and Delhi,

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[1] "Rock Inscriptions of Kapur di Giri, Dhauli, and Girnar," by H H Wilson — *Journal of the Royal Asiatic Society*, xii, p 236

[2] "Bhilsa Topes," p 100

[3] "Journal of the Bombay Branch of the Asiatic Society," iii, p 149 Sir Erskine's notice is chiefly based on Lassen's "Indische Alterthumskunde"

returning by way of Dig and Jaipur, Canouj, Lucknow, and Jaunpur, and visiting all the cities on the Ganges as far as Gour and Murshidabad In 1836 he was present at the festival of Juggernath at Puri, and visited all the places of interest in Cattack In 1839 he again visited most of the cities in the Gangetic valley, including Agra and Delhi, and went on as far as the Sutlej He also passed four months in wandering through Central India, visiting most of the principal cities of Rajputana, as far west as Abu, and thence making his way to Bombay, by Ajunta, Ellora, and Karli He examined these caves, as well as those of Salsette and Elephanta, before leaving Bombay on his return to England in 1839 Mr Fergusson had occasion to revisit India in 1842, and he took the opportunity of making a coast voyage from Bombay to Goa, Cannanore, and Calicut, thence crossing the peninsula by way of Tanjor, Trichinápalli, Chellumbarum, Conjeveram, and the rock cut temples at Sadras He thus made himself acquainted with the architecture of Southern India During all these journeys Mr Fergusson kept a careful record of what he saw, and made drawings of everything of interest The next object was to give the results of his investigations to the world, and in 1843 he read a paper before the Royal Asiatic Society on the "Rock cut Temples of India,"[1] which may be considered as having placed the theory of the age and uses of those monuments on a basis of certainty, which has never since been called in question This paper was followed, in 1847, by a folio volume of plates entitled "Picturesque Illustrations of Ancient Architecture in India," with an introductory historical essay and full descriptions of the plates He intended to have continued the work by publishing similar volumes on Buddhist, Jaina, and Muhammadan architecture, but the expense was so great and the encouragement so small that the idea was abandoned Since that time various papers by Mr Fergusson on the architecture of India have appeared in the transactions of learned Societies, and chapters on all its branches are given in his handbook, and with greater fulness and detail in his "History of Architecture" The great project, to which all these steps were merely preliminary, was the completion of an illustrated history of Indian architectural art

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[1] Printed in vol viii of the "Journal of the Royal Asiatic Society," and afterwards published separately in 1845, with a folio volume of plates

The luminous classification of Indian architecture by Mr Fergusson furnishes the means of reviewing the researches of the last 30 years in a more systematic way than was possible in the case of earlier labours, in days when the distinctions of time and race were only very imperfectly understood The subject is now divided under the following heads

1 Prehistoric archæology of India
2 Buddhist monuments (The Aryans who composed the Vedas built no permanent edifices )
3 Dravidian architecture of Southern India
4 Bengali architecture
6 Rajput or Chalukya architecture
7 Jaina architecture
8 Saracenic architecture, which Mr Fergusson divides into eight styles, as developed at different times and in various parts of India
9 The collection and deciphering of coins, and inscriptions on metal or stone plates is a distinct and very important branch of research, through which the ancient history of India has been elucidated

### 1 *Prehistoric Remains*

The prehistoric remains in India consist of cairns, cromlechs, and other cognate remains of unknown age, and constructed by an unknown people They are probably scattered widely, but have hitherto only been examined in a few localities In 1820 Mr Babington described the Kodey Kulls or Pandu Kulies of Malabar,[1] which consist of several stones set upon ends with their points meeting, on which a large mushroom shaped stone is fixed Underneath are found urns containing fragments of human bones mixed with charcoal and fine sand The next notice of prehistoric remains was by Captain Harkness, who published an account of some cairns he found in the Nilgiris in 1832 He was followed by Captain Congreve, who wrote a detailed account of the cromlechs

[1] "Transactions of the Literary Society of Bombay,' vol iii

and cairns of the Nilgiris,[1] and 12 years afterwards the Rev J T Kearns, an S P G missionary, published an interesting paper on the cairns, containing urns, which occur in the Tenkasi taluk of Tinnevelly[2] Captain Newbold discovered some ancient sepulchres, consisting of slabs of granite forming four sides and a top, surrounded by circles of stones, in a secluded valley of North Arcot, three miles from Chettur[3] Captain Congreve described a remarkable cromlech near Pullicondah, in the Carnatic[4] Colonel Meadows Taylor has devoted much attention to the prehistoric archæology of India, and has himself made important discoveries in the Shorapur province of the Deccan, just above the junction of the Bhima and Krishna rivers The Shorapur remains consist of cairns, cromlechs, and kistvaens of sandstone slabs placed upright on their sides, and covered with a slab monolith which projects over them They are scattered over the province in groups[5] Large groups of cairns also occur near Haidarabad in the Deccan,[6] in the Raichur, Doab, in Bellary, and in the Central Provinces, where excavations have recently been made by the Archæological Society at Nagpur Sir Bartle Frere also described some cairns and cromlechs in Baluchistan[7] On the Khasia Hills, Colonel Yule found megalithic monuments scattered on every wayside They consist of rows of pillars some 27 feet high, cromlechs or large flat stones resting on four rough pillars, and tombs formed of four large slabs on their edges, roofed over by a fifth placed horizontally[8] The whole subject was recently discussed by Colonel Meadows Taylor in a paper read before the Ethnological Society,[9] and he has also

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1 "Antiquities of the Neilgherry Hills, by Captain H Congreve (1847) —*Journal of Literature and Science of Madras*, xiv, p 77 "Remarks on Druidic Antiquities of Southern India," by Major H Congreve, — N S, vol vi, p 205 The recent work on Nilgiri antiquities by Mr Breeks is noticed further on

2 Ibid, N S, v, p 27

3 "Journal of the Royal Asiatic Society," x, p 90

4 "Madras Journal,' xiii, pt ii, p 47

5 "Ancient Remains at the Village of Jiwarji, near Farozabad, on the Bhima," by Colonel Meadows Taylor —*Journal of the Bombay Branch of the Asiatic Society*, iii, p 179 "Cromlechs and Cairns in Sorapore,' by Colonel Meadows Taylor,—*Ibid* iv p 380 See also the "Transactions of the Royal Irish Academy" (1865), vol xxiv

6 "Transactions of the Royal Irish Academy (1867)

7 "Journal of the Bombay Branch of the Asiatic Society," v, p 349

8 "J A S B," vol xiii, pt ii, p 612 See also Hooker's Journal

9 "On Prehistoric Archæology of India,' by Colonel Meadows Taylor —*Journal of the Ethnological Society*, i, No 2, p 157

drawn attention to its importance in an official memorandum[1] Quite recently, Mr Boswell has reported upon the kistvaens and rude stone circles in the Kistna district[2]

## 2 *Buddhist Remains*

A wide interval lies between the cromlechs and cairns and the Buddhist remains that come next in order, for the Aryans who composed the Vedic literature and poured out soma juice to their gods in their own houses, built nothing that has endured to our time We, therefore, come at once from the period of unknown antiquity when the cromlechs were built, to the centuries immediately preceding and following the Christian era, when Buddhism flourished in India From B C 250 for five centuries all monuments in India are Buddhist Fergusson calls this earliest style "a wooden art, painfully struggling into lithic forms" Gateways and railings of masonry were imitated from the earliest forms carved out of timber The Buddhist remains consist of rock inscriptions,[3] *lats* or pillars[4] with inscriptions, *topes* or *stupas*, rock-hewn temples, and viharas or monasteries The inscriptions on the rocks and pillars had already received full attention from James Prinsep and his predecessors The topes have been examined by General Cunningham, Colonel Maisey, Sir Walter Elliot, and others

The most important group of topes,[5] or vast mounds for the reception of relics, is near Bhilsa in the Bhopal State of Central India There are about 30, but that known as the Sanchi Tope is the largest, and indeed the finest in Central India, the dome being 42 feet high and faced with masonry It is surrounded by a stone fence consisting of uprights with three horizontal cross pieces, and is approached by four masonry gateways covered with sculpture The Sanchi Tope was first injudiciously dug into by Sir H Maddock in 1819 Captain E Smith sent copies of the sentences carved on

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1 "Report on the Illustration of the Archaic Architecture of India,' Appendix E

2 Boswell s "Report on the Archæology of the Kistna District

3 The rock inscriptions are at Girnar in Guzerat, at Dhauli near Cuttack, at Kapardi Giri near Peshawur, and a fourth copied by General Cunningham at Debra Dhoon

4 The *lats* are, 1,—that of Feroze Shah at Delhi 2, another of iron near Delhi, 3, that in the fort at Allahabad 4, 5, 6, near the Gunduck in Tirhoot, and 7, was used as a roller on the Benares road by an engineer officer

5 An Afghan word, meaning a solid mound of masonry It is the same as the Pali *thupo*, and Sanscrit *stupa*, a mound of tumulus

the pillars to James Prinsep in 1837, and Captain W Murray made a series of drawings[1] In January 1851 the Bhilso Topes were minutely examined and opened by Major Alexander Cunningham, an enthusiastic scholar and antiquary, and a friend of James Prinsep, with whom was associated Lieutenant F Maisey, who had previously been employed in describing the antiquities at Kalinjar[2] Colonel Maisey executed a beautiful series of drawings in 1854, and a series of photographs of the Sanchi Tope was taken by Lieutenant Waterhouse General Cunningham published a full description of the Bhilsa Topes, with an interesting sketch of the rise and progress of Buddhism, in the same year,[3] and Mr Fergusson's superb work on "Tree and Serpent Worship," illustrated by Lieutenant Waterhouse's photographs and by lithographs of Colonel Maisey's drawings of the Sanchi Tope, appeared in 1868[4] A brief account of the Bhilsa Topes will also be found in the "History of Architecture"[5]

The Amravati Tope is another magnificent Buddhist monument It is in the Guntur district near the mouth of the Kistna, and elaborate drawings were made of it, and of its minutely carved stones in the last century, by Colin Mackenzie He first visited the spot in 1797, and in 1816 he caused careful plans and maps, and 80 drawings of sculptures, to be made by his assistants, which are unsurpassed for accuracy and beauty of finish[6] Sir Walter Elliot, who was Commissioner in Guntur in 1840, excavated a portion of the monument, and sent 160 fragments of sculpture to

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1 "J A S B," vi, pt i, p 451

2 Ibid, pt i, vol xvii, p 171 and "Report to the Government of the N W Provinces, 1847" Kalinjar is mentioned in the Vedas

3 "The Bhilsa Topes or Buddhist monuments of Central India comprising a brief sketch of the rise, progress, and decline of Buddhism," by Brevet Major Alexander Cunningham (Bengal Engineers) Illustrated with 33 plates London, 1854

4 "Tree and Serpent Worship' or illustrations of mythology and art in India in the first and fourth centuries after Christ, from the sculptures of the Buddhist Topes at Sanchi and Amravati, prepared under the authority of the Secretary of State for India in Council, with introductory essays and descriptions of the plates," by James Fergusson, Esq, F R S (London, India Museum, 1868)

5 Fergusson's "History of Architecture," ii, p 463

6 "Asiatic Researches,' ix, p 272 Three copies of Colin Mackenzie's drawings were made, one for the library of the Court of Directors, one for the Asiatic Society of Bengal, and a third for Madras Specimens of sculpture were also sent to the India House See "Description of the Amravati Tope in Guntoor,' by James Fergusson —*Journal of the Royal Asiatic Society*, N S, iii, p 132

Madras,[1] which were forwarded to the India House in 1856 Some of these sculptures were exhibited in the museum at Fyfe House, and the others, on account of want of space, were placed in store, where they remained until they were brought to the notice of Mr Fergusson, at whose desire photographs were taken of the entire series The whole of these remarkable sculptures have recently been arranged in the inner court of the India Office, and 52 photographs of them, with descriptions by Mr Fergusson and a map, are published in "Tree and Serpent Worship"[2]

The examination of the Jalalabad Topes by Masson, and of those in the Punjab by Ventura and Court, took place in Prinsep's time, and has already been alluded to There is another group of Buddhist ruins near Benares, called Sarnath, the principal of which is a tower 100 feet high It was opened in 1835 by General Cunningham, who made the excavations, as well as a set of drawings of the elaborate ornament of the great tower, entirely at his own expense Subsequently, some further excavations were made at Sarnath, at Government expense, under the superintendence of Captain Kittoe, in 1852 After his departure they were continued by Mr Edward Thomas[3] and Professor Hall

The cave temples have been visited and noticed by numerous travellers from the time of Thevenot, and described in detail by Mr Fergusson[4] in his "Illustrations of the Rock cut Temples of India" Dr Wilson, of Bombay, has also written two memoirs on the rock cut temples At the suggestion of Mr Fergusson in 1850, the Asiatic Society had represented to the Court of Directors the propriety of taking steps for the preservation of the cave temples and other ancient monuments,[5] and Dr Wilson then prepared a

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[1] "Selections from the Records of the Madras Government," 2d series, No xxxix, p 195

[2] See also "History of Architecture," ii, p 471

[3] "Notes on the excavations at Sarnath"—*J A S B* (1854), p 469

[4] *Ubi sup* See also the "History of Architecture," ii, p 479 In 1863 Mr Fergusson edited a small volume of 78 photographs of the caves of Ajunta and Ellora, by Major Gill, which, though containing little that is new, are interesting as confirming the accuracy of the lithographs published by Mr Fergusson 18 years before

[5] Karli cave was described by Lord Valentia, and fac similes of inscriptions were taken by Dr Stevenson and Dr Wilson

Ajunta caves were first mentioned in Mr Erskine s paper a short account of them was read before the Royal Asiatic Society, by Lieut J E Alexander, in 1829 (*Trans R A S*, iii, p 62) Mr Ralph also described them in the *J A S B*, v p 557 descriptive list of all the rock temples in Western India [1] There are 900, of which nine tenths are in the Bombay Presidency Dr James Bird published descriptive accounts of the sculptures in the caves,[2] Westergaard gave a brief account of some minor caves near Karli,[3] Sir Bartle Frere described those at Karadh and at Wai,[4] and Colonel Sykes wrote a paper on inscriptions from Buddh caves near Joonur [5] The Court of Directors, through the efforts of Colonel Sykes, employed Major Gill to copy the paintings in the caves, and he was engaged upon this work for twenty years Eventually a series of oil paintings was transmitted to the India House The paintings were exhibited in the Crystal Palace at Sydenham, where they were all burnt in December 1867, except four, which had been forgotten to be sent, and which are now at the India Office Unfortunately some application that had been made to the originals in the caves, to bring them out more clearly for copying, has injured them irremediably, and they are now rapidly fading away [6]

The *raths* or rock hewn edifices at Mavalipuram, near Sadras, on the Coromandel coast, which were described in the last century by Chambers and Goldingham, and are commonly known as the seven pagodas, are classed by Mr Fergusson as forms of Buddhist architecture adopted by the Hindu [7] He considers them to be close copies of a Buddhist storied *vehara* or monastery The most complete descriptions of these monuments were written by

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Fac similes, transcripts, and translations of the inscriptions were made by Dr Bhau Dajee in 1863 See "Journal of the Bombay Branch of the Asiatic Society, vii, p 53

Ellora caves were first described by Sir C Mallet in the "Asiatic Researches Drawings were taken by Mr Wales, and Colonel Sykes wrote a paper on them in vol iii of the "Transactions of the Bombay Literary Society'

Aurungabad caves were first described by Dr Bird Junegad and Girnar caves were visited by Dr Wilson

1 "Memoirs on the cave temples, and monasteries of Western India," by Dr Wilson. —*Journal of the Bombay Branch of the Asiatic Society*, iii, p 36 iv, p 340

2 Historical researches on the origin and principles of the Bouddha and Jain religions, illustrated by descriptive accounts of sculptures in the caves of Western India,' by James Bird —*Ibid*, ii, p 71

3 Ibid, i, p 438

4 Ibid, iii, p 36, and p 108

5 "Journal of the Royal Asiatic Society," iv, p 287

6 At Mr Fergusson's suggestion, the plans, photographs, and drawings of Ajunta and other temples were purchased from Major Gill by the Government in 1868, 61 negatives, 36 pencil drawings, and books containing ground plans and sketches

7 "History of Architecture," ii, p 502

Dr Babington, who gives drawings and copies of inscriptions,[1] and by Sir Walter Elliot,[2] and they are also described by Bishop Heber in his journal.[3] The Madras Government have recently printed all these papers together, in a small octavo volume, edited by Captain Carr, with a map drawn under instructions from Colonel Priestley.[4]

### 3. *Dravidian Architecture*

The Dravidian style of architecture extends over all India south of the river Kistna, except Mysor, and had its origin in the three ancient kingdoms of Pandya, Chola, and Chera. The Dravidian temples are of vast extent and magnificent design. They consist of the *vimana* or shrine, the *mantapas* or porches leading to it, the *gopuras* or lofty gate pyramids in the quadrangular surrounding walls, and the pillared halls or chooltries. In 1830 a learned native of Tanjor, named Ram Raj, wrote an essay on the architecture of Southern India. His project was to collect treatises on architecture in the native languages, collate them, and produce an exposition such as should enable a European reader to form an opinion on the system. The holy Rishi Aghastya, who brought the first Brahman colony into Southern India, is said to have written a treatise on architecture, and others were also composed in ancient times, which collectively were called Silpa Sastra, but few traces of them remain. One, called Mánasára, on the building of sacred edifices, and eight others, are extant. From these sources Ram Raz described the mouldings of pedestals, the bases, pillars, shape of the padma or lotus, and other architectural details. But his descriptions and illustrations are more applicable to the modern system of temple building, and are of no great archæological value.[5]

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1 "Transactions of the Royal Asiatic Society," ii, p. 258.

2 "Madras Journal of Literature and Science," xiii, pt. i, p. 46, and pt. ii, p. 36. "A guide to the sculptures and excavations at Mamallaipur, generally known as the "seven pagodas, by Lieut. John Braddock, archæological notes by Rev. W. M. Taylor, "and a supplementary account of the remains at Salvan Cuppam, by Walter Elliot."

3 iii, p. 216.

4 "Descriptive and historical papers relating to the seven pagodas, on the Coromandel Coast, by G. W. Chambers, J. Goldingham, B. G. Babington, Rev. G. W. Mahon, Lieut. J. Braddock, Rev. W. Taylor, Sir Walter Elliot, and C. Gubbins, Esq. Edited by Captain M. W. Carr.—Madras, 1869, 8vo.

5 Ram Raz was a native judge at Bangalore. He was born in about 1790, and died in 1833. His work was published by the Oriental Translation Fund. "Essay on the Architecture of the Hindus, by Ram Raz. (48 plates. London. 1834.)

The only complete account of the Dravidian temples will be found in Mr Fergusson's "History of Architecture,"[1] and they are best illustrated in Daniell's great volumes of engravings Descriptions will be found of some of the Southern Indian temples in the manuscript memoirs of the early Topographical Surveys, and there are scattered notices elsewhere[2] Mr Fergusson considers the style to be well deserving of more attention than has hitherto been bestowed upon it, and that the buildings to which it gave rise, often combine grandeur of form with great beauty of detail

Of late years the Madras Government have, from time to time, shown an interest in the preservation and illustration of architectural monuments In Lord Harris's time, and at the instance of Sir Walter Elliot, Captain Tripe, of the 51st Regiment, was appointed to execute a series of photographs, but he only held the office for three or four years, and it was abolished by Sir Charles Trevelyan During that time he took photographs of most of the edifices in the southern half of Mysor, and the whole of the inscriptions on the great temple of Tanjor But unluckily the photographs were not well fixed, and have since faded sadly In 1857 the Madras Government ordered district engineer officers to report upon the ancient architectural remains in their several districts This order was issued, irrespective of the tastes and knowledge of the subject of those who were expected to attend to it, and it naturally bore little fruit Mr Fraser, the engineer at Coimbatore, took great pains with his report, and sent in a description of temples, tumuli, cromlechs, and other monuments Captain Harington reported upon an inscription on a rock in Ganjam, Captain Mullins upon an ancient inscription on a tank in Nellor, Captain Emery sent in annual reports on the architectural remains in Cuddapah, Captain Prendergast described the old fort at Arcot, and Lieutenant Drewer reported upon the ruins at Gurseppah[3] Dr Hunter, the Superintendent of the Government Industrial Schools at Madras, has trained pupils in photography, and sends them out to take photographs of the most interesting

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[1] ii, pp 558–584.

[2] See an account of the temple of Ramisweram with a plan, by Lieut Christopher, I N, in the "Journal of the Bombay Geographical Society," vol vii

A description of the temple and other edifices at Madura will be found in "Travels in Peru and India,' by Clements R Markham, p 415

[3] "Madras Journal of Literature and Science," N S vol vi (1861)

remains in various parts of the Presidency The Government have also recently employed Captain Lyon to execute a series of photographs designed to illustrate the ancient architecture of Southern India,[1] but there is a great want of accurate plans and descriptions

### 4 *Bengali Architecture*

Dravidian temples are at once recognized by their pyramidal form, distinction of storeys, and separation into compartments by pilasters The Bengali or northern temples, on the contrary, have no trace of division into storeys, no pilasters, and a curvilinear outline, with a polygonal base The best examples are found at Bolaneswar, in Orissa, and round the temple of Jagarnath, and thence across India as far as Dharwar The style first appears in the 6th or 7th century, but Mr Fergusson looks upon its origin as mysterious and unaccountable, and as one of the art problems that await solution He is inclined to date back its invention to a period anterior to Buddhism

### 5 *Chalukya Architecture*

This style is that of Gajrat, Mysor, and Rajputana, and originated with the Rajpoots, the Scythian hordes which entered India during the first two or three centuries after Christ The most magnificent remains are at Halabid, and Bellur, in Mysor, and there are others in various parts of Mysor and Dharwar The Halabid temple, which was built at the same time as Lincoln and Salisbury cathedrals, is perhaps the finest example of minute and elaborate carving made subservient to unity and grandeur of general effect that is to be found in India Mr Fergusson considers it to be among the most marvellous exhibitions of patient human labour the world ever produced[2]

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[1] "Notes to accompany a series of photographs designed to illustrate the ancient architecture of Southern India, taken for the Government and described by Captain Lyon Edited by James Fergusson, F R S (London, Marion & Co , 22 & 23, Soho Square, 1870 )

[2] "Architecture in Dharwar and Mysore, photographed by the late Dr Pigou, A C B Neill, Esq , and Colonel Briggs, R A , with a memoir by Colonel Meadows Taylor, and architectural notes by James Fergusson" (Murray, 1866, folio )

This superb work contains 52 plates illustrative of Chalukya architecture, including the Hullabeed and Belloor temples, and the ruined city of Bijayanuggur

See also the "History of Architecture," ii p 609

## 6 *Jaina Architecture*

The temples of the Jains are nearly as numerous and quite as elaborate as those of any other sect in India The most extensive group is that on the sacred hill of Satrungya, near Palitana, where the temples exist literally in hundreds, some of great beauty and magnificence They have been well described by Mr Burgess, and photographed by Messrs Sykes and Dyer of Bombay,[1] and also by Captain Lyon Mr Burgess has also illustrated the Jain temples at Girnar, which form the group next in importance in Gujrát[2] In the same neighbourhood are the wonderful white marble temples on Mount Abu, and further on that of Sadri,[3] one of the most elaborate and extensive temples of the class in India, built by a Rana of Udaipur, in about the middle of the fifteenth century Jain temples are also found all along the western coast as far as Belgaum, and there is an important establishment of this sect at Beligola,[4] in the Mysor country Jain temples are also found on Mount Parisnath and other places in Bengal, and throughout the Central Provinces No temple, in its present form, is earlier than A D 1000, while many hundreds were built within the present century In elaborateness of detail, and in elegance of form, they, in some respects, surpass even the thirteenth century buildings of the Chalukyas[5]

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1 "Satrungya, photographed by Sykes and Dyer, with explanatory text by J M Burgess"—(Folio Bombay, 1869)

2 "Somnath, Girnar, and Junaghad, photographed by Sykes and Dyer, with descriptive letter press by J M Burgess"—(Folio Bombay, 1869)

See also the "Account of the remains of the temple at Somnath, by Alexander Burnes (1834)—*Journ R A S*, v, p 104

3 See "Tod s Rajasthan"

4 "Architecture of Dharwar, Mysore, &c"

5 For accounts of Jaina Temple, see "Colonel Tod s Travels in Western India" Also his "Annals and Antiquities of Rajast'han, or the Central and Western Rajput States" (2 vols 4to London, 1829) It contains a plate of a Jaina temple at Ajmir, and others There is also an account of the Jains in "The Cities of Gujarashtra, their topography and history,' by Henry George Briggs (Bombay, 4to 1847) Colin Mackenzie s account of the Jains is in the "Asiatic Researches,' vii, p 176 Dr Bird s, on the origin and principles of their religion, in the "Journal of the Bombay Branch, A S' ii, p 71 "Account of the remains of the temple of Patan Somnath,' by A Burnes (1834)—*Journal of the Royal Asiatic Society*, v, p 104 Lieut Postans wrote accounts of the Jaina temples at Badrasir and Badranagiri in Kach—*J A S B*, vii, p 431 See also the "History of Architecture, ii, p 620 and the "Asiatic Researches,' vol xvi, p 284

7 *Saracenic Architecture*

The beautiful mosques and tombs of the Muhammadans, which are scattered over nearly all parts of India except the extreme south, were the first monuments to attract the attention of travellers, and are those which have been most thoroughly examined The various styles bear the impress of the localities in which they were originated, combining the general features of Islamism with many special details peculiar to native art According to Mr Fergusson's division the earliest Muhammadan style is that of the Patans at Delhi, which possesses a certain stern severity It includes the Kutub Minar, a careful plan of which has been made by Mr Fergusson, and the tombs of Altumsh and Togluk The dates of the Patan monuments range from 1196 to 1235, and much of their detail is copied from the old Jaina edifices The tomb of Altumsh is mentioned as a remarkable example of Hindu art applied to Muhammadan purposes [1] At Gour, where the Patans established their Bengal capital, the buildings are peculiar for their segmental form of roof and cornice, representing the bamboo roofs of huts in Lower Bengal The large mosques and tombs at Jaunpur (A D 1397–1478), fine illustrations of which may be seen in the volumes of Daniell, are noticeable instances of the use of Hindu forms At Ahmedabad the mosques and tombs are in the Jaina style in every detail The Jama Masjid at Ahmedabad is one of the most beautiful mosques in the east Its 15 domes are supported by 260 pillars, and perforated stone screens of exquisite beauty exclude the glare of the sun A series of photographs of the Ahmedabad edifices by Colonel Briggs has recently been published in a magnificent volume, to which Premchund Ramchund, a Jaina of Gujrát, contributed 1,000*l* [2] The style of architecture at Bija pur forms an exception to the usual influence of Hindu art on Muhammadan buildings In that wonderful city everything is pervaded by Muslim ideas From the time of Tavernier, many observers have recorded the wonders of Bijapúr After the visits of Moore and Sydenham, Colonel Sykes contributed notes respecting the principal remains of the ruined city,[3] and Dr Bird wrote a paper

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[1] "Asiatic Researches," iv, p 313

[2] "Architecture of Ahmedabad, photographed by Colonel Briggs Historical sketch, by Theodore C Hope, Bombay Civil Service Architectural Notes, by James Fergusson" (4to, Murray, 1866) 120 photographic plates See also "Forbes's Oriental Memoirs," iii, ch xxx

[3] "Transactions of the Literary Society of Bombay," iii, p 55

on the ruins of Bijapur and its Persian inscriptions[1] In 1866 a work on Bijapúr, containing 46 photographs and four woodcuts, with memoirs by Colonel Meadows Taylor and Mr Fergusson, was published by Murray, chiefly at the expense of a wealthy native of India named Kursondas Madhowdas[2] The Mogul architecture, represented in the tomb of Akbar, and above all in the Taj Mahal, that great triumph of art, has been thoroughly examined and illustrated, and the monuments of that period will now, there is reason to hope, be well and carefully preserved

The extensive ruins at Brahminabad, in Sind, do not come under the head of any of the architectural styles, but they are too interesting to be omitted in this enumeration The great city, entirely built of baked bricks, and nearly four miles in circumference, was the capital of a Hindu dynasty from about the seventh to the eleventh century It was entirely destroyed by an earthquake, and nothing but one tower is intact We are indebted to Mr Bellasis for a detailed account of these ruins, and he discovered beautiful engravings on cornelian and agate, and other relics among the debris[3]

## 8 *Coins and Inscriptions*

The collection and deciphering of coins and plates is an important branch of Indian archæological research, because, by the study of such relics alone can the chronology and sequence of the ancient dynasties be ascertained It has been seen that much was done in this line in the time of the Asiatic Researches, and the scattered numismatic memoirs of James Prinsep[4] have been collected and reprinted Mr Wathen discovered and reported upon ten inscriptions on stone and copper in the Deccan,[5] and, besides the great collection of *sasanums* made by Colin Mackenzie, which have already been mentioned, Sir Walter Elliot has done great

1 "Journal of the Bombay Branch of the Asiatic Society," i, p 367

2 "Architecture at Beejapore, from drawings by Captain Hart and A Cumming, C E and photographs by Colonel Briggs and Major Loch Memoir by Colonel Meadows Taylor, and Architectural Notes by James Fergusson" (Folio Murray 1866)

3 "An Account of the Ancient and Ruined City of Brahminabad, in Sind," by A F Bellasis—*Bombay Branch, R A S*, v, p 413 (1856)

4 "Essays on Indian Antiquities," by the late James Prinsep (2 vols, 1858)

5 "Ten inscriptions on stone and copper found on the west coast of India, and translated by W H Wathen, with remarks by H H Wilson"—*Journal of the Royal Asiatic Society*, ii, p 378

service to Indian historical knowledge by his labours in this branch of inquiry He obtained copies of 595 inscriptions, collected in Dharwar, Sunda, and North Mysor Most of them are engraved on blocks of basalt, others are carved on pillars of temples, and a few consist of deeds on sheets of copper The monumental stones are invariably in Canarese, the others are in Sanscrit, with Canarese words intermixed They all record grants of land or money, or transfers of rights to temples, and relate to four dynasties reigning over the Deccan, the oldest being the Chalukya dynasty of Rajputs [1] Sir Walter Elliot also contributed two important papers on the coins of Southern India, with descriptions and plates A large collection was formed by Colin Mackenzie, and deposited in the India Museum, and there are scattered notices of other cabinets which have enabled Sir Walter to furnish a lucid review of the subject [2] He points out that the only trustworthy data, from which a knowledge of the earlier southern dynasties and kingdoms can be obtained, are the contemporary records offered by deeds inscribed on stone and copper, and by coins In the north of India, numismatics have found zealous students in James Prinsep, Wilson, Cunningham, and Edward Thomas In his paper on the coins of the Ghazni Kings, collected in Afghanistan by Mr Masson, and now in the India Office Museum, Mr Thomas throws doubt on the assertion that Mahmud was the first Sovereign who used the title of Sultan, and shows that one of his successors, Modud (A D 1041), adopted the Siva bull or *nandi* as a device Mr Thomas, by means of coins, has also illustrated the history of the Sassanians, the epoch of the Sah Kings of Gujrát, the chronology of the Bactrian Kings, of the Gupta dynasty, of the Patan Sultans of Hindustan, and of the Parthian Arsacidæ [3] General Cunningham has contri-

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[1] First published in the "Journal of the Royal Asiatic Society," iv, p 1, (1836), but the paper was incorrectly printed, and was republished more accurately in the "Madras Journal," vii, p 190

[2] "Numismatic Gleanings, being descriptions of the Coins of Southern India," by Sir Walter Elliot —*Madras Journal*, iii, p 220

Wilson wrote a paper on the Collection of Colin Mackenzie in the "Asiatic Researches, vol xvii Moore figured 23 specimens of coins of Southern India, which were bought by Major Price at the prize sale of Tippu's Treasury, in his "Hindu Pantheon, and a series of Mysor coins in his "Narrative of Little s detachment," p 455 See also Prinsep s notice of Southern Indian coins in the "Journal of the Asiatic Society of Bengal,' vol vi, plate xx

[3] In the "Journals of the Asiatic Society," for 1848, 1849, 1852, 1859, 1862, and 1866, there are 16 papers by Mr Thomas on eastern coins, bound up as "Tracts on

buted papers on Bactrian and Indo Scythian coins, and on the coins of the Indian Buddhist Satraps[1] The few pre Muhammadan written histories are so confused as regards dates and the succession of Kings that nothing reliable could be established without the aid of coins and deeds, and even as regards the records of Ferishta and other Muhammadan authors, coins are of essential use as corroborative evidence Thus there can be no doubt of the great importance of this branch of the investigation

In 1874 Mr Thomas undertook, with the co operation of the most learned oriental numismatists, to edit a new issue of Marsden's "Numismata Orientalia"[2] Each author will give a history of the dynasty whose coins are the subject of review, a critical list of regal succession, a notice regarding values of current coins, and a resumé of the sites and designations of mint cities The first Part of the series, by Mr Thomas himself, is a very interesting essay on ancient Indian weights, and the origin of a currency in India It was published in 1874 The section on the coins of the Saljukis, Urtuki Turkumans, and Atabegs was undertaken by Mr Stanley Lane Poole, and the Urtuki portion was published in 1876 Four other parts are completed, namely the coins of Ceylon by Mr Rhys Davids, those of the Tulúni Dynasty of Egypt by Mr Rogers of Cairo, those of the Parthians by Mr Percy Gardner, and the coinage of Lydia and Persia from the earliest times to the fall of the Achæ-

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Oriental Literature," by Edward Thomas, Bengal, C S Mr Thomas has also written on Cufic and Sassanian coins in the "Journal of the R A S, vol xx, pp 337 and 525

[1] "Journal of the Asiatic Society of Bengal, ix, pp 531, 867, xiv, p 430, xi, p 130, xxiii, p 679

[2] "International Edition of the Numismata Orientalia," edited by Edward Thomas, Esq, F R S (Trubner)

Part I—"Ancient Indian Weights," by Edward Thomas, F R S (Trubner, 1874), pp 74, quarto, with map of the India of Manu

Part II—"Coins of the Urtuki Turkumáns,' by Stanley Lane Poole (Trubner, 1876), pp 44, quarto, with Plates

Part III—'The Coinage of Lydia and Persia from the Earliest Times to the Fall of the Dynasty of the Achæmenidæ by Richard V Head, Assistant Keeper of Coins, British Museum (Trubner 1877), pp 55, 3 Plates

Part IV—"The Coins of the Tuluni Dynasty by Edward Thomas Rogers (Trubner 1877), pp 21, 1 Plate

Part V—"The Parthian Coinage, by Percy Gardner, M A (Trubner 1877), pp 65, 8 Plates

Part VI—"On the Ancient Coins and Measures of Ceylon, with a discussion of the Ceylon date of the Buddha's death," by T W Rhys Davids, late of the Ceylon Civil Service (Trubner 1877), pp 68, 1 Plate menidæ by Mr Barclay V Head Sir Walter Elliot has undertaken the coins of Southern India, Sir Arthur Phayre those of Arakan and Pegu, General Cunningham those of the Indo Scythians, Dr H Blochmann of Calcutta those of the Bengal Sultans, M F de Saulcy the early Arabico-Byzantine adaptations, Professor Gregorief those of the Russo Tatar Dynasties, Don Pascual de Gayangos those of the Khalifas of Spain, Dr Julius Euting those of the Phœnicians, Mr F W Madden those of the Jews, Mr Reginald Poole those of the Ikhshídis, M Sauvaire those of the Fatimites of Egypt, and Mr Thomas himself the Sassanians of Persia

Regarded as an introduction to the study of Eastern history this work will be invaluable Each section is undertaken by the most learned man in Europe on the particular subject to which it is devoted, and his knowledge of numismatics is brought to bear on the elucidation of history, and especially of chronology, by the unerring guidance of coins As triangulation furnishes the accurate framework by which geographical description receives precision, and is made useful, so the landmarks fixed by the study of coins and inscriptions are the essential guides to a correct knowledge of history In future the student of Indian history will no more be able to dispense with the information contained in the "Numismata Orientalia" than the geographer can pursue his researches without the aid of the surveys Messrs Trubner and Co have undertaken this costly publication entirely at their own expense, and it is to be hoped that the work will receive that patronage and encouragement which is undoubtedly its due

The above enumeration of the various branches into which Indian archæological research is now systematically divided will give an idea of the extent and scope of the subject, and, while showing how much has already been done, will also prove how much remains to be achieved The great need has always been a proper organization, which could only be partially attempted by the Societies at the Presidencies, whose admirable efforts and encouraging assistance to individual enquiries, though most important, could not possibly bring the needful power and means to bear An efficient archæological survey can only be carried on, with any prospect of satisfactory completeness, through the agency of the Government

General Cunningham, the old friend of James Prinsep, whose zeal and sagacity as an antiquary he emulates, published his views on archæological investigation in 1848[1] But it was not until 1860 that the Government of India instituted an Archæological Survey, with the object of preserving ancient monuments, rendering them easy of access, obtaining correct copies of inscriptions and pieces of sculpture, and thus facilitating the studies of future antiquaries and historians General Cunningham was the officer selected by Lord Canning to conduct the operations of this survey, and certainly no better choice could have been made As a scholar, an antiquary, and a numismatist, Cunningham was in the foremost rank, and he had already done important service in the examination of the Sarnath and Bhilsa topes, and in other kindred work

The year 1861–62 was the first of General Cunningham's operations as archæological surveyor They extended over the country between Gaya and Gorakpur, on both sides of the Ganges, embracing the principal ruins in the ancient kingdom of Magadha, the centre of Indian Buddhism during the period of its ascendancy Two Chinese pilgrims, named Fa Hian (A D 399–414) and Hwen Thsang (A D 629–42), whose travels have been translated by Mr Beal and M Stanislas Julien,[2] visited India when Buddhism was in the ascendant, and described many cities and temples It has thus been one very important and interesting object among Indian antiquaries to identify the spots mentioned by these ancient pilgrims General Cunningham has observed[3] that as Pliny, in his eastern geography, follows the route of Alexander, so an in quirer into Indian archæology should tread in the footsteps of the Chinese pilgrims, Hwen Thsang and Fa Hian During his labours in 1861–62, General Cunningham succeeded in identifying a number of Buddhistic ruins of viharas and stupas with buildings that are minutely described in the writings of the ancient pilgrims At Buddha Gaya especially, several objects enumerated by Hwen Thsang were recognized from their exact correspondence with his descriptions Cunningham carefully examined 24 ruins

1 "Proposed Archæological Investigation," by A Cunningham —*Journal of the Asiatic Society of Bengal*, xvii pt i, p 335

2 The first translation of Fa Hian's pilgrimage was published by Abel Remusat in 1836, and entitled *Fo koue ki* The English translation is by the Rev S Beal, late chaplain of H M S "Sybille"—(Trubner, 1869) In 1853, M Stanislas Julien published his "Histoire de la Vie de Hiouen Thsang et de ses Voyages dans l'Inde, traduite du Chinois," which was followed in 1857 by his "Memoires sur les contrees occidentales par Hiouen Thsang"—(2 vols Paris)

3 "J A S B,' xvii pt i, p 535

during his first season, including the caves in the Barabar hills, excavated by King Asoka Much had been gone over, in early days, by Dr Buchanan Hamilton, but Cunningham made a more careful and accurate examination of the different ruins, took impressions of inscriptions, and recommended that some of the more important pieces of sculpture should be photographed His first report concludes with a full account of the great Buddhist tower at Sarnath, near Benares, which had been one of the objects of his earlier research, twenty-six years before The operations of 1861–62 bore fruit in some valuable deductions Thus, judging from the style of an inscription at Gaya, on which the date is given as the year 1816 of the *nirvana* of Buddha, General Cunningham assigns the year B C 477 as the period of that event, a calculation which has been adopted by Max Muller, though a century later than the Ceylon era By a similar calculation, the dates of the foundation of Rajagriha, the capital of Magadha, and of Nalanda, once the most famous seat of Buddhistic learning in all India, are fixed Interesting accounts are given, in the Report, of the ruins which he identifies as the sites of these ancient cities

In the season of 1862–63 the surveyor's tour was extended through Fathigarh, Kanouj, Rurki, Khallsi, and Mattra, to Delhi He examined the ruins of Sankissa, the spot on which Buddha alighted when he descended from heaven At Khallsi he made an impression of that famous inscription of King Asoka, containing the names of five Grecian Kings, and pronounced the fifth name, which had not before been made out, to be that of Alexander II of Epirus At Mattra and Delhi he copied several inscriptions, and made numerous drawings and measurements At Delhi he examined two human statues lately found inside the area of the palace walls, and the remains of two statues of elephants in black stone He thinks it probable that these are the statues mentioned in Baber's Memoirs as standing outside the gate of Gwalior, whence they are believed to have been removed by Aurangzeb They are now erected in the Delhi Garden, as unique specimens of Indian portrait sculpture of life size General Cunningham made a complete examination of the ruins in the vicinity of Delhi After a careful investigation he came to the conclusion that not a single stone remains of Indraprastha, the capital of the Pandus, the most ancient city near the site of modern Delhi.[1] He described, in the Report for this season, the architectural remains attributable to Hindi and to various epochs of Muhammadan ascendancy. He made a careful impression of the very important pillar inscription of Asoka, already published by James Prinsep, and the corrections he has supplied show the justice of Burnouf's opinion, that "a new collation of the pillar inscriptions would be of the greatest value."

In 1863–64 the surveyor explored the ruins in the Punjab, and worked at the identification of the cities and peoples described in the expedition of Alexander the Great. Commencing from the west bank of the Indus, he worked downwards, on the track of Alexander and the Chinese pilgrims, examining every site mentioned either by the Grecian writers or by Hwen Thsang. His accounts of Taxila, Manikyala, and of the scene of Alexander's battle with Porus on the Jhelum, are especially interesting. He also explored, during this season, the famous region watered by the Saraswati, including Sirhind and Thanesar.

In the season of 1864–65 General Cunningham continued his labours, explored and described the ancient cities between the Jamna and Narbada, and drew up an interesting account of the Dhamnâr caves.[2] He had now carefully examined and described the ruins and inscriptions in nine of the ancient kingdoms of Hindostan.[3] But in 1866 Lord Lawrence abolished the appointment of Archæological Surveyor, and for a season these useful and important labours were stopped. At the same time their value was appreciated by the Secretary of State for India, who considered that they fully justified the anticipations which were entertained

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[1] The date of the occupation of Indraprastha by Yudhisthira, the eldest of the Pandus, is fixed in the latter half of the 15th century B.C., from certain positions of the planets recorded in the Mahabharata.

[2] Also described by Fergusson in his "Rock hewn Temples of India."

[3] Namely, Magadha (Behar), Mithila (Tirhout), Ayodhya (Oudh), Panchâla (Rohilkhand), Antarbeda (the Doab), Kurukshetra (Thanesar), Madra Desa, Sindhu Sauvira (Punjab), and Madhya desa (Central India).

See "Reports of the operations of the Archæological Surveyor to the Government of India during the seasons 1861–62, 1862–63, 1863–64, 1864–65." There are copies in the India Office, and in the libraries of the Society of Antiquaries and of the Royal Asiatic Society. These Reports were re-published in two volumes at Simla in 1871. "Archæological Survey of India. Four Reports made during the years 1862 to 1865, by Alexander Cunningham, C.S.I., Major General, R.E., Director General of the Archæological Survey of India, &c. (Simla, 1871.)

by Lord Canning when he first conceived the idea of the survey, and that similar operations should be set on foot in other parts of India The Secretary of State also expressed an opinion that the preservation of the historical monuments of India, and their accurate description by competent observers, were objects well deserving the attention of the Government[1] General Cunningham's survey has borne rich fruit since his return to England, in his learned work on the ancient geography of India, in which he discusses the routes taken by Alexander the Great and by the Buddhist pilgrim, Hwen Thsang, and identifies the places mentioned by the Grecian and Chinese writers His chief discoveries have been Aornos, the rock fort captured by the Macedonian king, Taxila, the ancient capital of N W Punjab, Bairât, the capital of Matsya, south of Delhi, Sankisa, near Kanouj, the spot where Buddha descended from heaven, and Nalanda, the most famous Buddhist monastery in all India[2]

In 1868 Lieutenant H H Cole was appointed to conduct an archæological survey in the North West Provinces and the Punjab He was occupied until November in examining the principal ancient temples of Kashmir, with a photographer, and afterwards surveyed the ancient buildings in the neighbourhood of Mattra, accompanied by the Rev Mr Simpson, who took 58 photographs In May 1869 Lieutenant Cole left Bombay for England, to make arrangements for casting one of the great stone gateways of the Sanchi tope Three sappers were trained in the most recent methods of making elastic moulds with gelatine, and in October 1869 Lieutenant Cole returned to India with these men and the necessary materials It took 60 carts to convey the 28 tons of material from Jabalpûr to Sanchi, which was reached in January 1870 There were 737 square feet of carved work on the gateway, to be cast in 112 pieces The work was completed in February, and the pieces composing the "parent" cast were carefully packed and sent to England to be fitted together, in order that copies of the gateway might be reproduced for the museums at Kensington, Dublin, and Edinburgh Detailed drawings were made of the other gateways

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1 Despatch (Public Works) June 24th, 1864, No 28
,, ,, June 16th, 1866, No 29

2 "The Ancient Geography of India I The Buddhist period, including the campaigns of Alexander, and the travels of Hwen Thsang" By Alexander Cunningham, Major General, R E—(Trubner 1871 13 maps)

It was decided to publish two volumes illustrative of the Archæological Survey conducted by Lieutenant Cole The first contains the photographs of the Kashmirian temples, with descriptions The second contains photographs of the buildings round Mattra, with descriptive notes Lieutenant Cole considered that the principal aims to be kept in view in collecting illustrations should be to show the faith and state of civilization of the natives who occupied any particular period or locality, as represented in their sculptured architecture, to offer a means of elucidating the true position of architecture in India by widening the base of observation, to instruct native builders and artizans in different Indian styles, and to furnish the means of selecting appropriate forms out of which to design municipal and other buildings for native purposes [1]

In 1869 Dr Forbes Watson of the India Office drew up a valuable report on the various means of illustrating the archaic architecture of India, by means of photographs, drawings, plans, and sections, models, moulds, and casts In the appendices attached to the report there is a memorandum by Mr Fergusson on the architectural objects in India, of which it is desirable to obtain photographs, with some account of the work of this kind that has already been done, and two others on objects for casts,[2] and on the conservancy and representation of ancient monuments He considers that plans and descriptions, accompanied by photographs and drawings, would convey more information than castings, and at the same time aid the selection of objects that should be cast, and he urges that an officer should be appointed in each Presidency, to devote his whole time to archæology

In August 1867 the Government of India had forwarded a circular to the Local Governments, expressing their sense of the desirability of conserving ancient architectural structures or their remains, and other works of art in India, and of organizing a system for photographing them Lists were called for, of all such remains

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1 "Archæological Survey of India," Lieut H H Cole's Report for the year 1869–70

2 He recommends that casts should be taken of various sculptures in the Calcutta, Madras, and Lahore museums, of those in the Udyagiri caves near Cattack, of objects at the black pagoda, of the rail once surrounding the bo tree at Budh Gaya, of fragments of the Buddhist rail at Mattra, of the carved details on the old Patan tombs and mosques, of the Somnath gates in the Agra arsenal, of the pillars and brackets of Akbar's tomb sculptures at Elephanta, the double elephant capitals at Karli, and sculptures at Halabid

and works of art in Bengal, Oudh, the North West Provinces, the Punjab, the Central Provinces, Haidarabad, Bombay, Madras, Burmah, and Mysore. The proposal in the circular was that photographs should be executed by amateurs, and that some assistance should be given by Government, through the purchase of a certain number, if they were really good. This circular met with some response, and a considerable number of photographs were received by the Government during the two following years.[1] The Government of India also proposed to expend a sum of 52,000 Rs. a year for the employment of parties in Bombay, Madras, Bengal, the North-West Provinces, and the Punjab, to make complete sets of models of one or more large buildings, with accurate plans, photographs, and descriptions, and the Principals of the schools of art at the presidency towns were to train men in the art of modelling.

The interest shown by the Government of India in the preservation and illustration of ancient monuments was very encouraging, as it thus became clear that the importance of the subject was fully appreciated. But it was necessary that the researches should be conducted in a more systematic manner, and on some definite plan, and in July 1870 it was resolved that a central establishment should be formed to collect the results of former researches, to train a school of archæologists capable of conducting local enquiries, and to direct, assist, and systematize the various efforts and enquiries made by local bodies and private persons, as well as by the Government. The direction of this establishment was offered to General Cunningham. India was so fortunate as again to secure the services of that eminent scholar and archæologist, and he left England, to

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[1] Photographs were forwarded, of the palace at Sambalpur, the black pagoda, the caves in Cuttack, Jaganath, and others. A set of photographs were furnished of ancient buildings in Mysore, and Captain Lyon was employed to complete a series in the Madras Presidency. Reports and photographs were also sent from Rajputana, the Central Provinces, (where a separate chapter on archæology is given in the Administration Reports,) the Haidarabad Assigned Districts (where a Committee was formed at each station to prepare archæological reports,) Nepal, and Sikkim. In Bombay Mr. Sykes was employed to take photographs of the caves and temples round Nasik, and his negatives were purchased by Government. There was also a grant of Rs. 10,714 at Bombay, which was entrusted to Mr. Terry, the acting superintendent of Sir Jamsetjee Jejeebhoy's school of art. This sum was employed by Mr. Terry in moulding, sketching, measuring, and photographing the temple of Ambernath near Bombay, with a staff of artists, moulders, and draftsmen. He produced a set of casts from the moulds, and sent in his Report in July 1869.

resume those useful and interesting labours which had already occupied so many years of his life, in December 1870

So long ago as in 1848, General Cunningham had pointed out the necessity for confiding the selection of objects for preservation to an instructed archæologist, with a knowledge of ancient Indian history, and that without such a guide the labours of the best drafts men and photographers would be thrown away Under such trained supervision, however, much important and valuable work has been done, and a glance at the appendices by Mr Fergusson and General Cunningham at the end of Dr Forbes Watson's report will give some idea of the amount of work that remains to be done before the archæological survey of India approaches completion There were portions of the Central Provinces which are rich in ancient and most interesting remains, but which were unexplored Much also awaited investigation in Gujrat and Kach, from Sadri to Somnath At a place called Ajmirghur there is a sacred tank whence flow the sources of the rivers Son, Narbada, and Mahanadi, and the spot is surrounded by temples This region required examination, and Mr Fergusson thought it possible that here the problem of the origin of that Bengali style of architecture which had hitherto puzzled him might be solved The districts round the delta of the Krishna, including the beautiful and ancient temples of Shrichellum, are full of antiquities of great interest, utterly unknown to Europeans, and the sculptures at Amravati, in the Krishna district, had not yet all been photographed *in situ*[1] The rock inscription in Ganjam, which is another version of the Asoka edict, required photographing The buildings about Kalyan and Deoghur, the central region of the Chalukya style of architecture, were also unexamined, as well as the Saracenic monuments of the Bahmani and Golconda dynasties in the Deccan, and a good survey of Vegi, the capital of a Buddh dynasty before the foundation of the Eastern Chalukya kingdom, was another desideratum

In 1871 General Cunningham commenced work with the aid of two assistants, Mr J D Beglar and Mr A C L Carlleyle, beginning with a survey of the two great capitals of the Mongol Empire, Delhi and Agra Mr Carlleyle undertook the survey of Agra, and

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[1] Mr Fergusson, in June 1868, suggested that the photographers engaged in observing the eclipse of the sun, as soon as they had done their work, should be instructed to photograph the sculptures at Amravati, the caves and temples at Dachapalli in the Palnaud district, and the caverns in Ellora But nothing was done then Since that time Mr Sewell has been at work at Amravati See p 272

Mr Beglar that of Delhi, and both surveys were completed in October 1871 In 1872 Mr Carlleyle was sent to Rajputana, and Mr Beglar to Bandalkhand, General Cunningham himself visiting Mattura, Buddha Gaya, Gour, and other points of interest The reports of explorations at Delhi, Agra, and in the Doab, comprise the third volume of the reports, being those for 1871–72 [1] This volume also contains a detailed account of General Cunningham's plan for executing the survey, with the memorandum of instructions to his assistants The fourth volume consists of the detailed reports on Delhi by Mr Beglar, and on Agra by Mr Carlleyle [2] The fifth volume contains an account of General Cunningham's tour in the Punjab during the cold season of 1872–73 [3] The chief results during this tour were the acquisition of a new copy of the rock inscription of Asoka at Shahbazgarhi, and of an extensive collection of Buddhist sculptures of the Indo Scythian period

In 1872–73 General Cunningham and Mr Beglar explored the greater part of the Central Provinces, the General taking the western, and Mr Beglar the eastern half The most interesting discovery was at Bharahut, nine miles to the south-east of the Sutna railway station, and 120 miles south-west of Allahabad Here is the site of an old city, and of a large brick *stupa* 68 feet in diameter The colonnade of the Bharahut *stupa* is of the same age and style as that of the great Sanchi *stupa*, near Bhilsa, but at Bharahut every pillar and every railing is sculptured with an inscription on almost every stone From the characters of the inscriptions the erection of the railing is assigned to the age of Asoka, or about B C 250 A full description of these important discoveries will be found in the "Abstract of the Reports of the Surveys for 1872–73 "[4]

In order to carry into effect the proposals made by the Secretary of State for India in a despatch of the 11th October 1871, with a view to the production of a complete survey of the Rock Cut Temples of Western India, the Government of Bombay, in July 1873, submitted a scheme for the survey of the archæological remains in Western India, suggesting the employment of Mr J Burgess to conduct the survey The Government of India, in sanctioning this scheme, however, introduced a clause limiting the

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[1] Published at Calcutta in 1873

[2] Published at Calcutta in 1874

[3] Published at Calcutta in 1875

[4] Pages 34 to 40 See also the "Geographical Magazine" for August 1874, p 200

area of research to the Bombay Presidency, and restricting the expenditure to such an amount as to allow only Rs 3,000 for establishment, photography, scaffolding, &c per annum Mr Burgess returned to Bombay in January 1874, and, with one School of Art student and an assistant, he started on the 24th January for Vingorla *en route* for Belgâm, where he began work on the 2nd of February He completed the season's work in the field on the 16th of April at Aiwalli, and his ' Report of the Operations of the Archæological Survey of the Bombay Presidency for 1874" was published in London in the same year by Messrs Allen The operations were confined to the Belgâm and Kaladgi districts, and the work which records them is a handsome quarto containing 37 plates and 19 photographs, out of 54 photographs that were taken

During 1874–75 Mr Burgess was engaged in the examination of antiquities in Ahmedabad, Katiawar, and Kach, and made a complete set of impressions of the great Asoka inscription at Girnâr, which is now lodged in the India Office Library The work in the field occupied him from October 1874 to April 1875, and is recorded in a quarto volume published in 1876 —"Report on the An-"tiquities of Kathiawad and Kachh, being the result of the second "season's operations of the Archæological Survey of Western India, "1874–75," by James Burgess, with numerous photographs The section on the Sâh and Gupta coins is by Mr E Thomas

Since 1872 Mr Burgess has edited a valuable periodical at Bombay, called the "Indian Antiquary," which is published monthly It is devoted to oriental research, and contains articles on the archæology, history, literature, languages, philosophy, religion, and folk lore of different parts of India The "Indian Antiquary" has published several ancient inscriptions, and, chiefly with a view to securing the continuance of this useful work, it is subsidized by the Government

In March 1870, Mr Boswell, the collector of the Krishna district, had submitted a very interesting report on the archæological remains in his district to the Madras Government[1] It included descriptions of natural caves, enlarged by man and used as dwelling-places, of cromlechs and stone circles, of Buddhist topes and temples, and of more recent edifices His account of the cave near

1 "Letter from J A C Boswell, Esq, Officiating Collector of the Kistnah district, to the Acting Secretary to the Board of Revenue Madras Dated, Masulipatam, 31st March 1870"

Bezwada almost certainly identifies that place with the capital city visited by Hwen Thsang, while the ruins at Amravati, with their exquisite sculptures, are those of a cluster of religious buildings. Mr. Boswell anticipated that important results would follow the prosecution of further researches, especially at Amravati, and the Madras Government gave orders that steps should be taken for the preservation and protection of all sculptures and other archæological remains. They also expressed their readiness to aid the efforts of any archæologist of eminence, who might be disposed to institute further inquiries in the Krishna district, by every means in their power. The death of Mr. Boswell temporarily checked these researches.

But in consequence of representations made by the President of the Oriental Congress of 1874, the Secretary of State addressed the Madras Government on the subject of appointing an Archæological Surveyor for Southern India, in the same way as has been done in the other presidencies. It was pointed out that, with a few exceptions, the antiquities of Southern India, though equally important, have not attracted the same attention that had been bestowed by the Asiatic societies of Bengal and Bombay on the archæology of Hindustan before the organization of the present Survey. The difficulties attending an Archæological Survey in the south are greater than those that operate in the north and west, on account of the greater variety of characters used in inscriptions and ancient documents, which are not easy to decipher, and on account of the mixture of Sanscrit with forms of local vernaculars now little understood. There is only one man living who possesses *all* the qualifications required for an archæological surveyor of Southern India. Mr. A. C. Burnell, District and Sessions Judge at Tanjore, combines, with a rare knowledge of the literary and religious history of Southern India, not only a thorough familiarity with Sanscrit and the modern Dravidian vernaculars, but also a unique acquaintance with South Indian palæography, a science which he has been the first to elaborate in a work recently published. The appointment of this gentleman to the post referred to has been suggested to the Government.

Towards the end of 1875, Mr. R. Sewell, of the Madras Civil Service, obtained a small grant from the Government in order to carry on excavations mainly for the discovery of the remaining marbles of the great Buddhist Stupa, at Amravati, near the Krishna river, and the opening out of a half concealed rock cut temple at

Undavilli, near Bezwada The temple turned out to be a magnificent one of four storeys Mr Sewell also discovered about 90 new and splendidly preserved sculptured marbles at Amravati, with the promise of plenty more as the excavations proceed, and procured copies of 900 ancient inscriptions on stones, in and about the Krishna district No better commencement could be made for systematic archæological work in the Madras Presidency than by employing Mr Sewell to complete the Amravati tope excavations, and to translate the very numerous inscriptions

The first volume of Babu Rájendralála Mitra's "Antiquities of Orissa" has appeared in the shape of a large quarto, illustrated by 36 lithographed plates It contains the results of the author's labours while engaged on the archæological mission to Bhuvanes'vara in 1868–9,—an undertaking sanctioned by the Government of India mainly at the suggestion of the Royal Society of Arts in London, who recommended the grant of a large sum of money for the purpose of obtaining casts of some of the more important sculptures of ancient India The second volume deals with the antiquities of the different localities

A work on the primitive tribes and monuments of the Nilgiris, by the late Mr J W Breeks, Commissioner of the Nilgiris, has recently been published by Government[1] Mr Breeks' researches were undertaken in 1871, principally at the instance of the Trustees of the Indian Museum, Calcutta, who urged upon Government the desirability of making a collection of the arms, ornaments, dresses, household utensils, and agricultural implements, and all other products of the manufacturing skill of these aboriginal tribes, whose ancient and distinctive customs are now fast disappearing The work referred to contains the results of Mr Breeks' labours to attain this object It forms a handsome volume in quarto, and is profusely illustrated by photographs[2]

In 1876 Mr Fergusson published his "History of Indian and Eastern Architecture," which nominally forms the third volume of the new edition of his "History of Architecture"[3] But in reality it

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[1] See also page 249

[2] "An account of the primitive tribes and monuments of the Nilagiris," by the late James Wilkinson Breeks of the Madras Civil Service, edited by his widow, (India Museum, 1873), with map and 82 plates

[3] "History of Indian and Eastern Architecture," by James Fergusson, D C L, F R S, &c, forming the third volume of the new edition of the "History of Architecture" (Murray, 1876), pp 756, and 394 illustrations

is a new work For in the former edition the Indian chapters extended only to about 300 pages with 200 illustrations Now more than half the original text has been cancelled, so that at least 600 pages of the present work are original matter, and 200 illustrations have been added There are now very few buildings in India of any importance which have not been photographed, and Mr Fergusson found his collection of photographs, for purposes of comparison, to be simply invaluable[1] "For detecting "similarities or distinguishing differences between specimens "situated at distances from one another, photographs are almost "equal to actual personal inspection, and when sufficiently nume"rous, afford a picture of Indian art of the utmost importance to "anyone attempting to describe it" The work is divided into nine books on Buddhist architecture, Jaina architecture, the architecture in the Himalayas, the Dravidian style, the Chalukyan style, the northern or Indo Aryan style, the Indian Saracenic architecture, the architecture of further India, and of China In the preparation of this work Mr Fergusson had before him the five volumes of General Cunningham's Archæological Reports, and the results of Mr Burgess's researches among the western caves and the structural temples of the Bombay Presidency

Mr Fergusson will now proceed with the preparation, for the India Office, of a complete history of the cave temples of India, in which important work he will have the assistance of Mr Burgess

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[1] Mr Fergusson has a collection of more than 3,000 photographs of Indian buildings

# XVI

## METEOROLOGICAL OBSERVATIONS

THE practical importance of meteorological observations is so great as to have ensured their registration in India, at a very large number of stations, and over a long period of time They affect the operations of the seaman and of the husbandman, and are a vital element in the calculations of health officers, of administrators, and of engineers [1] Their usefulness, therefore, has always been fully recognized, but it was long before any attempt was made to introduce an organized system of registration, all work connected with the generalization and utilization of the ever accumulating materials was left to the zeal and industry of volunteers, and even now, though excellent measures have recently been adopted, there is more to be done before a meteorological department in India can be considered as established on a perfectly satisfactory footing

Medical officers at stations and hospitals have been expected to keep meteorological journals from a very early period, and numerous volunteers have registered observations, but, owing to the want of a central department, and to other causes, much of the earlier material is lost, and much that is preserved is of but moderate value

In the Bengal Presidency the earliest series I have met with is the meteorological journal of Colonel Pearse [2] kept at Calcutta between March 1st, 1785, and February 28th, 1788 It includes observations of the barometer, thermometer, hygrometer, direction

[1] "It can scarcely be necessary to insist on the practical importance of this science to the agriculturalist, to the navigator, and indeed to every branch of human affairs, or to dilate on the benefits which must accrue to mankind in general from any successful attempts to subject to reasonable and well grounded prediction the irregular and seemingly capricious course of the seasons and the winds or on the advantages, purely scientific, which must arise from a systematic development of laws, exemplified on the great scale in the periodical changes of the atmosphere, depending, as they do, on the agency of all the most influential elements, and embracing in their scope every branch of physical science"—*Sir John Herschel*

[2] See page 55

and force of wind, and rainfall, taken generally at about 7 a m and 2 15 p m [1] A similar diary was kept at Calcutta by Mr Henry Traill, from February 1st, 1784, to December 31st, 1785 [2] The hygrometers of those days were of very primitive construction Mr Traill used a bit of fine sponge suspended in a scale on the end of a steel yard, with a semicircular scale at the top, and Captain Kater's ingenious device for ascertaining the amount of moisture in the atmosphere has already been described [3]

James Prinsep took a careful series of meteorological observations at Benares for two years, and published his general results for 1823, including the mean daily range of the barometer for each month, the monthly means and extremes of the thermometer, the hygrometric entries, the rainfall, direction of the wind, and weather [4] General Thomas Hardwicke kept a meteorological register at Dam Dam from 1816 to 1823 It contains daily and monthly means of seven daily observations of the thermometer, barometrical observations taken daily at sunrise, noon, and evening, with monthly means, a register of the hygrometer, an enumeration of days of rain, and prevailing winds [5]

When Sir John Herschel was at the Cape he sent a circular to India, suggesting that horary observations should be taken for 24 hours together at the time of the equinoxes and solstices [6] Several observers complied with the great astronomer's directions, in various parts of India Mr Barrow, the mathematical instrument maker at Calcutta, took observations of the barometer and thermometer every hour, on the 21st and 22nd of December 1835, and on the 21st and 22nd of March 1836,[7] and Colonel Colvin, assisted by Lieutenants Baker and Durand, registered horary readings at Dadapur, on a day in September 1835, and on another in March 1836

Numerous observations were made, from time to time, by travellers and residents, while the registers of medical officers were con

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1 "Asiatic Researches,' i, p 442

2 "Asiatic Researches," ii, p 420

3 See note at page 63

4 "Asiatic Researches," xv, App p vii

5 "Journal of the Royal Asiatic Society," i, App

6 Sir John Herschel recommended 3 and 9 a m and 3 and 9 p m as the most important hours for observation and that hourly observations for 24 hours should be taken on the 21st of March, June, September, and December These are called "term observations '

7 "J A S B,' v, p 51 and p 243

tinually accumulating In 1798 Dr Hunter recorded observations on the rainfall and climate at Ujain[1] In 1835 the Rev R Everest wrote an essay on the revolution of the seasons, and on the correspondence between atmospheric phenomena and the changes of the moon,[2] and the same observer also published a valuable paper on the rain and drought of eight seasons in India, from 1831 to 1838, giving the rainfalls at Calcutta, Madras, Bombay, and Delhi[3] Among travellers General Cunningham, in his work on Ladak, gives a series of meteorological observations taken in the Spiti valley, Kashmir, Ladak, and other parts of the Himalayan region,[4] Dr Hooker, in his journal, furnishes a series of observations registered in Darjiling, Khasia, and Cachar, the Bahar hills, the valley of the Son, Mirzapur, and the Kaimor hills, which include minima, maxima, and means of the thermometer, the wet and dry bulb, and solar and terrestrial radiation,[5] and Colonel Richard Strachey made some hourly observations of the barometer in August 1849, at 18,400, 16,000, and 11,500 feet above the sea, in the mountains of Tibet[6] A notice of the climate of Kumaun and Gurhwal will be found in Mr Henry Strachey's paper[7] Dr Royle took a series of observations at Saharunpur from 1826 to 1830, and wrote an account of the meteorology of the plains and mountains of N W India,[8] and Drs Hooker and Thomson have given a sketch of the meteorology of India, in the Preliminary Essay to their *Flora Indica*[9] It would be a hopeless task to attempt a complete enumeration of all the observations of this kind, or of those kept by medical officers and others at fixed stations, but the enquirer will find abstracts of a great number of registers in the volumes of the journal of the Asiatic Society of Bengal[10]

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1 "Asiatic Researches," vi, p 53
2 "J A S B," iv, p 257, vi, pt i p 303
3 "J A S B," viii, pt i p 313
4 Cunningham's "Ladak" On climate pp 171–190, and tables, p 449
5 "Hooker's Journal," ii, p 357 Appendix A, on Meteorology
6 "R G S J," xxiii, p 64 Colonel Strachey's observations at great heights tend to show that the atmospheric pressure is subject to the same sort of fluctuations on the Tibetan table land as prevail in the lower regions elsewhere
7 "R G S J," xxi, p 72
8 "Illustrations of Himalayan botany," i, p xxx
9 "Flora Indica," i, p 74
10 At Simla, vol v, p 825, at Bijnor, ii, p 206, Bombay, v, p 821, Kathmandu, v, p 824, and xii, p 768, at Tirhoot, v, p 822, Socotra, v, p 821, Bangalore, v, p 296, Darjiling, vi, pt i, p 308, Rangoon, vol xxii, Agra, xxii, Bankura, i.

From time to time endeavours have been made to classify and utilise the ever accumulating meteorological observations of medical officers in India In 1852 Dr Lambe drew up an abstract of the registers of 126 stations in Bengal and the N W Provinces for the year 1851, giving the monthly mean temperatures and rainfalls [1]

The Messrs Schlagintweit, who were in India from 1854 to 1858, published the meteorological volume of their work in 1866 [2] The meteorological registers received by the Medical Board at Calcutta were handed over to them in 1857, comprising a series of 38 folio volumes in manuscript The observations thus obtained were taken at no less than 250 stations They consist of entries for temperature and rainfall, and sometimes for readings of the wet and dry bulb thermometers, and in the sun's rays The results from this great mass of material are a series of tables of monthly means of temperature, with maxima and minima in some instances for two and sometimes for three years [3]

A regular series of meteorological observations has been kept at the Surveyor General's Office at Calcutta from 1829 until the present year, and monthly and yearly abstracts of them have been published, first in the "Gleanings in Science," and since 1832 in the "Journal of the Asiatic Society of Bengal" At first the hours of observation were sunrise, 10 a m , noon, and sunset , but afterwards they were altered to sunrise, 9 50 a m , 2 40 p m , 4 p m , and sunset ,[4] and since 1856 the observations have been taken every hour Observations of maxima and minima temperatures first appeared in 1848 The abstracts were also published in the "Calcutta

Chinsura, ii Gazipur, ii Lucknow, xxiii , Masauri, iv Cherrapunji, i Mozuffurpur ii Nagpore, ii , p 239 Singapore, ii , Nushirabad, ii , p 128, and v Dadapur, v Ambala, iv Sir John Malcolm registered the barometer and thermometer five times a day at Mundleysir in July, and at Mhow in January 1821 *Central India*, ii , p 350 See also a meteorological register at Shillong and Cherrapunji for August 1860, and a register of temperature at Kampti and Muhtur hills for May 1860, in the "Report on the Sanitary Establishments for European Troops in India, (No iii , Calcutta, 1862) Abstract of meteorological observations made at Futtehgur by John C Pyle in 1850 See " *British Association* xx , p 40

[1] "J A S B ,' vol xxi , p 383 and *British Association Reports*, xxi , p 52

[2] "Meteorology of India , an analysis of the physical conditions of India," vol iv , (1866)

[3] A list of works on the subject of Indian meteorology will be found in this volume of the Messrs Schlagintweit s work

[4] Observations at sunrise, noon, and sunset involve computations for determining diurnal barometric oscillations

Journal of Natural History," but as the registers were bulky, little used if given in detail, and useless if too much abridged, Dr McClelland, the editor, discontinued their publication, and gave instead the general results to be deduced from these records for the year 1843–44 in a series of tables These tables show the monthly means, maxima, and minima of the thermometer and barometer, the monthly rainfall, direction of wind and weather[1] In 1848 Colonel Thuillier prepared a tabular statement of the number of rainy days, and the quantity of rain which fell in Calcutta, for every month from the year 1829 to 1847[2]

Since 1868 the abstracts of the results of the hourly meteorological observations taken at the Surveyor General's Office at Calcutta have been published separately in monthly parts They give daily means of the hourly observations of the barometer and thermometer, for means, maxima, and minima, daily and hourly means of the wet bulb, dry bulb, dew point, dry bulb above dew point, mean elastic force of vapour, mean weight of vapour required for complete saturation, mean degree of humidity, and the maximum solar radiation, rainfall, direction of wind and weather Two tables have also been published showing the mean monthly and the mean hourly variations of temperature and humidity for fifteen years, from 1855 to 1869, as determined in the Surveyor General's Office at Calcutta Facsimiles of the indications given by the anemometer at the time of the cyclones of May 16th and June 9th, 1869, showing the direction and pressure of the wind per square foot, have also been published

A valuable series of meteorological observations was taken at Simla, under the direction of Major Boileau, between 1841 and 1846 They consisted of registers of temperature, of maxima and minima, of readings of the dry and wet bulb thermometers, from which were deducted the dew point, tension, and temperature, dew points by Daniell's hygrometer, solar and terrestrial radiation, wind and quantity of rain The observations were made hourly for six days in the week[3] Dr Lloyd, of Dublin, reported that the Simla

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1 "Reduction of the meteorological register kept at the Surveyor General's Office at Calcutta for the year 1st Nov 1843 to 31st Oct 1844," by J McClelland "Calcutta Journal of Natural History,' v p 533

2 "J A S B, vol xvii pt i, p 312

3 All the Simla observations had been printed, and were packed at Agra, ready for transmission to England, when the mutiny broke out, and they were burnt The manuscript monthly abstracts of the observations from September 1841 to the end of

observatory, under Major Boileau's superintendence, was in all respects admirably organized, and pointed out the great value of an extended and complete series of observations made at an altitude of 8,000 feet[1]

A complete series of meteorological observations has been registered at the astronomical observatory at Madras since 1796 by the astronomers who have successively been in charge The earliest I have seen are for 1819[2] The hours of observation were then at sunrise, noon, 2 p m, sunset, and 9 p m, and the entries were the readings of the thermometer rain gauge, wind and weather The series from 1822 to 1843, taken by Mr Goldingham and Mr Taylor, successive astronomers, was published in a folio volume with plates[3] From 1837 the hours of observation were 10 a m, 4 p m, and 10 p m A further series of observations by Mr Taylor, Major Worster, and Major Jacob, from 1841 to 1850, has also been published[4] Hourly observations were taken from March 1841 to February 28th, 1861, when the series was

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1845 are preserved, and are now in the hands of the Royal Society, but the mass of the original observations was lost in the fire The Simla observations were among the most extensive and carefully made records ever taken, and their loss is a great calamity as regards science, as well as a source of deep disappointment to General Boileau That officer also published a useful volume of tables "A collection of tables astronomical, meteorological, and magnetical also for determining the altitudes of mountains," by Lieut Colonel J T Boileau, computed at the office of H E I Co s magnetic observatory at Simla (Umballa, 1850) See also *J A S B*, xiii, p 135

In 1874 the first volume of the series of meteorological observations, taken at Simla by Major General Boileau, F R S, between 1841 and 1845, was published by order of the Secretary of State for India The hourly and daily means of all the instruments observed are given in a separate volume Copies of the work have been placed in the hands of the principal observers in India

[1] 'Reports of the British Association, xiv, p 3

[2] There are the following manuscripts in the Geographical Department of the India Office —

"Meteorological Journal kept at the Madras Observatory for 1819"

"Meteorological Journal kept at the Madras Observatory for 1824"

"Meteorological Journal kept at the Madras Observatory in 1830'

[3] There are printed meteorological observations taken at Madras in 1841, 1842 1843, 1844, and 1845

See also—"Meteorological register kept at the observatory at Madras for the years 1822–1843 by John Goldingham and Thomas Glanville Taylor" (Plates Folio Madras, 1844)

[4] "Meteorological observations made at the Honourable East India Company's Observatory at Madras, by the late T G Taylor, Esq, F R S, Captain Worster, M A, and Captain Jacob, Astronomers, 1841–50"

The meteorological abstracts from the Madras Observatory have been published in considered complete, and discontinued as no longer necessary Since 1861 observations have been registered thrice daily, and published weekly in the "Fort St George Gazette," but they have not been collected in a separate volume A new anemometer was erected at the Madras Observatory in June 1864 Rain returns have been kept at 350 stations, more or less regularly, since 1852, under the control of the Revenue Board They will furnish an interesting rain map of the Madras Presidency, showing the comparative influences of elevation above the sea-level, and proximity to the coast [1]

In 1846 the Court of Directors gave orders that a series of meteorological observations should be taken at a considerable height above the level of the sea, on the Nilgiri hills, and sent out a set of instruments for the purpose Mr Taylor, the Madras astronomer, considered that no set of observations could really be considered valuable unless they were made on the summit of the peak of Dodabetta, 8,640 feet above the sea, and within the influence of both monsoons A bungalow was accordingly erected, and on the 12th of January 1847 the instruments were fixed, under the charge of John de Cruz, an assistant of the Madras Observatory The instruments were an Osler's anemometer, a standard barometer, thermometers, and rain gauges, and the hours of observation were at 9 40 a m, and 3 40 p m, the supposed hours of maxima and minima At this great elevation, as in Colonel Sykes's Deccan observations, to be noticed presently, there is not a single day throughout the year in which the pressure at 3 40 p m is higher than that at 9 40 a m On the 21st and 22nd of each month horary observations were taken for 24 consecutive hours [2] Work was commenced in February 1847, and was continued until about 1858, when the Dodabetta Station was abolished by Sir Charles Trevelyan Observations for temperature, rainfall, and directions of wind at Utakamund and Kotergiri on the Nilgiris, will be found in

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the "Journal of Literature and Science of Madras" since 1833 There was a long hiatus in the publication of the journal from 1840 to 1847, but in the latter year the monthly meteorological abstracts re appeared, and have been continuously published ever since They are signed by Mr Norman Robert Pogson, the present astronomer at Madras, since 1861

[1] "Proceedings of the Astronomical Society," vol xxiii, p 178

[2] "Meteorological observations made at the meteorological bungalow on Dodabetta Peak, 8,640 feet above the sea, in 1847–48, under the directions of T G Taylor, Esq, F R S" See also Colonel Sykes's paper, *Phil Trans* 1850, pt ii (xv)

Ouchterlony's report of the survey made in 1847, where there are also some remarks on the climate.[1]

The foundation of the observatory at Trivandrum was due to the great interest taken both by the late Rajah of Travancor and by General Fraser, the Resident at his court, in the sciences of astronomy and meteorology. Mr. John Caldecott received the appointment of astronomer, and the building was erected, in 1836, on a hill 190 feet above the sea.[2] Mr. Caldecott died in December 1849, and, during an interregnum of two years, Mr. G. Spershneider registered the observations. The Trivandrum observations will be found in several numbers of the "Madras Journal of Literature and Science," and the means of Mr. Caldecott's hourly observations, between 1837 and 1842, were published by Professor Dove.[3] General Cullen also had observations taken to ascertain the rainfall, from 1842 to 1846, at Cochin, Kollam, Alepy, Cape Comorin, and other points on the Travancor coast.[4] But the best and most extensive observations in Travancor were made by Mr. John Allan Broun, who formerly had charge of Sir Thomas Brisbane's observatory at Makerstown in Scotland, and arrived at Trivandrum, as astronomer to the Rajah of Travancor, in January 1852. He continued the series of meteorological observations at Trivandrum, and, after two years consumed in the undertaking, he established a branch observatory on the summit of the peak of Agustia-mulla, 6,200 feet above the sea. In reaching this lofty site, paths had to

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[1] "Geographical and Statistical Memoir of the Neilgherry Hills." Presented to Parliament, and also printed in the "Madras Journal," xv., p. 1. There is a series of meteorological observations taken on the Nilgiri Hills by J. Glen, from 1829 to 1836, in the "Journal of the Physical and Medical Society of Bombay." See also "Travels in Peru and India, by Clements R. Markham," pp. 359 and 382, and tables in McIvor's Annual Reports on Chinchona cultivation.

[2] See a sketch and plan of the building in the "Madras Journal of Literature and Science," vol. vi., p. 56 and p. 339. Mr. Caldecott also published "A notice accompanying a series of meteorological observations made at Trivandrum."—*Report, British Association*, (pt. 2, 1840), p. 28. "Observations on the temperature of the earth in India."—*Proceedings of the Edinburgh Royal Society*, i., p. 432 (1845), and "Observations on the ordinary temperature of the ground at Trivandrum from May 1842 to Dec. 1845."—*Transactions of the Edinburgh Royal Society*, xvi., p. 379, and *Proceedings*, ii., p. 29.

[3] "British Association Reports," ix., p. 28.

[4] General Cullen also published a series of barometrical levellings in the Madras Presidency.—"Reports of the British Association," xv., p. 22, xvi., p. 42, and xvii., p. 39.

be cut through jungles infested by wild elephants, and there were delays owing to labourers running away, from fear and cold [1]

The Agustia-mulla Observatory was at last completed in March 1855, and from its platform the whole south of the Indian peninsula is seen, from Cape Comorin to Cochin on one side, and to Adam's Bridge on the other, an almost unequalled view Mr Broun has given a most interesting account of the observatory, and of the difficulties overcome in its construction, in his Report of 1857 The assistants at this lofty observatory were arranged into three sets of four men each, according to their castes, the first set being Syrian Christians, the second Brahmans and Sudras, and the third Roman Catholics, relieving each other every three months The observations were commenced on July 1st, 1855, but during Mr Broun's absence in England in 1860 the observatory was allowed to fall to pieces On his return in 1863 he had it rebuilt, and a second series of observations was taken, which extended over ten months Mr Broun also caused a series of hourly observations to be taken in different years, simultaneously with those at Trivandrum and Agustia, at stations near the latter, and at 5000 feet lower level, one east and one west This series had special reference to questions connected with the atmospheric pressure, temperature, humidity, and evaporation In 1859 a similar series of hourly observations was taken at five different stations rising about 1,200 feet one above the other, in connexion with the same meteorological questions In all these series the best instruments were used Base lines were measured by Mr Broun on both sides of the Agustia peak, in order to ascertain trigonometrically the exact height of the observatory, and the lower stations When the Travancor Government decided on abolishing the observatories in 1865, Mr Broun obtained leave for the continuation of a limited series to be made by the two oldest and best of his native observers, and a Syrian Christian, his principal assistant, continued in charge, and forwarded monthly reports and abstracts of meteorological observations to Mr Broun, in Europe

Sir John Herschel's suggestion, that horary observations should be taken for 24 hours together on four fixed days of each year, received due attention from the Madras observers Such observa

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[1] Report on the "Observatories of His Highness the Rajah of Travancore," by John Allan Broun, F R S, *Director* (Trivandrum, 1857) Reprinted, in quarto, by Messrs King, 1874 "Reports of the British Association," xxiv, p 25, xxvii, p 30

tions were registered, both at the Madras and Trivandrum Observatories, on December 20th and 22nd, 1836, in January 1838 at both places, and also by Dr Gilchrist at Hunsur in June and September 1838, in April 1839, and again in 1840 [1] Dr Mouat, also, at Bangalor, took horary observations, in conformity with Sir John Herschel's circular, on the 21st and 22nd of March 1836 His previous meteorological observations extended over the years 1834 and 1835 [2]

Registers of observations have been published, which were taken in the hill regions of Wynaad and Coorg Captain Minchin observed at Manantawaddi in Wynaad during the year 1832, and gives the monthly mean temperature at daylight, noon, the mean and greatest heat, and the number of days of rain [3] In Coorg the register was kept at Mercara by Dr Baikie, who published his notes on the climate, with a table giving the monthly means of the barometer, thermometer, and hygrometer, observed at 6 a m, 10 a m, and 5 p m [4]

A diagram showing the meteorological condition of Sikandrabad for the year 1864 was lithographed and published at Madras in 1866 It gives the amount of ozone, atmospheric pressure, rainfall, temperature of the air in sun and shade, the amount of humidity, and prevailing winds The work is valuable, and does great credit to the industry and zeal of its author, Dr W Arnold Smith [5]

In the Bombay Presidency a regular register of the thermometer was kept for 26 years, from about 1816, by Mr Benjamin and Mr George Norton, of the Company's service, but the leading meteorologist of India, who first classified and drew sound deductions from his work, was Colonel Sykes This accomplished observer kept a register in the Deccan and at Bombay from 1825 to 1830, and gave his results to the world in an elaborate paper which was read before the Royal Society in 1835 [6]

Colonel Sykes points out that the great features in his barometrical indications are the diurnal and nocturnal tides, embracing

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1 "Madras Journal of Literature and Science," v, p 214, vii, p 144, viii, p 397, ix, p 454

2 "J A S B," vol v, p 296

3 "Madras Journal," i, p 38

4 Ibid iii, p 338

5 There are several copies of this diagram in the Geographical Department of the India Office

6 "Philosophical Transactions," No x (1835), p 161 "On atmospheric tide and the meteorology of the Deccan," by Lieut Colonel W H Sykes, F R S

two maxima and two minima in the 24 hours, the former between 9 and 10 a m and 10 and 11 p m, and the latter between 4 and 5 p m and 4 and 5 a m In many thousand observations there was not a solitary instance in which the barometer was not higher at 9 to 10 a m than at sunrise, and lower at 4 to 5 p m than at 9 to 10 a m His hygrometric observations, and those for the direction of the wind, were very complete and satisfactory The great feature as regards wind in the Deccan is its extreme rareness from the north or south Whirlwinds are common in the hot months, columns of dust in the form of trumpets, chasing over the treeless plains, and carrying sand, straw, clothes, and baskets to a height of 200 feet in the vortex of heated air The deductions derived from the observations by Colonel Sykes were important and numerous In the first place, they removed the doubts, previously entertained by Humboldt, as to the suspension of the atmospheric tides during the monsoon in Western India, next, Colonel Sykes proved the existence of four atmospheric tides in the 24 hours, two diurnal and two nocturnal, and each consisting of a maximum and minimum tide, as well as the occurrence of the tides within the same limit hours as in America and Europe He discovered that the greatest mean diurnal oscillations took place in the coldest months, and the smallest tides in the damp months of the monsoon in the Deccan, that the diurnal and nocturnal occurrence of the tides was regular, without a single case of intervention, and that the diurnal and annual oscillations were trifling, compared with those of extra tropical climates He found that the annual range of the thermometer was less than in Europe, but that the diurnal range was much greater He also described the remarkable circular and white rainbows in the Deccan, the peculiarities of the winds, the frequency of calms, the quantity of electricity in the atmosphere under certain circumstances, and the singular opacity of the atmosphere in hot weather The tables which accompany this important paper show the oscillations of the barometer, the barometric observations at Poona, Bombay, and Mahabaleshwur, the hygrometric observations, the register of the ombrometer, and the prevailing winds

The Bombay Observatory at Colaba was first established under Mr Curnin in 1823, but the records previous to 1840 are scanty and imperfect In the end of the latter year a set of instruments, originally intended for Aden, were transferred to Bombay, and

Mr Arthur B Orlebar, who was Elphinstone Professor of Astronomy and Mathematics, took charge of the observatory, at the request of Colonel Sykes His series extends over the year 1841–42, and on the 15th of July 1842 Dr George Buist assumed charge of the Colaba observatory[1] The results of Dr Buist's meteorological observations from 1842 to 1844 were published monthly in the "Journal of the Bombay Branch of the Asiatic Society" He had three native assistants, and horary readings were registered of the barometer, thermometer, wet and dry bulb, and direction of the wind[2] Dr Buist had devoted much attention to meteorological subjects He collected a vast amount of data, and the newspaper he edited at Bombay is full of information respecting phenomena connected with the weather Dr Buist published the results of a comparison of the observations of nine different barometers read every half hour for 24 successive hours,[3] a catalogue of remarkable hail storms from 1822 to 1850, in India,[4] and a notice of remarkable meteors[5] He put thermometers for recording solar and terrestrial radiation into use at the Colaba Observatory, and constructed a diagram of hourly barometric curves at Bombay, comparing them with those at Madras and Trivandrum Dr Buist endeavoured to make the study of meteorology interesting, and in his very pleasantly written paper on the climate of Western India, he complained that "picturesque and descriptive meteorology had almost altogether been buried under minute instrumental details"[6]

Dr Buist furnished General Sabine with observations taken in 1843, consisting of the mean temperature, mean barometric pressure, mean tension of the atmosphere, and mean gaseous pressure at

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[1] Dr Buist published an account of "the Observatories of India" in the *Times of India*, June 15th, 1850

[2] "Meteorological Observations, Bombay, 1842," Dr George Buist, LL D, 1843

"Journal of the Bombay Branch of the Asiatic Society,' i, pp 49–90, 145–200, 255–354

"Provisional Report on the Meteorological Observations at Bombay for 1844' (Cupar, 1845)

"Journal of the Bombay Branch,' i, p 287, and printed separately

"Journal of the Bombay Geographical Society,' ix, p 184 and p 1

[3] "Journal of the Bombay Branch,' i, p 207 and printed separately

[4] "Journal of the Bombay Geographical Society,' ix, p 104, and xii, p 1, and "British Association Reports," xx, p 31, and xxiv, p 35

[5] Ibid ix, p 197

[6] "Sketch of the Climate of Western India," by Dr Buist—*Reports of the British Association*, xx, p 29

every second hour These data formed the subject of a paper read before the British Association by General Sabine in 1845,[1] and assisted in the explanation of the diurnal variation of barometric pressure General Sabine had already noticed, from observations taken at Toronto, that the aqueous and gaseous constituents of barometric pressure, when presented separately, exhibited, in their variations, a striking accordance with variations of temperature The data supplied by Dr Buist tended to confirm these deductions, which suggest an extension in height and consequent overflow of the column of air in the higher regions of the atmosphere, over the place of observation in the day time, when the surface of the earth is gaining heat by radiation, and a contraction when the temperature is diminishing

Dr James Murray was actively engaged in meteorological studies in the Deccan during the time that Dr Buist was at work in Bombay He registered a series of observations at Satara from 1844 to 1847, consisting of means, maxima, and minima, and daily ranges for each month, and had previously completed a series at Mahabaleshwur, extending from 1829 to 1843,[2] which had been commenced by Drs Walker and Morehead

Professor Orlebar resumed the charge of the Colaba Observatory in 1844, and superintended the registration of hourly readings in 1845[3] He prepared a series of hygrometric tables, based on those of Major Boileau[4] In 1846 the Colaba Observatory was handed over to Captain Montriou,[5] of the Indian Navy, who had the observations registered every two hours His elements were atmospheric

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1 "British Association Reports," xiv, p 73 Reprinted in the "Madras Journal of Literature and Science," xiii, p 106

2 See his "Observations on the climate of the Mahabaleshwur hills"—*Journal of the Medical and Physical Society of Bombay*, i, p 79 (1838), and "Notes on the meteorology of the Sattara Territory for 1848"—*Journal of the Bombay Geographical Society*, vol ix, p 13 (1850)

See also his paper entitled "Practical observations on the nature and effects of the hill climates of India, in which he gives the mean temperature at Simla, Utakamund, Darjiling, Kotagiri, Landur, Mahabaleshwur, &c—*Transactions of the Medical and Physical Society of Bombay*, vol vii, p 3 (1844)

3 "Meteorological Observations, Bombay, 1845" Arthur B Orlebar (Bombay 1846 4to) "On magnetic and meteorological observations at Bombay," by A B Orlebar *Reports Brit Ass*, p xvi, p 28

4 "Journal of the Bombay Branch," ii, p 309

5 "Observations made at the Bombay Observatory for 1847" C W Montriou, Commander, I N" Part ii, meteorological (Bombay, 1851 4to)

pressure, temperature of the free air, of the stratum of air in contact with the ground, of the ground six feet below the surface, of the wet and dry bulbs, the force and direction of the wind, rainfall, evaporation and clouds He also gives tables of means Captain Montriou was succeeded by Lieutenant Fergusson, of the Indian Navy, who held the appointment until 1864[1] In his time the instruments were in an open shed like building at Colaba, fitted with screens to regulate the absence of glare and sunshine The observations were horary, and he published summaries of results, with diagrams of diurnal changes of the meteorological elements, and of variations of temperature[2] Lieutenant Fergusson was succeeded by Mr Morland, and Mr Chambers has continued the series down to the present year

In 1852 five complete sets of new and verified instruments were sent out from England, and placed at Belgaum, Poona, Bombay, Disa, and Karáchi, and the Court of Directors hoped that the zeal of the medical officers at these stations would ensure the due registration of observations, without entailing any public expenditure But the arrangement would not work, and in 1856 two European soldiers, previously instructed at the Colaba Observatory, were told off for service at each station, on a salary of Rs 25 a month There have been two daily registrations, at 9 30 a m and 3 30 p m, of barometric pressure, temperature of air and evaporation, direction and pressure of the wind, and dew point, and one daily observation of maxima and minima of thermometer in the sun and on the grass, and of the air and evaporation, of the rainfall and of ozone

In 1850 Colonel Sykes contributed another valuable paper, embodying the results of the further progress that had been made in India up to that date It is entitled "A discussion of the meteoro- "logical observations taken in India at various heights, embracing "those at Dodabetta on the Nilgiri hills at 8,640 feet above the sea"[3] The paper contains many important generalizations, and the additional information gives occasion for a further examination of the

[1] "Meteorological Observations" Bombay, 1853, Lieut E F T Fergusson, I N Also 1857 (Bombay, folio, 2 vols 1855,) and 1859–64

[2] A Report on the subject of the rainfall in the Deccan, and on the climatic disturbance apparent during 1861 and 1862, was published in 1863 See "Bombay Selections, No 78, N S

[3] "Philosophical Transactions" (1850), pt ii xv

phenomena of horary oscillations, and the times of ebb and flow of atmospheric tides at an increased number of observing stations, some of them, like Dodabetta, at great elevations above the sea Among other deductions, Colonel Sykes points out that climate is not absolutely dependent on latitude, but is affected by numerous local circumstances Thus the three hill stations of Mahabaleshwur, Mercara, and Uttray Mullay in Travancor are exactly the same height above the sea,[1] but widely separated as regards latitude. The mean temperatures of Mahabaleshwur and Mercara are almost identical, while Uttray Mullay, which is much nearer the equator, is 3° 35′ lower It is within the influence of both monsoons. Colonel Sykes points out great anomalies in the hours of the occurrence of maxima and minima of temperature at Madras, and remarks upon the range of temperature at Calcutta, Satara, Mahabaleshwur, and Dodabetta The Dodabetta temperature, at 8,642 feet, compared with that of Mahabaleshwur, at 4,500 feet, has a decidedly diminished daily, hourly, and annual range The probable sources of error in the degree of humidity in the air, as represented by the wet bulb observations in India, are discussed at some length, and Colonel Sykes recommends caution in generalizations from a limited number of local observations for the determination of the dew point He then gives a most valuable comparative summary of the amount of rainfall in various latitudes, and at different heights above the sea, showing that, on the ghats, the elevation of greatest fall is 4,500 feet above the sea; and that there is an extraordinary difference between points on the western rim of the ghats and others a few miles further east At Mahabaleshwur the fall in 1849 was 338 inches, and at Panchgunny, only 11 miles to the eastward, 58 inches The phenomena of wind, fogs, and electricity are also discussed Colonel Sykes's paper is accompanied by tables showing the mean oscillations of the barometer at Calcutta, Bombay, and Madras, and the mean horary oscillations at Calcutta from 1845 to 1848, and at Bombay and Madras from 1843 to 1845

Of late years the increased attention that has been paid to sanitary measures, to the causes of periodical famines, and to the phenomena of cyclones, has led to a more systematic study of the laws affecting the changes in the atmosphere over India It has been seen how

[1] 4,500 feet

zealously the study of the law of storms was pursued,[1] on the publication of Colonel Reid's work by Piddington at Calcutta, Biden at Madras, and Buist and Thom in the Bombay Presidency At about the same time the Government of India gave some attention to the more complete registration of meteorological data, with reference to the prospects of the harvests On the 21st of January 1846 the collectors were ordered to submit reports, and in 1847 they were supplied with thermometers and rain gauges For three years these statistics were given in the Annual Revenue Reports, but in 1852 the instruments were made over to the medical officers at the several stations, who were charged with the duty of keeping registers of the rainfall and temperature It appears, however, that these records were not satisfactorily kept The hours of observation were nominally at sunrise, 10 a m , 4 p m , sunset, and 10 p m

In 1863 Mr Glaisher prepared a report upon the meteorology of India from all the data that were then accessible His most reliable sources of information were the observatories at Madras and Bombay, but he also availed himself of a great mass of observations taken at other stations He found those for humidity of the air to be far too few, as well as those for solar evaporation Mr Glaisher discussed his materials with a view of rendering the results applicable for the purposes of the Army Sanitary Commission, and especially endeavoured to indicate, at different seasons of the year, the height at which the English climate is most nearly approached The most valuable and reliable section of his report is that on the fall of rain in India All the materials that could then be collected were examined and utilized by Mr Glaisher, but they were far from satisfactory, and he expressed a hope that future meteorological observations in India might be carried out under some general system, and on a uniform plan, both with respect to instruments, their position, and general instructions [2]

Admiral FitzRoy's introduction of the system of warnings and forecasts in England gave a fresh impetus to similar investigations in the east The Admiral's "weather book" was published in 1863,

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[1] See p 36

[2] "Report upon the Meteorology of India in relation to the health of the troops," by James Glaisher, F R S In the "Report of the Royal Commission on the Sanitary State of the Army in India" I, pp 781–943 (London, 1863 )

and in March 1865 a Meteorological Committee was appointed at Calcutta, to consider the best means of establishing a system of observations for the protection of that port The Committee recommended the appointment of observers, generally assistants in the Electric Telegraph Department, to be stationed at a series of points round the coast of the Bay of Bengal, and in some other directions, which should be in telegraphic communication with Calcutta They were supplied with instruments for observing the barometric pressure, humidity of the air and rainfall, and were to observe at 9 30 a m and 4 p m Their observations were to be transmitted daily by telegraph, and to be received at the meteorological observatory attached to the Surveyor General's Office at Calcutta, whence, if necessary, they were to be communicated to the master attendant The Committee also recommended that the thermometrical observations should be restricted to six first class stations, namely, Patna, Monghir, Hazaribagh, Berhampur, Shillong, and Goalpara[1] Sheds of uniform pattern were ordered to be erected for dry and wet bulb, and maximum and minimum thermometers The second-class stations were to be those under the Medical Department, where the rainfall only was registered

These measures were followed by the appointment of Meteorological Reporters to the Governments of the Punjab, the North-West Provinces, and Bengal Dr A Neil was appointed for the Punjab in 1866 The records from the various stations,[2] comprising registrations of atmospheric pressure, humidity, temperature, rainfall, and force and direction of the wind, were forwarded to him monthly besides daily registers of rainfall at 32 stations, from the Revenue Returns, and he prepared an annual condensed report on the general barometric phenomena, with barometric and wind charts[3]

Dr Murray Thomson, the meteorological reporter for the North-West Provinces, assumed charge in February 1865 In the first

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[1] Jessor, Gaya, Cachar, and Debrughur have since been added

[2] The stations were Lahore, Multan, Shahpur, Dera Ismael Khan, Peshawur, Rawal Pindi, Sealkot, Srinagar, Bahawulpur, Leh, Dalhousie, Rungi, Ludiana, and Hoshiarpur

[3] *See* "Annual Reports of the Meteorological Observations registered in the Punjab,' by Dr A Neil 1867, 1868, 1869

Dr Neil also supplied a summary of the weather in the Punjab for 1868, which is printed in the 5th Report of the Sanitary Commissioner with the Government of India (1868), p 13 year he received returns every month from 23 stations, of which three were in the Himalaya above 5,000 feet, and the rest on the plains at elevations from 1,800 feet at Ajmir to 250 at Benares Six of these had complete sets of instruments, namely,

| | | |
|---|---|---|
| Rurki, | Agra, | Jhansi, |
| Naini Tal, | Ajmir, | Benares |

The officers in charge are generally the civil surgeons of the stations, and the barometers are read at all the extreme periods of the daily oscillations Two volunteers also supplied valuable meteorological data, namely, Dr Bow from Chunar, and Mr Hennessey, of the Great Trigonometrical Survey, from Masauri, and afterwards from Dehra The second class stations, where observations are taken at 6 and 10 a m and 4 and 9 p m, are the civil and military hospitals Dr Murray Thomson, in the first year, delivered lectures on meteorological instruments and their use, at the Agra Medical School His Report for 1866 contains a general retrospect of the weather, and monthly tables of the barometric readings at 10 a m and 4 p m of the dew point, elastic force of vapour, relative humidity, the thermometer exposed and in shade, and six inches below the surface of the ground, the rainfall and winds [1] In 1868 the number of stations was 14, namely, Chakrata, Dehra, Rurki, Naini Tal, Mirut, Bareilly, Futtehgur, Agra, Lucknow, Ajmir, Gorruckpur, Allahabad, Benares, and Jhansi Each year, from the materials submitted to him, Dr Murray Thomson drew up an annual report, giving a retrospect of the weather, remarks on the climate, and tables of means [2]

In the Central Provinces sets of instruments were distributed to nine stations, namely,

| | | |
|---|---|---|
| Nágpur, | Seoni, | Chanda, |
| Jabalpur, | Ságar, | Pachmari, |
| Raepur, | Hoshangabad, | Sambalpur |

The first four date from 1868, and the other five were added in 1870 They are under the superintendence of the civil surgeons

The rainfall is also carefully registered by the canal officers, and

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[1] "Report on Meteorological Observations in the N W Provinces," by Dr Murray Thomson, 1866 It is published as Appendix C to the third "Annual Sanitary Report for Bengal" (Calcutta, 1867)

[2] "Report on the Meteorological Observations in the North West Provinces for 1868," by Dr Murray Thomson, Reporter on Meteorology Printed in the "Selec

a great deal of information on that branch of the subject will be found in the various irrigation reports

On the 1st of April 1867 the office of Meteorological Reporter to the Government of Bengal was established, to carry on the system of storm warnings for the protection of the port of Calcutta, and to perform duties similar to those of the Meteorological Reporters who had already been appointed for the Punjab and the North-West Provinces He was also to examine existing records, and undertake their supervision, and conversion into a form in which they might prove useful The reporter's work was thus divided into two branches, the collection of data, and its utilization

The appointment was accepted by Mr H F Blanford, who had already done good service in the geological survey in 1857–62, on the Nilgiri hills,[1] among the crystalline limestones of Coimbator and the sandstones of Trivicary, as well as with his brother in Cattack in 1856 The office work consists of sending daily reports to the newspapers, weekly to the "Calcutta Gazette," monthly abstracts and rainfall reports from the different stations to the Board of Revenue, and of preparing storm warnings and special reports In 1868 the first and second-class stations were equipped, and in 1869 they were in good working order, while some additional stations were established The elements recorded at the first class stations were the atmospheric pressure, mean and extreme temperatures of the air, solar and terrestrial radiation, humidity, rainfall, wind and proportion of clouds, and the hours for observation are 4 a m, 10 a m, 4 p m, and 10 p m[2] The stations were at Akyab on the Arakan coast, False Point Lighthouse near the mouth of the Mahanadi, Cattack, Sagar Island at the mouth of the Hughli, Chittagong, Calcutta, Jessor, Dacca, Darjiling, Silchar, Shillong on the northern slope of the Khasia hills, Goalpara, Berhampur, Monghir, Hazaribagh, Gaya, and Patna Mr Blanford also received reports from

tions from the Records of the Government of the N W Provinces Second series, vol iii, No 1, (1870)

Dr Murray Thomson supplied a summary of this report to the Sanitary Commissioner, and it is printed in the 5th Report, p 13

The Sanitary Commissioner in the Central Provinces has also taken steps to establish a number of meteorological stations, on the same plan as those in the North West

[1] See page 227 (*note*)

[2] Most of the stations are in charge of electric telegraph assistants, and the instruments supplied to each station are two mercurial barometers, dry and wet bulb and maximum and minimum thermometers a glass minimum radiating thermometer, a Robinson's anemometer, rain gauge, and wind vane

Benares, Rurki, Madras, and Port Blair, from Mr Nursingrow's observatory at Vizagapatam, where the register is uniform with those of the Bengal stations, from the manager of the Tea Company's garden in Upper Assam, and of the rainfall from the chinchona plantations in Sikkim, and on the Khasia hills Mr Blanford also set on foot a system of meteorological registration in the Indian seas, on a small scale, and registers are now kept on board six of the British India Steam Navigation Company's vessels The barometers have been compared with the Calcutta standard The third class stations, of which there were 36, only record the rainfall

In his annual reports, Mr Blanford digested the information he received from the numerous stations, and showed the results in a series of tables These include the monthly means of atmospheric pressure,[1] the monthly mean pressure at all the stations reduced to the sea level, the maximum, minimum, and mean monthly temperatures, humidity, serenity, comparison of serenity, solar radiation and mean temperature in hot weather months, rainfall, comparison of rainfall with averages, summary of observed winds, and monthly wind resultants There is also a sketch of the normal character of the monsoons, with notices of the storms on May 1st and 13th, June 5th and 10th, and October 7th and 8th of 1869[2] Mr Blanford supplies memoranda on the chief characteristics of the meteorology of each year to the Sanitary Commissioner[3] "The accumulation of "trustworthy and systematic observations," Mr Blanford reports, "which far exceed anything previously available for Bengal, has "admitted of a more scientific discussion than had previously been "practicable, and a beginning has been made to educe from the "tabulated and reduced results some general conclusions"

The Sanitary Commissioners in the three Presidencies have greatly promoted meteorological science, in the well founded expectation that systematic observations over wide areas would enable them to

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[1] He communicated a paper on barometric irregularities to the "Journal of the Asiatic Society of Bengal, 1870," pt ii, No 2

[2] See also the "Report on the Calcutta cyclone of October 5th, 1864," by Colonel Gastrell and Mr H F Blanford, noticed at page 38

[3] Mr Blanford has submitted annual reports, "Reports of the Meteorological Observer to the Government of Bengal," since 1867, and Administration Reports

See also the "5th Report of the Sanitary Commissioner with the Government of India (1868)," p 13 form conclusions as to the effects of climate on the diseases of the country In 1865 the Madras Sanitary Commissioner, Mr Ellis, prepared and submitted a scheme for recording meteorological observations at each of the chief, civil, and military stations, which received the sanction of the Supreme Government The stations are under the superintendence of the senior medical officer, and the copies of the registers are forwarded half monthly to Mr Pogson, the astronomer at Madras, for reduction, who prepares the annual reports The Sikandrabad register dates from July 1863, that of Trichinápalli from July 1866 The establishment of the 14 other meteorological stations was sanctioned in 1867, and 12 had commenced work in April 1870 —

1 Salem (1st December 1867)
2 Bangalor (1st January 1868)
3 Ballári (1st February 1868)
4 Coimbator (1st February 1868)
5 Madura (6th February 1868)
6 Cochin (16th March 1868)
7 Karnúl (16th April 1868)
8 Trichinapalli (1st July 1868)
9 Negapatam (16th July 1868)
10 Masulipatam (17th August 1868)
11 Sikandrabad (1st July 1869)
12 Jakatala (17th April 1870)

The stations are equipped with complete sets of meteorological instruments, and the observations are recorded by paid observers who have been trained in the Madras Observatory The backward state of the meteorological publications of Madras arose entirely from the circumstance of the astronomer having no European assistant, but a remedy was provided in 1871, and the arrears will now be duly worked up The registers of rainfall at 216 stations are kept by the Sheristadars and forwarded to the Astronomer They are now placed on a better footing, and more accurate gauges have been supplied There is also an excellent private observatory at Vizagapatam belonging to Mr G V Jaggaran, which is superintended by Mr A V Nursingrow The monthly results are published annually, and Mr Blanford speaks highly of them

The meteorological registers at the Bombay Observatory have always been regularly kept, and yearly abstracts by Mr Chambers, who has been the Superintendent since 1856, are published with the

Reports of the Municipal Commissioner [1] These abstracts give the pressure of the air, temperature, dew point, humidity, rainfall, and force of the land and sea winds for each month Half yearly Meteorological Reports, by Mr Chambers, are also regularly transmitted to the Astronomer Royal But the observations taken at the five other stations in the Bombay Presidency were sent to the India Office, where no use was made of them, and several sets were lost

The machinery is, however, available for making important scientific deductions from observations taken at points scattered over the greater part of India, all of which are in regular communication with central stations Mr Blanford has pointed out that the distribution of relative pressures is an important object of inquiry, because the local character of the south west and probably of the north-west monsoon is greatly affected by its variations in different years There are other points which require a very wide field of observations for their elucidation, and thus Bengal, or any one local province, cannot usefully be treated independently of the other parts of India It is thus necessary to include the data of a wide area, and, indeed, of the whole Indian Empire, in one general Meteorological Report "The business of a meteoro-"logical department," says Mr Blanford, "is to discuss as "well as to record facts, to compare and correlate them under "the guidance of accepted physical laws, and to endeavour to "trace out the causes which operate in producing the normal "features of our seasons, as well as those of their irregularities, the "important influence of which on the welfare of the country has, "of late years, been too painfully obvious In order to do this, "however, with any degree of completeness, a uniform system "of registration must be extended much beyond the limits of "Bengal"

In 1872, Dr Forbes Watson, the Reporter on the Products of India to the Secretary of State, prepared an elaborate paper on the conditions under which the wet and dry bulb thermometer should be

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[1] Annual Reports of the Municipal Commissioner of Bombay, 1866 App i, p 45 Do for 1867, p 52 Do for 1868, at the end of Dr Lumsdaine s Report, the Health Office, p 6 Do for 1869, by Dr Hewlett See also "Reports of the Superintendent of the Government Observatory, Colaba 1866, 1868, 1869, 1870, "Normal Winds of Bombay,' by Charles Chambers, Esq, F R S —*Bombay Builder* (June, 1869)

Statistics of the rainfall will be found in the "Bombay Times' Directories employed, to give accurate results as an hygrometer This paper represents a vast amount of laborious work and careful thought, and the tables of observations that accompany it tend to show that the results hitherto obtained by the use of the wet and dry bulbs are nearly worthless After giving the evidence on which his conclusions are founded, Dr Forbes Watson proceeds to suggest the steps that should be taken to ascertain the conditions under which it may be possible to obtain reliable results from the use of the wet and dry bulb thermometer Mr Buchan, the Secretary of the Scotch Meteorological Society, has expressed his sense of the great value of Dr Watson's paper, and of the admirable manner in which the different points have been investigated and discussed, and he has pointed out the importance of the discussion to the practical working out of the problem of Indian meteorology Dr Watson's paper ought to be in the hands of all observers in India But it has not yet been printed

During 1873 the system of meteorological registration which had been established by Mr Blanford was carried on, and he received the monthly abstracts of results from the North-West and Central Provinces, but not from other parts of India Such obstacles to work were always to be expected so long as there was an independent system of registration in each province This absence of central control was noticed and deplored, not only in India and in England, but in other countries, and it was especially the subject of remark in the "Zeitschrift" of the Meteorological Society of Vienna In the North-West Provinces there were 14 meteorological stations, under the direction of Dr Murray Thomson, who prepared the annual report, and twelve in the Punjab

It is impossible to exaggerate the importance of placing Indian meteorology on an efficient footing, when it is considered how absolutely the crops and with them the very existence of the people depend upon the regularity or otherwise of the winds and rains, and on an intelligent comprehension, based on long series of observations taken over a vast area, of the laws which govern them

The most valuable meteorological work during 1873 was Mr Blanford's paper on the winds of Northern India in relation to the temperature and vapour constituent of the atmosphere Its object is to describe the normal wind currents of Northern India and their annual variation, and to trace out their origin and causes so far as these can be discovered in the local physical changes of the atmosphere. Mr. Blanford describes the winds of the principal geographical regions of North India in detail, commencing with the Punjab. In this part of the area under discussion the currents from the westward predominate as a rule throughout the year. In the most northern part of the Punjab westerly winds prevail in the cold and hot dry months, easterly in the rainy months. In the central districts northerly winds predominate over southerly, having in the cold months a westerly tendency, but drawing round to the north east as the hot weather comes on, while as the rainy season sets in the winds tend to east and south east, returning to west after the rain ceases in September. In the southern part of the Punjab and Sind easterly winds never prevail, and southerly, south westerly, and north westerly winds predominate—the two former in the rainy months, the last in the cold and hot dry season. In the coldest months the winds veer towards the north. The Gangetic plain, sloping from an elevation above the sea of 900 feet eastward to 150, is skirted on its northern edge by the chain of the Himalaya, which determines in a great measure the direction of its prevailing winds. Those from the north west and south east much exceed those from other quarters. The change from the westerly to the easterly direction accompanies the change from the hot and dry season to the rains, and from easterly to westerly that from the rains to the cold season. The plateau of Rajputana is somewhat elevated above the Gangetic plain, varying from 800 to 1,800 feet above the sea level. Winds from west and south west greatly exceed those from other quarters in the southern districts, commencing as early as February and continuing till November, when they are replaced by northerly and north easterly winds. There is a similarity to the winds of the southern Punjab. The Central India region is considerably broken up into valley and mountain, so that the winds are more influenced by merely local conditions than in the more northern areas. Westerly winds on the whole prevail. Central India participates in the characteristics both of the plains of Northern India and of the Peninsula, which last is under the influence of the true south west and north-east monsoons. In the Gangetic delta the winter monsoon becomes well established in November, blowing from the north. As the season advances the wind draws round towards the west, and eventually backs by south-west to south and south-east, in which direction it blows during the rainy season and till September In October the winds are chiefly easterly, but unsteady and inclined to be stormy The local configuration of the Assam valley, forming an open passage for the monsoons to pass to and from the region north of the Himalaya, affects its winds On the whole the characteristic of Assam is the prevalence of easterly winds, which is here as conspicuous as that of the westerly winds over the Gangetic plain and Punjab

It will be seen that the winds of Northern India are very different from those of the adjacent seas Instead of two monsoons from the north east and south west alternately prevailing during about equal periods of the year, there are three distinct seasons in which special winds prevail, the directions of which mainly depend on the relative positions and directions of the mountain ranges and plains During the cold weather months, November to January, light westerly and northerly winds blow from the plains of Upper India down the valleys of the Ganges and Indus, and across the table-land of Central India, and join into the north-east monsoon of the Punjab The easterly winds of the Assam valley add to this current In April and May, as the hot weather comes on, the winds of Northern India become more westerly and powerful, and take the form of the hot winds, blowing till sunset, and then being followed by calms At the same time southerly winds are commencing on the coast, and are felt from Sind across to Bengal, but only at intervals and feebly, except near the sea In June the south west monsoon, being established in the equatorial ocean, sets in round both coasts of the peninsula, penetrates up the valleys of the Indus, Narbada, and Tapti, carrying a west or south west current over Central India, and from the Bay of Bengal pouring up the funnel shaped openings occupied by the Ganges delta, whence, turning westward, it passes up the Gangetic valley towards the Punjab, which seems to be the limit of the south-easterly winds This is the period of the rainy season in Northern India In October, as the south east monsoon ceases, the southerly current is recurved towards the heated region along the Coromandel coast, and blowing as a south-east wind, causes the autumn rains, which some writers have erroneously attributed to the north east monsoon

The seasons of Northern India present three distinct phases the cold season, from the end of the rains in September to March, the hot season, characterised by a dry atmosphere and great diurnal range of temperature, and the rainy season, in which the temperature is moderately high and equable, and the air humid. At the close of the rains, in the end of September, the temperature of Northern India, from the Punjab to the sea, is nearly uniform, at about 81° or 82°. But evaporation and radiation to a cloudless sky soon reduce the temperature of the interior below that of the maritime regions, and in January the Punjab is about 11° colder than Bengal, the plains of the North-West Provinces being about midway in temperature between the two. In March the advance of temperature in Central India has brought out two thermal foci, one on the west in Rajputana, and the other on the east, in the hilly tracts of Western Bengal. In April the Central Indian thermal focus is well developed. In May the thermal focus has gone further to the north-west, and lies in the northern part of the Rajputana plateau. In June it has reached the Punjab, the temperature there rising to 95° and more, while that of the south of India begins to fall, consequent on the rains. In July the Punjab ranges above 90°, while the greater part of Central India is below 85°. After July the temperature again falls, so that by the end of September it is nearly equalised all over Northern India.

Thus in the cold weather there are two foci of minimum temperature, one in the Punjab, and the other in Assam, and the isotherms nearly conform to the parallels of latitude. In the hot months a focus of heat is formed in Central India, round which the isotherms are bent, the temperature on the coasts and in the northern plains being considerably lower than that in the interior. Finally, during the rainy season the seat of highest temperature is in the Punjab, the coolest regions then being those of the maximum rainfall, consisting of two tracts extending from the coasts of Bombay and Bengal along the course of the monsoon currents.

The available data for discussing the atmospheric pressure are imperfect, but, subject to this explanation, the mean pressure reduced to sea level, in October, is nearly uniform over Bengal, in the Central Provinces, and the Ganges valley. In the following months the pressure rises over the whole area, but most in the North-West Provinces and Western Bengal, and in December an axis of maximum pressure lies in a line down from Cattack to the North-West Provinces in a north west and south east direction. The distribution of pressure remains much the same until February. In March a rapid fall takes place in Northern India, but the line of higher pressure still remains, extending now from north western India across to the coast of Arabia, round the delta of the Ganges In April, with a continued rapid fall, a trough of low pressure becomes apparent, which extends from the head of the delta of the Ganges into Central India In May this area of low pressure occupies a line from Western Bengal to Nagpur, and in June the conditions are generally similar, but with much reduced pressure in the Punjab, in the north west of which province the absolute minimum is probably to be found In July the minimum of pressure is reached without important relative change In August a rise begins, greater over Northern India, which continues during September and October, when the uniformity of pressure is once more approximately restored The distribution of pressure follows within certain limits, that of temperature in an inverse ratio of intensity Mr Blanford's conclusion is that these changes of pressure are influenced by the proportion of aqueous vapour in the air by carrying heat from the lower to the upper strata, and by arresting solar and terrestrial radiation, thus equalising the temperature of the air column In general terms he concludes that the changes of temperature are the principal causes of the variations of pressure

There is evidence that anti-monsoon currents blow in the upper strata of the atmosphere, at the various seasons of the year, and at varying elevations, causing corresponding modifications in the general temperature, and Mr Blanford is inclined to attribute the rains of the cold season to the descent of the anti monsoon current from the south This valuable paper indicates the direction which future investigations must take, and the practical importance of the conclusions to which they will lead The barometric pressure has a direct influence on the winds, and the winds on the rainfall, and when these elements are thoroughly understood, it is probable that the normal or abnormal character of a year's meteorology may be known as early as April[1]

Mr Blanford's Meteorological Report for the year 1873 was the seventh that had been submitted since the Department was established in 1867 It was the first which had to treat of a year of

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[1] See also "The winds of Northern India in relation to the temperature and vapour constituent of the atmosphere,' by Henry F Blanford, F G S (*Proceedings of the Royal Society* No 150 1874) (The more complete paper is published in the "Philosophical Transactions," vol 164, pt 2 No xvii, p 563

disastrous drought and serious failure of crops, leading to a threatened famine in the Lower Provinces

India is pre-eminently a country in which the systematic study of meteorology promises to be attended with the greatest and most speedy results The peculiarities which have already been observed, justify the expectation that, when a more complete knowledge has been obtained, a forecast may be made of the seasons, so that their probable character may be known for some months in advance The most important question is that of the causes which determine the distribution of rainfall and its irregularities, and Mr Blanford says, in his Report for 1873, "that it is within the power of science "to solve this problem, I see no reason to doubt"

That any progress had already been made was, however, still due to the voluntary association of the meteorological officers of Bengal, the North-West and Central Provinces, and Berar, with a view to the free interchange of results, and their unification But the Punjab registers were untrustworthy and not comparable, and nothing was then received from Bombay, Madras, or Burma It was then only possible to frame a conception of the general distribution of pressure and temperature over about half India and its seas It was not, however, possible to gain a satisfactory understanding of the meteorology of any part of India, and therefore to derive from the meteorological system the really valuable information which a sound methodical system is capable of affording, until the whole of India and Burma was brought into one *nexus*, so that the records of all could be studied as a whole Ceylon and Singapore have long been associated with Bengal

In 1873 there were 18 first-class stations in Bengal, at which the following meteorological elements were observed —Atmospheric pressure, temperature of the air, extreme temperatures, temperature of solar evaporation, temperature of grass, nocturnal evaporation, vapour tension, relative humidity, serenity, rainfall, number of days of rainfall, wind, and mean diurnal movement of wind There were 10 second class stations, to which two were added, including one at Nancowry in the Nicobar Islands, and 145 third-class stations for observing rainfall It was arranged that there should be a Meteorological Observatory at Calcutta, Sir George Campbell having secured a suitable piece of ground at Alipur, and provision having been made in the Budget for the building and for the self-registering instruments to be constructed in England Self registering anemometers, giving a simultaneous record of the direction and velocity of the wind, were much needed, to obtain a knowledge of the real movements of the air The first has lately been set up over the Calcutta Meteorological Office The whole cost of the Bengal Meteorological Department was 1,936*l*

The chief meteorological characteristics of 1873 were excessively high temperature, especially in Oudh and the North West Provinces, unusually low pressure in the same region, abnormally high pressure in East Bengal, great unsteadiness in the winds, and a general deficiency of moisture in the atmosphere The monsoon current was, as a whole, either unusually weak or unusually dry, but that portion from the Bay of Bengal failed to a greater extent than that from the Arabian Sea The deficiency in Lower Bengal was as much as 40 per cent The dryness was probably due to a persistent barometric pressure in the south east part of the Bay of Bengal, and to the irregular depression in the upper part of the Gangetic Valley, together with the high pressure in East Bengal Other causes were, no doubt, in operation, of which we are ignorant

These persistent barometric irregularities exercise a very important influence on the winds Mr Blanford divides the fluctuations of atmospheric pressure under five heads, two regular and periodical, and three irregular The first is the semi diurnal tides of pressure The second is the great annual variation which, in the plains, has one maximum in December and one minimum in June or July, the amount of rise or fall varying according to the locality The third is the local and temporary variations of short duration, such as accompany local storms The fourth is general and temporary fluctuations affecting a large area simultaneously, as a rule, the more intense the higher the latitude The fifth is the local and persistent variations, which are the most important in relation to irregularities in the monsoon rainfall

What has been brought to light by Mr Blanford's systematic observations is that *the abnormal features of each monsoon are almost as persistent* as its normal characteristics The persistent irregularities in the relative distribution of pressure first became apparent in comparing the distribution of atmospheric pressure of the two rainy seasons of 1868 and 1869, and attention was drawn to the subject in 1870[1] In 1868 there was unduly low pressure at Sagar and False Point, in the north-east corner of the Bay of

[1] "Journal of the Asiatic Society of Bengal," vol xxxix, p 123

Bengal, affecting the winds and obstructing their passage up country, while causing unusually heavy fall of rain in the south-west corner of the Gangetic delta, with drought in the region to the north west Each subsequent year has confirmed the general truth of the law by which abnormal meteorological conditions have a tendency to be persistent in India If, therefore, the connexion of these irregularities with those of the rainfall can be once clearly ascertained, it may be possible, even at an early period of the season, in April, to obtain a clue to its probable peculiarities During the year 1873 the distribution of atmospheric pressure differed more widely from that of average years than was the case in 1868 The effect was to weaken the current of wind which blows from the Bay of Bengal, and therefore to affect prejudicially the rainfall of the Lower Provinces

The winds of the monsoon blow from the Arabian Sea and the Bay of Bengal towards a line south of the Ganges, where a barometric depression begins in April, and is well established by the time the rains set in in June The pressure decreases along this line from east to west, where the trough, as it may be termed, merges into the great barometric depression of the Desert and the Punjab To the south of this trough of barometric depression the winds from the Arabian Sea blow across the Central Provinces from the westward To the north of it, those from the Bay of Bengal, turning with the Gangetic valley, blow in the opposite direction, their line of meeting being along the trough

In 1873 this trough did not exist The pressure declined thence to the north, so that the place of lowest barometer lay far to the north west, in Oudh and Rohilkhand, immediately under the Himalayas Differences of barometric pressure are the causes of winds A current of air coming from the Bay of Bengal could only reach this barometric depression along its northern margin, and here there is a great physical obstruction in the shape of the Himalaya mountains

Any weakening of the monsoon current implies a deficiency of rain, for all the vapour that is condensed as rain on the uplands and hills of India is brought by this current from the ocean The persistent barometric depression in Oudh, instead of that which usually appears in summer and autumn as the trough to the south of the Ganges, seems to be intimately connected with the failure of rainfall in Bengal But whether these ascertained conditions were the principal agents operating to cause the drought of 1873 cannot be known without some knowledge of the state of things prevailing in the Punjab, Bombay, and Madras This Mr Blanford points out is but one of a vast number of most important inquiries which present themselves for solution at the hands of the Indian meteorologist

An important paper on "The Meteorology of the Bombay Presidency" has been completed during the year 1876 by Mr Charles Chambers, F R S, Superintendent of the Colaba Observatory The work consists of four parts—the first dealing with registrations of meteorological phenomena at the Colaba Observatory during a period of twenty-seven years, the second with moderately full observations at five military stations in the Bombay Presidency during a period of nineteen years, and the third with large numbers of observations from civil hospitals and revenue stations, being those of selected registers extending over various periods from not less than a fortnight up to a number of years, in this part the phenomena treated are temperature of the air, winds, and rainfall only, and the extent of territory to which the observations refer includes the whole of the Presidency, Sind, and the western half of Rajputana In the fourth part are discussed the general distribution (as regards both space and season) of temperature and rainfall, and the variations of the wind, first with respect simply to the physical geography of the country, and then in combination with certain theoretical views, the elucidation of which, by means of the dynamical theory of heat and the kinetic theory of gases, occupies much space

Nearly half the memoir is devoted to the work of the Colaba Observatory, of the history of which a short sketch is given The design of this part is to give a compendious account of the results of a long and continuous maintenance of the observatory, both in the shape of numerical determinations of meteorological elements and of their periodical and other variations, and in throwing light by means of these upon the physical conditions and actions which give rise to the observed relations between different phenomena, and to the variation of these relations with time

In the course of the work the author introduces several new modes of picturing clearly to the mind, and of representing graphically, the general results of the various phenomena observed, he also develops a theory of aerial circulation, including a dynamical theory of convection currents, which is original, and, so far as he knows, is put forth now for the first time The publication of Mr Chambers's valuable Report has been sanctioned by the Secretary of State for India [1]

A useful new serial publication has been issued by Mr Blanford, under the name of "Indian Meteorological Memoirs," being occasional discussions and compilations of meteorological data relating to India and the neighbouring countries It is not intended to issue the parts at fixed dates, but papers accepted for publication will be printed and issued as expeditiously as circumstances will admit of The work is designed as a vehicle for publication of such portions of the work of the meteorological officers as do not form part of the regular Annual Report on the Meteorology of India Thus descriptions of local climates, of important and unusual phenomena, and of investigations in meteorological physics, will more fitly find place in the present serial Part I of the first volume contains three papers viz, (1) on the winds of Calcutta, (2) on the meteorology and climate of Yarkand and Kashgar, being chiefly a discussion of registers kept by Dr Scully during his deputation with the Mission in 1874–75, and (3) on the diurnal variation of the barometer at Simla

In 1875 Mr Lowis Jackson published some useful Indian meteorological statistics for the use of engineers, in his "Hydraulic Manual"[2] He gives the average rainfall of 72 stations in India, according to the seasons, notes on long continuous rainfalls and special rainfall data, comparative humidities for 27 places, averages of monthly mean pressures for 28 places, average monthly temperatures, average wind resultants of 24 stations, and some general remarks on the meteorology of India

The phenomena connected with periods of drought in India have necessarily received close attention, and Dr Hunter [3] has devoted much time to an investigation of the possible connexion of years of minimum and maximum sun spots with the amount of rainfall When at Madras, in 1876, he collected the facts from the meteoro-

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[1] An abstract of Mr Chambers's Report was published in the "Proceedings of the Royal Society,' vol xxv, No 178 1877

[2] "Hydraulic Manual Part I, consisting of working tables and explanatory text, intended as a guide in hydraulic calculations, and field operations and Indian Meteorological Statistics for the use of engineers,' by Lowis D A Jackson, A I C E (Allen, 1875)

[3] "The Cycle of drought and famine in Southern India," by W W Hunter, LL D, Director General of Statistics to the Government of India Feb, 1877

logical registers and arrived at certain provisional conclusions, which he afterwards put forward in a paper read before the Royal Society During his comparison of the rainfall at Madras with the sun spots, he came upon indications of a periodicity in the rainfall, apparently connected, although not in a uniform manner, with the solar cycles The annual rainfall of Madras appears to be subject to regular cyclical variation in periods of about eleven years It would be a discovery of great importance that seasons of famine in Southern India also tend to recur at epochs of eleven years, and at the epochs of sun spot minimum It is to this conclusion that Dr Hunter's investigations seem to tend But Mr Blanford[1] has pointed out that a similar rule certainly does not hold good in Northern India The meagre data now available seem to show that if famines are more frequent in Southern India, at the epochs of minimum sun spots, they are more frequent in Northern India at those of maximum sun-spots Existing data are insufficient to admit of any reliable generalization, but the discussion of the question will be useful in drawing attention to a practically important branch of meteorological inquiry

The appointment of Mr Henry F Blanford as Meteorological Reporter to the Government of India in 1875 is a most important step in advance[2] His first Report in this capacity was for the year 1875 He brought together, for the first time, the meteorological data of the whole of India and its dependencies, and the survey showed that there was much to be done in order to secure general efficiency Most of the instruments in use (excepting the barometers) were still unverified, large tracts of country were imperfectly represented, and corrections had yet to be determined for the elimination of differences which depend on the diurnal variation of the elements discussed But a beginning has been made to remedy defects The efforts of all are steadily directed to unify and systematize the work, so that there will be steady progress in securing improvement in the quality as well as the completeness of the record

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[1] "Report on the variation of rainfall in tropical India, with the cycle of sun spot frequency," by H F Blanford May, 1877

[2] The Meteorological Department was officially established by the order of the Government of India in the Department of Revenue, Agriculture, and Commerce, (No 56) of the 27th of September 1875

In Bengal and Assam there are one first class, eight second class, and eight third class stations During 1875 the meteorology was under the charge of Mr W G Willson, whose sudden death in February 1876 was a most serious loss He made admirable reports on the cyclones which occurred on the coast during the two years that he was in charge Mr Willson has been succeeded as Bengal Meteorological Reporter by Mr Elliott, who made a valuable and exhaustive report on the destructive Vizagapatam and Bakarganj cyclones of October 1876 [1]

In the North West Provinces there is one first-class station at Allahabad, two second-class and six third class, besides a private station at Dehra Mr Elliott had charge of the meteorology during the year 1875 Lucknow has an excellent observer, with good instruments, in Dr Bonavia, but in the Punjab the supply of instruments was somewhat unsatisfactory Deficiencies have, however, been supplied, and the results will appear in future reports There is one first class station at Lahore, and 10 third class, besides independent stations at Bhawalpúr, Simla, and Leh In Berar Dr Abbott, the Sanitary Commissioner, has brought the registers up to the standard, and has greatly improved the observatories Dr Townshend, in the Central Provinces, has had the elevations of the barometers carefully verified, and has compared the instruments with the Calcutta standards There are four third-class stations in Berar In the Central Provinces there are three second-class and eight third class stations In Bombay Mr Chambers has verified all the instruments at the four observatories of Poona, Belgaum, Karachi, and Disa, and has obtained the levels of the barometers Besides the above four second class stations, there are nine third-class and two independent observatories at Bombay and Goa The Madras registers have been carefully kept and reduced under a system devised by Mr Pogson, which has been in operation for some years, but the registers of the previous years are still unpublished In Madras there are independent observatories at Madras and Vizagapatam, two second class and nine third class stations. The insular stations of Port Blair and Nancowry are under Dr Rean In Burma there is a second class station at Rangoon and eight third class stations In Rajputana there are six third class stations,

[1] "Report of the Vizagapatam and Backergunge cyclones of October 1876," by J Elliott, Esq, M A, Meteorological Reporter to the Government of Bengal (Calcutta, 1877) 4to pp 187, with maps

one at Sikanderabad, and one in Baghalkand Thus throughout India there are three first-class, 21 second class, and 71 third-class stations under the Department, besides nine independent observatories

The first-class stations are Calcutta, Bombay, Allahabad, Lahore, and Madras, at which either self-recording instruments register continuously, or at short intervals, the pressure, air and evaporation temperatures, and wind movement At second class stations two sets of observations are recorded at 10 a m and 4 p m, and hourly observations on four days in each month At third-class stations two sets of observations only are recorded daily

In his Report for 1875,[1] Mr Blanford has brought together the results of the observations at all these stations He prefaces the account of the meteorology of the year with a brief but very interesting description of the physical features of the country, more especially with reference to the form and clothing of the surface, and to those climatic features which are the average outcome of its meteorological conditions He then gives a more particular account of each meteorological station in India, most of them described from personal experience After these introductory sections, Mr Blanford proceeds to discuss the meteorology of the year under eight heads —

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| Solar radiation | Anemometry |
| Terrestrial radiation | Hygrometry |
| Air temperature | Cloud proportion |
| Atmospheric pressure | Rainfall |

Abstracts of the registers, classified in tables under the above headings, are then given, and the original observations of five chief stations, namely, Calcutta, Lucknow, Nagpur, Madras, and Bombay

Thus for the first time the meteorology of India has been brought together and discussed as a whole, and, under the able direction of Mr Blanford, the work of the Meteorological Department, the importance of which can scarcely be over estimated, will

1 "Report on the meteorology of India in 1875," by Henry F Blanford, Meteorological Reporter to the Government of India First year (Calcutta, 1877) See also Mr Blanford's "Report on the administration of the Meteorological Department of the Government of India in 1875–76" (Calcutta, 1877)

soon hold a worthy place by the side of that of the other scientific departments of India [1]

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[1] The papers relating to the constitution of an efficient Meteorological Department were presented to Parliament, having been moved for, on May 8th, 1874, by Mr Egerton Hubbard, M P, in a speech in the course of which he explained the great importance of the study of meteorology in India *See* Hansard's Parliamentary Debates, vol ccxviii

"Copies of the Despatch from the Secretary of State on the organization of a Meteorological Department in India, dated 18th May 1871, with enclosures, and of all despatches to and from the Government of India during the last five years on the subject referred to (*Presented May* 1874)

# XVII

## TIDAL OBSERVATIONS

THE earliest recorded tidal observations in India, which I have met with, were taken at the Kidderpur dockhead on the Hugli, by Mr James Kyd,[1] for 22 years, from 1806 to 1827[2] Mr Kyd did not publish his results in tables, but showed them on a series of diagrams, which he accompanied by some suggestive remarks He observed that in the Hugli there were two long unequal tides, eight months of flood and four of ebb He assumed that the south-west wind in March caused the currents to set up the Bay of Bengal, and raise the sea several feet at its head, and in the Hugli long before the freshes from the rivers are felt This cause continues till October Then the river freshes of August and September, and the change of wind, give the currents a set in the contrary direction The rise of the Ganges affects the Hugli early in July, and its level is bodily raised, the low water (neaps) at the time of the freshes being even higher than the high water (also neaps) of the dry season Mr Kyd suggests that the Damodar, Rupnarain, and Hijili rivers occasion the height of low water in the season of freshes, by acting as a dam, and preventing the ebbing of the waters quickly into the sea Another local phenomenon of the Hugli tides which he could not satisfactorily explain is, that in the north-east monsoon the night tides are highest, and in the south-west the day tides The bores in the Hugli only occur on the highest spring tides

Mr Kyd's observations were continued in 1828 and 1829 at Mud Point, on Sagar Island, and a further series of tidal registrations was published by James Prinsep[3]

While these early tidal observations were being taken in the Hugli, the subject was being carefully studied in England by Sir John

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1 Mr Kyd was an East Indian, who set an example of independent enterprise to his countrymen, in forming a large docking establishment at Kidderpur, which afterwards became the property of the Government —*Calcutta Review*, iii, p 249

2 "Asiatic Researches, xviii, p 259

3 "Gleanings in Science," Nov 1829 and Jan 1830

Lubbock [1] and Dr Whewell Their papers on co-tidal lines in the "Philosophical Transactions" excited general interest, but on the chart which accompanied Dr Whewell's essay,[2] though a numerous series of co-tidal lines in other parts of the world was given, the coasts of India presented nearly a blank In the same year in which the essay was published, Dr Whewell's "suggestions to "persons who have opportunities to make or collect observations of "the tides" appeared in the "Journal of the Asiatic Society of Bengal,"[3] and the Governor General, at the same time, requested that the Society would undertake to promote inquiries on the Indian coasts to complete the co tidal lines for the Bay of Bengal [4] It was considered that the most important branch of the investigation was that for the determination of the diurnal inequality or difference between day and night tides, which depends on the declination of the moon north or south of the equator, and the Society sent a circular on the subject to members residing at coast stations [5] Dr Whewell also expressed a hope that tidal observations would be made from an extensive range of places in India [6]

The first result of these measures was the contribution of a table of the times of high water at the principal places between Calcutta and Point Palmyras, which was prepared by Mr P G Sinclair Then the results of observations made on the tides at Madras in 1821, by means of a tide gauge fixed near the north east angle of Fort St George, was published [7] In 1837, observations of tides were made by Lieutenant H Siddons at Chittagong, in conformity

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1 "Philosophical Transactions," 1831

2 "Phil Trans,' 1833 "Essay towards an approximation to a map of co-tidal lines" Dr Whewell wrote 14 memoirs on tides in the "Philosophical Transactions' from 1833 to 1850 'Researches on the tides, and their diurnal inequalities," were published separately (London, 1848) See also Professor Airy's article on "Tides and Waves," in the *Encyclopædia Metropolitana*

3 'J A S B," ii, p 151

4 "J A S B,' iv, p 401

5 "J A S B,' vi, p 401 James Prinsep expressed his confident belief that "all "who had seen Professor Whewell s laborious map of the tidal wave, traced in its course "over the whole surface of the globe, would willingly contribute to the perfection of so "interesting and useful a problem '

6 "J A S B," iv, p 517 "Though we have some detached observations on the coast of India, we have nothing which gives us a correct view of the progress of the tide" Dr Whewell, in a paper read before the British Association, "On our ignorance of the tides" (1851) xx, p 27

7 "Madras Herald,' June 3rd, 1835

with the circular of the Asiatic Society,[1] and a succinct review of observations of tides made in the Indian Archipelago in 1839 was also published,[2] as well as the registers of the rise and fall of the tide at Prince Edward's Island in 1840–41, and at Singapore in 1834–35[3] Professor Whewell also received the Singapore observations which were taken by Mr Scott, the Master Attendant, and he notices the enormous diurnal inequality[4]

A special series of tidal observations was ordered to be taken in the Hughi in 1869, with reference to the effect of a cyclone wave if the river was embanked Tidal observations are also taken at Kidderpur dockyard, and the Master Attendant at Calcutta predicts tide tables, giving the anticipated time of high and low water for every day, which are published annually But the tables, when compared by Mr Parkes with the register furnished from the Master Attendant's Office, were found to be so erroneous that they can be of no practical use For the complete investigation of the Hughi tides observations should be made near the mouth of the river

The earliest register of tides on the west coast of India will, I think, be found in a table showing the rise of the spring tides in Bombay harbour, during night and day, for 1832, which was communicated by Benjamin Noton, Esq[5] When the Colaba Observatory was first established, Captain Daniel Ross suggested a contrivance for registering tides by means of a large float and pulley in a well 22 feet deep, with a register house over it, just above high-water mark, but it was found impracticable to connect the well with the sea by a cutting Nothing was, therefore, done until Dr Buist took charge of the observatory, in July 1842, when the self registering tide gauge was put into working order, and the well was connected with the sea by a siphon pipe[6] The tides have since been observed at the Colaba Observatory, though with much irregularity The registers, while Captain Montriou was in charge, have been published for 1846, 1847, and 1848 Serjeant Dunn, of the Sappers and Miners, a very active and intelligent man, was the actual observer, and the series for 1846 is partially reliable, but

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1 "J A S B," vi, p 949

2 "J A S B," x, p 302

3 "J A S B," xi, pp 149 and 263, and xix

4 "7th series of researches on the tides On diurnal inequalities at Singapore" *Phil Trans* 1837, p 75

5 "J A S B," ii, p 247 And in "Rushton's Gazetteer" for 1842

6 "Journal, Bombay G S," vi, p 235

those for subsequent years are very doubtful Captain Montriou remarked that the law of tides had been found to differ materially from that which had been determined relative to the tides in Europe[1] Captain Ross, as Master Attendant at Bombay, constructed a set of tables from observations made at the dockhead, from May 1835 to December 1840[2]

In the paper which accompanies Captain Ross's tables, Dr Buist observed that the amount of information respecting the tides of the west coast of India was then singularly meagre in amount and incomplete in kind Great tidal irregularities prevail at Mahim, Tannah, Panwell, and Nagotna, and there are remarkable local currents dependent upon tides, but none of these phenomena have been carefully observed Further irregularities are said to have been subsequently caused in the tides by the construction of the Bandora and Mahim causeway

Tide registers were kept by the Surveyors of the Indian Navy, and were always sent in with the field books and journals of the respective ships These have never been published, but the tide tables, annually issued at the Admiralty, give the time of high water at the full and change of the moon, and the ranges of tides at springs and neaps, for 98 places on the coast of India The geographical arrangement of the table follows nearly the same order as the progress of the great tidal wave from S W to N E[3] The tidal wave strikes Western Hindustan, from the west, at right angles to the mean direction of the shore line, thus causing very little difference in the times of high water along the whole length of coast, except when the wave has to run up indentations of the land, such as the gulfs of Cambay and Kach From Mangalor to Jaighur (100 miles south of Bombay) no tidal stream is observed along the coast, except just off the mouths of rivers,[4] but along the Northern Concan the flood stream sets to the north, and increases until, in the Gulf of Cambay, it finishes with the well known bore which was described by Lieutenant Ethersey This tidal bore sets in like a straight wall of water

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1 "Observations made at the Bombay Observatory," by Capt Montriou and Lieut Fergusson (Bombay, 4to) See those for 1847 and 1862 especially

2 "Journal, Bombay G S," vi, p 243

3 See "Findlay's Directory for the Navigation of the Indian Seas" (2d ed 1870) p 77 Imray's "Seaman's Guide to the Navigation of the Indian Ocean," and "Horsburgh's Indian Directory"

4 "The West Coast of Hindostan Pilot," compiled by Commander A D Taylor I N (1866) p 8

with a head 5 or 6 feet high, each succeeding wave decreasing more and more, until the whole gulf is reduced to the same level with the sea outside[1]

South of Mangalor the flood stream is from the N W Karachi and Porbunder receive the tidal wave earlier than any other parts of India, and thence the flood tide sets eastward along the coast of Sind and Kach, north above Porbunder, and south east along the Katiwar coast to Diu head Off Diu head there are frequent eddies caused by the ebb stream of the Gulf of Cambay running westward, while the flood stream from Porbunder is running to the east

Captain Taylor has suggested other causes for tidal irregularities Where evaporation is so great, as it is in the Indian seas, there are doubtless local movements of the ocean dependent on that cause At Cochin the stream, flowing into the backwater, is sometimes constant for twenty hours, although the regular but inconsiderable rise and fall has been marked on the tide gauge[2]

It was also observed by Captain Taylor that, in the S W monsoon, in the harbours on the west coast of India, more especially in Jaighur, Viziadrug, and Karwar, the water in the daytime was on a higher level by 2 or 3 feet than in the dry season The three above mentioned ports are formed by points of land running out to seaward on their southern sides Captain Taylor suggests that the great body of water brought down by the rivers, at that season, is stopped by the force of the monsoon blowing upon the shore, and that the observed phenomenon of the water in these harbours being at a higher level in the rain is thus partially accounted for

In his new "India Directory" Captain Taylor devotes a section to the tides of the Indian Ocean, in which he treats of diurnal inequality, short and long period tides, the tidal wave, and tidal currents The section is illustrated by a tidal chart of the Indian Ocean[3]

Mr William Parkes, the Consulting Engineer of the Karachi Harbour Works, has computed very accurate tide tables, both for

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1 "R G S Journal," viii p 96 and p 202 For a notice of Lieut Ethersey's Survey, see p 20

2 "Taylor's West Coast Pilot," p 8 A tidal register was kept at Cochin so long ago as when Dr Buist wrote his remarks in 1836 —*Bombay G S Journal*, vi, p 250

3 "The Indian Directory" Part I, by Commander Alfred Dundas Taylor, F R G S (late Indian Navy) Allen, 1874, p xxxvii

that port and for Bombay His data for Karáchi were sets of observations taken at Manora Point from December 1857 to March 1858, and at Keamari from March 1st to August 31st, 1865

His calculations were made with a view to determining the laws which govern the tides of the Indian seas, where the diurnal inequality gives to alternate tides an elevation or depression in height, and an acceleration or retardation in time The theory of these diurnal inequalities has been elaborately investigated by the Astronomer Royal and others The desideratum is to bring the art of tidal prediction for Indian ports, where there is a large diurnal inequality, to the same degree of precision as has been arrived at in the case of English tides, where the irregularity is unimportant At Karáchi the diurnal inequality sometimes affects high water to the extent of two hours and low water 40 minutes, and as regards height, as much as 12 inches at high and 36 at low water These effects are far too great to be neglected in the prediction of tides

Mr Parkes based his investigation on the fact that the diurnal inequality was caused by a diurnal tide which alternately raises and depresses, accelerates and retards, the semi diurnal tides, and the problem was to find the relation between the movements of the sun and moon, and the varying times and heights of this diurnal tide The result of the calculations has been very satisfactory, and the rules for the prediction of tides for the port of Karáchi have been drawn up, and the tables computed, by combining the semi-diurnal and diurnal tides[1] The tidal observations at Karáchi, taken at Manora Point by a self acting register in charge of Mr Humby, since 1865, are now becoming of great value, at a very small cost, and have served to suggest further corrections in the formulæ by which the tables are calculated

The data used by Mr Parkes for his Bombay tide tables were the registers taken at the Colaba Observatory by the self acting tide gauge in 1846 From these materials the Bombay Time Tables are computed, and Mr Parkes, in his Report, gives the modifications necessary for making the rules given for the prediction of tides at

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[1] "Report on the tides of the Port of Kurrachee," by W Parkes, Esq, C E, 1866 See also a paper read before the Royal Society, "On the Tides of Bombay and Kurrachee," by William Parkes M Inst C E—*Phil Trans* 1868, xxix, p 685 Mr Parkes has computed the Tide Tables for Karachi and Bombay for the years 1866, 1867, 1868, 1869, 1870, and 1871

Karachi applicable to Bombay, as well as a diagram of curves of semi-monthly inequalities of time and height The Bombay Tables have been compared with tidal observations taken from January 28th to June 4th, 1867, by Mr Ormiston, the Government engineer of reclamations, by direct reading from a graduated staff at every ten minutes

Sir William Thomson, using materials furnished by Mr Parkes as part of the basis of his argument, suggested a new mode of investigating tidal observations, which was worked out under the auspices of a Committee of the British Association [1]

It is very important that the investigation of the laws of the tides of the Indian seas should be extended to other ports than Bombay and Karáchi, both from a purely scientific and from a practical point of view But so incredibly long does it take for such measures to pass from the stage of discussion to that of action that the suggestions of Dr Whewell, made in 1832, and the importance of which were fully recognized by the Government of India at the time, have hitherto borne little fruit Mr Parkes, the value of whose accurate tide tables are fully appreciated at Karáchi and Bombay, renewed the attempt of Dr Whewell He urged that a series of observations, extending over twelve months, should be taken at several judiciously chosen points round the coast, and that a competent person should be appointed to the special duty of systematically collating these observations, deducing from them formulæ for the computation of tide tables, and annually issuing the tables Such an investigation would be as valuable to practical seamen as to men of science

In 1868 Colonel Walker, Superintendent of the Trigonometrical Survey of India, was requested to take steps for determining the mean sea level at various points on the Indian coasts, and more particularly on the coasts of Katiwár and the Gulf of Kach, where it was believed that changes were taking place in the relative levels of the land and sea, the rate and magnitude of which it was desirable to ascertain Arrangements were made for the construction of self-registering tide gauges, and for connecting the tidal stations by levelling operations, the gauges were made in England and sent out to India, and the operations would soon have been in full swing, but for the financial difficulties of the Government of India and the consequent reductions of expenditure in all directions

1 "Reports, British Association," 1868, 1870

which led to the suspension of the proposed tidal and levelling operations.

When Colonel Walker was at home on furlough, in 1872, his attention was drawn to the tidal investigations which were being carried on in England under the superintendence of a Committee of the British Association, presided over by Sir William Thomson, and he suggested that when the tidal operations are resumed in India their scope and object should be enlarged, and that they should be carried on in such a manner as to contribute towards the attainment of a better knowledge of the laws of the tides. He believed that with very little additional labour or cost, beyond what is required for the primary object of determining the existing relations of the level of land and sea, it was possible to introduce similar methods of tidal observation, registration, and reduction to those which have been adopted by the British Association, and which are expected to lead—among other scientific results—to an evaluation of the mass of the moon, to definite information regarding the rigidity of the earth, an approximation to the depth of the sea from the observed velocities of tide waves, and to the retardation of the earth's rotation due to tidal friction; a variety of practical benefits arising from an accurate knowledge of the height of the tide at any time would also be obtained.

In compliance with Colonel Walker's recommendations, Lieutenant Baird, R.E.,—one of his officers who was at home on furlough—was deputed to study the practical details of the method of tidal registration and the harmonic analysis of the observations, as practised and recommended by the British Association. A new tide gauge was constructed by Mr. Adie after the pattern of those which had been previously supplied by himself for the operations in India, but with a few modifications which appeared to be desirable, the most important of which was the substitution of a chronometer escapement instead of a pendulum or gravity escapement for the clock which drives the barrel of the tide gauge, in order to permit of the instrument being set up on jetties or scaffoldings projecting into the sea, where they would be liable to concussions by the beating of the waves which would affect the rate of a pendulum clock and might even stop its action. The new tide gauge was set up by Lieutenant Baird at Chatham, with the assistance of a few men of the Royal Engineers, whose services were lent by the Colonel Commandant, and its performances were considered very satisfactory.

Lieutenant Baird drew up an account of the method of reducing tidal observations by an harmonic analysis, as conducted by the British Association The reductions are exceedingly intricate, and, though perhaps not materially more laborious than previous methods of calculation, very full and precise explanations are required both of the mathematical formulæ on which they depend and of the practical application of these formulæ These were furnished to Colonel Walker by Lieutenant Baird, who, however, was obliged to return to India before his memorandum could be printed, but it was completed by Mr Roberts, of the Nautical Almanac Office, who conducted the reductions of the tidal observations of the British Association, and was most obliging in placing Lieutenant Baird in full possession of the details of his calculations

In compliance with Colonel Walker's suggestions, a self-registering anemometer and self-registering aneroid barometer were constructed to accompany each tide gauge, in order that the direction and velocity of the wind and the pressure of the atmosphere might be recorded *pari passu* with the tidal levels, and thus all the necessary instrumental appliances for the investigation of tidal phenomena were made available in India for simultaneous observations at six independent stations

On his return to India Colonel Walker deputed Lieutenant Baird to make a reconnaissance of the coasts of the Gulf of Kach, with a view to selecting tidal stations, and more particularly to ascertain in what manner a station could be established at a point as far into the Rann of Kach as possible to which the tide has free access Lieutenant Baird fitted up a large country boat at Juria Bandar to be used in navigating the creeks and channels of the gulf, and secured the services of a good pilot He then embarked and crossed to Nawanái Point on the Kach coast, where he found a spot which is well adapted for tidal observations, having a minimum depth of 19 feet of water within 336 feet of a site for a station He next proceeded eastwards towards the head of the gulf, and discovered a position near Hunstál Point, which is well adapted for a tidal station, having a minimum depth of 72 feet of water within 160 feet of the site of an observatory Turning westwards along the Kattiwar coast, he finally selected a third station at the entrance of the gulf at Okha Point, where he met with a rocky foreshore having a minimum depth of 23 feet of water within 220 feet of a site for a tidal station Lieutenant Baird derived much assistance in his explorations from the admirable charts which were constructed by Captain A D Taylor, I N, in 1851, copies of which, on the full scale of the original survey, had been lithographed for Colonel Walker, through the Geographical Department of the India Office

It was decided to construct the stations on shore at the line of high water Masonry wells of a diameter of about three feet were sunk at the stations to a depth of several feet below the lowest tides In these wells iron cylinders of a diameter slightly exceeding that of the float of the tide gauge were set up vertically, and eventually connected with the sea by an iron piping carried along the shore down to the low water line, where a flexible piping was attached and carried into deep water The cylinders were closed below by an iron plate, to prevent the entrance of the water which may be expected to percolate through the sides of the well whenever the tide is falling The flexible piping terminates in a rose suspended a few feet above the bed of the sea, in order to prevent the entrance of silt as much as possible, and it was attached to the iron piping in such a manner as that it was readily removed and cleared whenever necessary The interior diameter of the piping was two inches, which was computed to be sufficient to permit of the transmission of the tidal wave from the sea to the cylinder in the well without sensible retardation, so that the height of the water in the cylinder may be expected to be always the same as that of the surface of the sea The tide gauges were set up over the cylinders, and their iron bed plates indicate the places to which the tidal measurements were referred, and they were connected by levelling with permanent bench marks fixed in the ground in the vicinity of the stations

In November 1873, Captain Baird, having despatched all the instruments and material for the tidal observations in the Gulf of Kách, proceeded himself to the Okha Tidal Station, near the mouth of the gulf, and operations were proceeded with at the three stations of Okha, Hunstál, and Nawanár The arrangements included the supply of the parties with fresh water and provisions, and the construction of boats, and were made under many and great difficulties The regular tidal registrations were commenced at Okha, near the entrance to the gulf on the southern side, by the end of December, at Hunstál, near the head of the gulf, by March, and at Nawanár, half way up the northern coast, by April 1874 Captain Baird, and his assistant Mr Rendel, made periodical inspections of the tidal stations, which necessitated a great deal of hard marching, and entailed much exposure and privation The first series of observations was completed in 1874, and the preliminary results from the combined tidal and levelling operations were that the mean sea level of the Gulf of Kach is higher by 7 inches at the head of the gulf, and by 4 inches midway up, than it is at the mouth

During 1874, also, the tidal observations taken at Tutikorin in 1871–72, with a self-registering tide gauge, were reduced by the harmonic method by Mr Roberts, of the Nautical Almanac Office

In the season of 1875, Captain Baird and Mr Rendel levelled over 420 miles, thus establishing a complete circuit connecting the tidal stations But the former able and zealous officer was attacked by fever, which obliged him to return to England, where he will reduce his observations, in concert with Mr Roberts Charge of the work in the Gulf of Kach has, meanwhile, been entrusted to Captain C T Haig, R E

A careful register of tides at Bombay, under the Port Trustees, was commenced in January and continued throughout the year 1876 At Karáchi tidal observations have been continuous for 15 years

Tidal observations not only afford data for calculating the rise and fall, they also enable a standard to be fixed for survey purposes, while they are of scientific interest, apart from their practical usefulness By a resolution, dated July 4th, 1877, the Government of India ordered that the tide gauges should be provided from port funds, and the general superintendence and control of all tidal observations on the Indian coasts was entrusted to Captain Baird, R E, who will determine the points at which they should be carried out Thus the investigation of the laws of the tides of the Indian Ocean, which has long been considered a desideratum, and the utility of which was originally pointed out by Dr Whewell in 1832, will now receive the attention it deserves

# XVIII

## ASTRONOMICAL OBSERVATIONS IN INDIA

"A LAUDABLE curiosity prompts to inquire the sources of know-"ledge, and a review of its progress furnishes suggestions tending "to promote the same or some kindred study We would know "the names at least of the individuals to whom we owe successive "steps in the advancement of knowledge" The above remark is equally applicable to all the sections of this Memoir, but it was made by Mr Colebrooke, when he introduced the ancient Indian astronomers, and opened his dissertation upon their systems Of all the sciences which have been cultivated in India under the auspices of the Government, astronomy alone has a history which goes back ages before the English occupation, and which requires, in this enumeration of those to whom, in India, we owe successive steps in the advancement of knowledge, a wider range than is included within the last century Rennell and Voysey, the fathers of Indian geography and geology, flourished within the memory of living men, but we must go back to the 5th century for the era of Aryabhata, the sage who stands at the fountain head of the history of Indian astronomy

Aryabhata must have flourished before the sixth century He affirmed the diurnal revolution of the earth on its axis, accounting for it by a current of aerial fluid, extending to a height of 114 miles above the earth's surface, and he calculated the earth's circumference to be 25,080 miles He believed the moon and primary planets to be dark, and only illumined by the sun, and he possessed the true theory of lunar and solar eclipses He is also the earliest author that is known to have treated of algebra [1] In his *Surya Siddhanta* he deduced from observations the values of the mean motions of the sun, moon, and planets, and of their apsides and nodes, and calculated eclipses Mr William Spottiswoode at one time had an intention of translating the *Surya Siddhanta*, and he has actually enabled an enquirer to understand the ancient astro-

[1] Colebrooke on Indian algebra

nomer's system, by giving his rules in modern mathematical language and formulæ [1]

Vahara mihira, another astronomer, flourished in the generation after Aryabhata

Brahmegupta, who wrote in 628 A D , set himself the task of correcting the earlier system, which had ceased to agree with the phenomena, and of reconciling computation with observation His *Brahma Siddhanta*, in 21 chapters, contains calculations of the mean motions and true places of the planets, of lunar and solar eclipses, of the rising and setting of planets, of the position of the moon's cusps, and of observations of altitudes by the gnomon The principles of his astronomical system are given in a compendious treatise on spherics He frequently quotes from Aryabhata

Bhaskara, a later astronomer, completed his work on algebra, arithmetic, and mensuration in about 1150 A D [2]

The systems of the earlier of the ancient Hindu sages were communicated to the astronomers of the court of the Abbaside Khalîfah Al Mamûn at Baghdad, and the knowledge derived from this source, combined with the learning of Ptolemy, after being cultivated by the more enlightened sovereigns of Central Asia, came back again to India, with the descendants of Timur

The Arabs began to study astronomy under the Khalîfah Al Mamûn, and in 827 the Almagest was translated into Arabic Al Batany, the most celebrated of their astronomers, noticed errors in the positions of stars in Ptolemy's catalogue, in consequence of that astronomer's error with regard to the precession of the equinoxes, and in 882 he determined the amount of this precession with greater accuracy Dr Halley calls Al Batany "Vir admirandi "accuminis ac in administrandis observationibus exercitatissimus" Ebn Younis observed three eclipses at Cairo between 977 and 979,

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[1] "On the Surya Siddhanta, and the Hindu method of calculating eclipses," by William Spottiswoode (1863) *Journ R A S*, xx, p 345 Dr Bhau Daji wrote "Brief notes on the age and authenticity of the works of Aryabhata" *Journ R A S* i, (N S) xiv, p 322 See also Dr Kern—"On some fragments of Aryabhata" *Journ R A S*, xx, p 375 Lassen's "Indische Alterthumskunde," ii, p 136 Burgess's translation of Aryabhata, and Fitz Edward Hall on the Surya Siddhanta, in the *Journal of the American Oriental Society*, vi, pp 145–559 Bentley's "Historical View of Hindu Astronomy" (London, 1825) Mrs Manning's "Ancient and Mediæval India," i, 362

[2] "Algebra, with arithmetic and mensuration, from the Sanscrit of Brahmegupta and Bhaskara" Translated by H T Colebrooke (Murray, 4to 1817)

and Abul Wefa, who died in 986, composed a catalogue of the fixed stars[1] The learning thus fostered on the banks of the Tigris spread to the east and west,[2] and the Mongol Hulaku Khan established an observatory at Maraga in Azerbaijan, where Nâsiru 'd Din composed his Ilkhâny tables in the thirteenth century

Ulugh Beg, the grandson of Timur, was for many years governor of Ma wara-'n Náhr during the reign of his virtuous father Shah Rokh, and reigned himself from 1447 until he was assassinated by his own son in 1449 Ulugh Beg attracted to his court all the most celebrated astronomers, from various parts of the world He erected a college and observatory at Samarkand, at which a hundred people were constantly occupied in the pursuits of science, and among other instruments he had a quadrant, the radius of which equalled in length the height of the dome of St Sophia[3] Having found that certain stars in Ptolemy's catalogue, reduced to his own epoch, did not coincide with observations made at Samarkand, Ulugh Beg and his learned assistants undertook to re observe the whole of the stars in Ptolemy's catalogue, and to construct a new set of astronomical tables This was ultimately accomplished The tables, called *Zig Ulugh Beg*, are divided into four parts, referring to treatises on epochs and eras, on the knowledge of time, on the courses of planets, and on the positions of fixed stars Ulugh Beg re-observed all Ptolemy's stars but 27, which were too far south to be visible at Samarkand[4] One of these was *Sohail* or *Canopus*, a

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1 "Asiatic Miscellany," i, p 34

2 Abu Obaidah Moslema, a native of Madrid, who had studied in the east, was the most renowned astronomer of Muhammadan Spain He was well acquainted with the movements of the heavenly bodies He reformed the *kiblah*, giving the true bearing of Mecca from Spain, and his work on the manner of constructing and using astrolabes is preserved in the library of the Escurial He is also said to have translated the Almagest of Ptolemy, and to have constructed some excellent astronomical tables See an account of his life in *Casiri*, i, p 378 c 2, and ii, p 147 c 2, and *Gayangos's Al Makkari*, i, pp 149, 427, 465 Moslema died at Cordova in 1007 A D, so that he was the contemporary of the eastern astronomers Ebn Younis and Abul Wefa

3 At least so the Turks, who had it from Persians of credit, told Professor Greaves But Mr Baily thinks it was more probably a gnomon The Spanish Ambassador, Ruy Gonzalez de Clavijo was at Samarkand, thirty years or more before Ulugh Beg built his observatory This is to be regretted, as Clavijo described all he saw at Samarkand very minutely See "Narrative of the Embassy of Clavijo to the court of Timur," translated and edited, with a life of Timur, by Clements R Markham, (printed for the Hakluyt Society, 1859), p 169

4 The tables of Ulugh Beg were first brought to the knowledge of Europeans by the great orientalist and mathematician, John Greaves, Savilian Professor at Oxford

star which was first seen by the great Timuride astronomer's cousin Baber, when he crossed the Hindu Kush, on his way to bring the learning of Aryabhata, increased by that of Ptolemy and Ulugh Beg, back to its native source on the plains of Hindustan

Thus the Timuride emperors at Delhi boasted of a famous astronomer among their collateral ancestors,[1] but none of the family had since turned their attention to the subject, and it was from among the Rajput princes, whose valour was a main support of the Delhi throne, that the greatest Indian astronomer since the days of Aryabhata was to arise The Rajahs of Dhundar, of the race of Kuchwaha Rajputs, and descended from Rama the king of Ayodya, were the first among the native rulers who became vassals of Muhammadan emperors Bhagwandas, the Prince of Dhundar, was the friend of the great Akbar, and his daughter married Akbar's son, the Emperor Jehanghir Man Sing, another Dhundar Prince, was the most brilliant courtier and the most successful general at the Delhi court Jai Sing, the great astronomer, succeeded as Rajah of Dhundar in 1699, and was famous as a general and a statesman, but above all as a man of science Amber was the ancient capital of his state, but in 1728 he founded another capital, the only one in India which is built on a regular plan, with streets bisecting at right angles, and he called it after himself—Jaipur It is six miles from Amber, which is included in the lines of its fortifications Under Muhammad Shah of Delhi the Rajah Jai Sing served as Subadar of Agra and Malwa, and he was also chosen to construct a new set of tables to supersede those of Ulugh Beg They were called Zig Muhammadshahy, in honour of the emperor, and were completed in 1728

The instruments formerly in use appear to have been in brass, but

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1642–48 See "Life of Greaves, and miscellaneous works," edited by Dr Birch, 2 vols 8vo, 1737 (London) Dr Thomas Hyde also translated and published the whole catalogue in 1665, with an account of the life of Ulugh Beg "Tabulæ long ac lat Stellarum fixarum ex observatione Ulugh Beighi, Tamerlanis magni nepotis, &c, 1 vol 4to, Oxon 1665 The work was reprinted, with corrections, by Sharpe, in 1767 M Sedillot translated the tables of Ulugh Beg, with the preliminary discourse In 1843 was printed in vol xiii of the *Memoirs of the Astronomical Society* —"The Catalogues of Ptolemy, Ulugh Beigh, Tycho Brahe, Halley and Hevelius,' with a preface to each catalogue by Francis Baily The Ulugh Beg tables here given are reprinted from Sharpe's edition of Hyde which is from a collation of three Persian MSS at Oxford See also, "Asiatic Miscellanies, i, p 51 Kinneir often quotes the tables of Ulugh Beg, in determining the latitudes of places in Persia

[1] Ulugh Beg was a first cousin of Baber's great grandfather

they did not come up to Jai Sing's ideas of accuracy, owing to the smallness of their size, to their imperfect graduation, to the shaking and shifting of their planes, and to the wearing of the axes He therefore invented enormous instruments of his own, of masonry work, and to confirm and check the observations he formed five observatories, each with a complete set of instruments, at Delhi, Jaipur, Matra, Banares, and Ujain Those at Delhi have been minutely described by Dr Hunter,[1] and Sir Robert Barker[2] has given an account of the instruments at Banares, with illustrations

The Delhi Observatory was outside the walls of the town The large equatorial dial is of stone, with edges of white marble for graduation The gnomon in the centre is 56 feet 9 inches high A masonry wall has a graduated semicircle for taking altitudes of bodies east and west, from the eye Another is the plane of the meridian, having a double quadrant described in it, with the two upper corners of the wall as centres, for observing altitudes of bodies passing the meridian north or south of the zenith One degree on these quadrants is $2\frac{5}{6}$ inches long, and the degrees are divided into minutes There are also two buildings of peculiar construction, for taking simultaneous observations of the altitudes and azimuths of heavenly bodies

At Ujain Observatory there was a double mural quadrant on a wall 27 feet high, and 26 feet long On the west side of the wall there was a stair to the summit, and the east side was smooth and graduated At the top, near the corners, were two iron spikes, 25 feet 1 inch from each other, and with these spikes as centres, and a radius equal to their distance, two arcs of 90°, intersecting each other, are graduated on the wall The divisions are into 6°, 1°, 6′, and 1′ By this instrument Jai Sing, who, as Subadar of Malwa, had a palace at Ujain, made the latitude 23° 10′ N Dr Hunter, by several careful observations, made it 23° 10′ 24″ N Ujain appears to have been the prime meridian of early Hindu geographers[3]

At Matra the instruments were on the roof of a room in the fort, and were small and imperfect, but at Banares they were large, and equal to those at Delhi and Ujain A drawing of the beautiful

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1 "Asiatic Researches," v, p 177

2 "Philosophical Transactions," vol 69, pt 2, p 5 The Banares Observatory is also described, with woodcuts of the instruments, in Dr Hooker's Journal

3 See Lieut Conolly's paper on Ujain —*J A S B* (1837), p 813

balcony of Jai Sing's observatory at Banares is given by James Prinsep, and the masonry equatorial dial at Delhi is among the drawings engraved by Daniell [1]

Jai Sing, with his instruments at Delhi, determined the obliquity of the ecliptic to be 23° 28′ in 1729, within a year of Godin's determination, which only differed by 28″ The great Rajput astronomer also constructed a table of the daily place of stars, and, hearing that other tables had been previously published in Europe, he sent skilful persons to Portugal, with a certain Father Manuel, to procure them Xavier da Silva was despatched to India with the tables of De la Hire, the first edition of which had been published in 1680, and the second in 1702 Jai Sing also had Euclid and Napier's logarithms translated into Sanscrit His own tables, which were completed in 1728, give the mean longitude and motions of the sun and of his apogee for 30 years, equation of time, and the motions of the moon and planets Down to Colonel Tod's time, all computations were made and almanacks constructed by the tables of Jai Sing

This great and wise prince intended to have completed his career, by performing the *aswameda yuga*, or horse sacrifice After a reign of 43 years he died in 1748, and three of his wives ascended the funeral pyre, on which Hindu science expired with him [2]

Dr Hunter was acquainted with a grandson of Vidhyadhur, a Jain, and one of the chief coadjutors of Jai Sing, who inherited his ancestor's learning and traditions Dr Hunter himself, as well as Colonel Pearse and others, towards the end of the last century, took many astronomical observations, but they were made more for the purposes of a survey than in the interests of pure astronomy, and have already been noticed Colonel Hodgson, the Surveyor General of India from 1821 to 1827, was an astronomer, and a series of transit observations were made under his superintendence at Calcutta [3] He also determined the longitudes of Calcutta, Madras, and Futtehgurh, by lunar transits, and eclipses of Jupiter's first satellite,

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1 Plates xix and xx See also "Life in Ancient India,' by Mrs Spiers, pp 422 and 460

Dr Hunter gives a complete translation of the preface to Jai Sing's tables, with the original text—*Asiatic Researches*, v, p 177

2 For a very interesting account of Jai Sing, his family, and his principality, see *Tod s Rajasthan*, ii, p 345

3 "Transactions of the Astronomical Society," iii, pt ii, p 358

the difference between his Madras result, and that of the astronomer Goldingham, being less than a second of time [1]

The King of Oudh established an observatory at Lucknow on a considerable scale, and Major Herbert was induced to hand over his editorial labours at Calcutta to James Prinsep, and take charge of it in 1832, but he died at Lucknow on September 24th, 1833 This observatory was supplied with a mural circle of six feet, an eight feet transit, and an equatorial by Troughton and Simms In about 1841 Major Wilcox assumed charge of it, and made a valuable series of observations with the help of native assistants, but he died in October 1848, and in 1849 the King of Oudh abolished the observatory The records were gradually eaten away by insects, and when the mutinies broke out the instruments were destroyed [2] Thus all the work of this once first class observatory has been lost to the world, and its records have perished without rendering any result to science

The Madras Observatory has been the centre of astronomical work during the British occupation of India It was founded in the days of Sir Thomas Munro, and has ever since been directed by a succession of able astronomers Besides the value of the work that has been performed at Madras to astronomical science, the observatory is specially important because the longitudes of the Great Trigonometrical Survey depend on the meridian passing through it The various determinations of the Madras Longitude, with reference to the Survey, have already been discussed in a previous section of this Memoir, and it is here only proposed to give a brief sketch of the other labours of the astronomers

The Madras series of observations commenced in 1787, and the observatory building was erected in 1792, and furnished with a 20 inch transit, and a 12-inch altitude and azimuth instrument by Troughton Mr John Goldingham was the first astronomer, and his labours have already been noticed, in the discussion on the

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[1] Hodgson's was 5h 21m 8 64s Goldingham's 5h 21m 9 4s John Anthony Hodgson was born at Bishop Auckland on July 2nd, 1777, and was educated at Durham He went to India, as a cadet, in 1799, and in 1817 was selected, with Herbert, to survey the sources of the Ganges and Jumna He was Surveyor General from 1821 to 1827 In 1845 he went out to India again as Major General of the Rohilkhand Division, and died at Ambala on the 28th of March 1848

[2] Report by Major Tennant—*Proceedings of the Astronomical Society*, xvii, p 63

longitude of Madras[1] He was an antiquary as well as an astronomer, and wrote papers on the seven pagodas, and on the cave of Elephanta He was also the architect of the banqueting room at Madras He retired in 1830, and died at Worcester, at an advanced age, in 1849[2]

Thomas Glanville Taylor, who succeeded Mr Goldingham, was born at Ashburton, in Devonshire, on November 22nd, 1804, a year before his father Thomas Taylor was appointed Assistant to Dr. Maskelyne at Greenwich Young Taylor was brought up as an astronomer, and in 1822 he was placed on the establishment of the Royal Observatory, taking charge of the night transit observations. He also gave Sabine much assistance in his pendulum operations. In the spring of 1830, at the recommendation of Mr Pond, then Astronomer Royal, he was appointed to the charge of the Madras Observatory At the same time a new five foot transit instrument was supplied, and Mr Taylor began his series of observations of moon culminating stars with it, in 1831–33, whence a new determination of the longitude of Madras was obtained[3]

Mr Taylor also made a catalogue of fixed stars,[4] on which Mr.

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[1] See p 64

[2] His labours at the observatory are printed in 5 folio volumes —

"Astronomical Observations,' by John Goldingham, 4 vols (fol), Madras, 1825–27

"Madras Observatory Papers, by John Goldingham, Astronomer (Madras, 1827)

See also "A paper on the longitude of Madras, as deduced from observations of eclipses of the first and second satellites of Jupiter, 1817–26,' by J Goldingham —(*Pro As Soc*, i, p 13) A notice of the life of Mr Goldingham will be found in the *Pro As Soc* x, p 80

[3]

| | | h | m | s |
|---|---|---|---|---|
| Goldingham's result was | | 5 | 21 | 9 35 |
| Hodgson's | „ | 5 | 21 | 8 64 |
| Taylor's | „ | 5 | 20 | 57 28 |

On June 13th, 1845, a paper was read before the Astronomical Society, giving Taylor's recomputed results, from 442 observations of the moon's first limb, and 86 of the second limb Mr Riddle, of the Greenwich School, in a paper read on April 10th, 1840, entered at length on the method of computing longitudes by moon culminating observations He makes the—

| | | | | h | m | s |
|---|---|---|---|---|---|---|
| Longitude of Madras, from 54 observations at | Greenwich and Madras | | | 5 | 20 | 55 |
| „ „ 56 | „ | Cambridge | „ | 5 | 20 | 55 |
| „ „ 65 | „ | Edinburgh | „ | 5 | 20 | 58 |

See "Proceedings of the Royal Astronomical Society, vi, p 247, v, p 49, xv, p 110

[4] Upwards of 8,800 stars In the second volume of observations by Taylor there is a catalogue of 11,015 stars collected from the five volumes of Madras observations, including all those in the Astronomical Society's and Piazzi's Catalogues visible at Madras, reduced to Jan 1st, 1835, being about the middle period of the observations

"Results of Astronomical Observations made at the H E I C Observatory at

Baily based his great catalogue The observations, during Mr Taylor's time, were regularly published in four volumes He visited England in 1840 After his return, he met with a severe accident at Trivandrum, a fall occasioned by extreme short sight, from which he never quite recovered Owing to his daughter's illness he again went home, but too late to see her, and died on May 4th, 1848, leaving a widow and three sons

Captain Jacob succeeded Mr Taylor as Astronomer at Madras William Stephen Jacob, son of the Rev S Jacob, was born at Woolavington, in Somersetshire, on November 19th, 1813 He was at Addiscombe in 1828, and sailed for India in 1831, where he was appointed to assist Colonel Shortrede in the surveys in the Bombay Presidency Between 1837 and 1841, assisted by Sir Andrew Waugh, he completed the Bombay Longitudinal Series, which was an excellent piece of work He went to England in 1843, but returned in 1845, and during the three following years he took astronomical observations at Poona with a five-foot equatorial by Dollond, and made a catalogue of double stars [1] In 1848 he was appointed to the charge of the Madras Observatory Captain Jacob was an accomplished astronomer, a careful and accurate observer, and an able computer, but the climate of Madras did not agree with him, and he suffered much from ill health In 1850 he was occupied in revising and perfecting Taylor's catalogue of stars, and on the orbits of *α Centauri* (which investigation he had made peculiarly his own), and other double stars In 1853 he sent home a catalogue of 144 double stars, as a continuation of his Poona catalogue [2] Neptune was also observed since 1849, and careful measures were taken of Saturn and his ring [3]

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Madras,' by J G Taylor, 4 vols (Madras, 1831–37) (*J A S B*, ii, p 380 *Pro A S*, v, p 27, vi, p 187, ix, p 62)

[1] "Memoirs of the Astronomical Society," xvii, p 79

[2] "Trans A S," vol xvii, Pro A S, x 87, x 103, xv 133

[3] In 1854 another volume of Madras observations was published, containing those for 1848–52, with an Appendix bringing some of them up to 1854

Captain Jacob has also written, 'Catalogue of 317 stars selected from the B A Cata logue, being such as are supposed to have large proper motions," by Captain Jacob, *Mem A S*, xix, p 61

"On the ring of Saturn and on Jupiter's Satellites," by Captain Jacob —*Mem A S* xxx, p 236

"Micrometrical measures of 12 double or multiple stars,' by Captain Jacob —*Mem A S*, xix, p 68

"On Jupiter's mass," by Captain Jacob —*Mem A S*, xxviii

In 1854 Captain Jacob was obliged to go home on sick leave, and Major Worster, of the Madras Artillery, assumed temporary charge of the observatory He was engaged in examining 400 stars affected by proper motion to the extent of 0 5″ annually

In 1856 a new meridional circle by Simms was ordered for the Madras Observatory, which arrived in 1857, Captain Jacob having resumed charge in December 1855 He commenced a series of equatorial observations of the satellites of Jupiter and Saturn, but he was again obliged to go home, owing to ill health, in April 1858, and Major Worster once more took temporary charge of the observatory A useful catalogue of stars was prepared under his management After recruiting his health, Captain Jacob purchased a nine inch aperture telescope, and set out, under the auspices of the Astronomical Society, to establish an observatory in the Bombay Presidency He landed at Bombay on August 8th, 1862, but died at Poona on the 16th, and the hopes that had been raised as to the results to be derived from the labours of so accomplished an observer came to an end

Major Tennant, of the Great Trigonometrical Survey, who had assisted at the measurement of the Karáchi base, assumed charge of the Madras Observatory on October 13th, 1859, but he only held the post for a short time, and in 1861 Mr Pogson was appointed Astronomer Norman Robert Pogson was already well known as an observer of variable stars, and as the discoverer of several small planets, and he had been in charge of Dr Lee's Observatory at Hartwell since 1858 In 1873 he submitted a report upon the proceedings of his department up to that date

Beyond announcements of discoveries, and the observations necessary to substantiate them, communicated to the Royal Astronomical Society, and the Astronomische Nachrichten, nothing had been published between 1860 and 1873 Mr Pogson undertook to work on a programme of operations which he afterwards came to the conclusion were unreasonably extensive without assistance, but he persevered in it, leaving publication to the future, in the full expectation that he would be provided with an efficient European assistant At last, in August 1870, Mr Pogson's son was appointed as his assistant, but the sanguine hopes then raised of being enabled to bring out the results so long awaiting publication were disappointed, owing to the illness and untimely death of young Mr Pogson in July 1873 As the heaviest work on hand, namely, the catalogue of stars made with the new meridian circle, was nearly complete, it was considered that, for a time, observations might be almost suspended, and the whole available force of the establishment concentrated on the reduction and publication of the arrears. By adopting this course from the commencement of 1875 the volumes might, it was hoped, be brought out in pretty rapid succession, and all arrears cleared off before any fresh undertaking was commenced.

When Mr. Pogson took charge of the observatory in February 1861 there was a catalogue of about 2,200 stars, chiefly selected from Taylor's Madras catalogue, and that of the British Association, observed between 1853 and 1858, awaiting completion. The observations to be incorporated in this catalogue will be little under 10,000, and much had already been done towards preparing it for the press. There are 1,331 observations of the sun, 345 of the moon, 1,680 of the principal planets, 333 of the minor planets, and 25 of Donati's comet of 1868, besides the mean places of the 144 Nautical Almanack stars from 1853 to 1858, observations of Mars at the oppositions of 1854 and 1856, of moon culminations for determination of longitude, and a long list of occultations of planets and fixed stars, and of the phenomena of Jupiter's satellites. These formed the arrears, and most of them were reduced and ready for the press. They are well worthy of publication, and prove that the predecessors of Mr. Pogson conscientiously exerted themselves for the attainment of such results as were within their very limited instrumental means. The hourly meteorological observations from 1851 to 1860 were still unpublished. Those from 1851 to 1855 were printed and nearly ready for issue. Of the hourly magnetic observations, only the results from 1846 to 1850 had been published. Those from 1850 to 1855 were printed.

Since Mr. Pogson assumed charge in 1861 he has had several works in progress. A catalogue of about 3,000 stars, observed with the meridian circle, towards which 23,506 observations had already been made, was closed with the year 1874. The catalogue contains a number of southern stars not previously observed elsewhere, chiefly between 110° and 150° of North Polar distance. Meridional observations have at the same time been made of the moon from 1862 to 1872, and of Mars and some of the minor planets. An atlas of telescopic variable stars consisting of over 120 maps, including all stars down to the twelfth magnitude in the vicinity of each of these interesting objects, was about two thirds finished in 1873 Discoveries of new planets and variable stars have chiefly resulted from a search regularly maintained over certain very perfect manuscript charts constructed by Mr Pogson

When Mr Pogson arrived at Madras in February 1861 he found the observatory in a most distressingly hopeless state of inanition Nothing had been done during the two previous years, and the only instruments available for work were the equatorial by Messrs Lerebours and Secretan, and a small portable transit used for finding the local time During 1861 Mr Pogson was engaged in setting up the new transit circle, and in observations with the equatorial The new planet "Asia," so named in consequence of its being the first discovery made in that quarter of the globe, was found early in April 1861, and the observations of it were printed in the monthly notices of the Royal Astronomical Society The solar eclipse of July 7th, 1861, the transit of Mercury on November 11th, and many other observations, were also duly attended to, and the meteorological and magnetical registers, and the local time signals by the telegraphic dropping of a time ball daily at 1 p m, were carried on throughout the year The mounting of the new transit circle was completed, and the instrument brought into use on May 31st, 1862 A monthly record of observations made with it has since been kept Much work was also done with the equatorial But 1864 was the best year as regards the general work of the observatory The maximum number of observations was attained with the transit circle With the equatorial the new planet "Freia" was independently discovered on the 2nd of February, 1864, but it proved to be one detected by Professor D'Arrest at Copenhagen in 1861, which had since been lost owing to the insufficiency of the observations made at its discovery Another new planet, called "Sappho," was discovered on the 3rd of May 1864 A second series of differential right ascensions of Mars was also observed, for the investigation of the solar parallax

In 1865 the meridian circle work continued to be all that could be desired The new large equatorial, by Messrs Troughton and Simms, had been received early in 1864, and a suitable structure was erected for it From 1866 a more complete form of tabular reports was introduced The great events for 1866 were the mounting of the new 8½ inch equatorial, and the discovery of the new planet "Sylvia" In 1867 the finding of the variable star *R Reticuli*, by

C Ragoonatha Charry in January is memorable as the first astronomical discovery achieved by a native of India, in modern times

In 1868 the total eclipse of the sun on the 18th of August was observed Actual micrometrical measurements of the positions of bright lines in the solar corona were obtained with the spectroscope at Masulipatam, and the visibility of the red prominences after the sun's reappearance was confirmed by measures taken half a minute after the end of totality The polarization of the light of the corona was satisfactorily proved by Mr G K Winter, and the observations of the ordinary phenomena of the eclipse were recorded by the late Mr C G Walker, C S On the 19th of November 1868 another new planet was discovered, called "Camilla"

A third series of measurements of Mars, for investigation of the solar parallax, was made in 1869 with the new equatorial In October 1871 an important change was effected in the mode of communicating Madras mean time to the shipping in the roads The invention of a new apparatus by Mr G K Winter (the Telegraph Engineer to the Madras Railway) and the construction of a new line of telegraph between the observatory and Fort St George, enable the astronomer to undertake the firing of both the noon and the 8 o'clock guns with strict accuracy, so that there are now two daily signals by which the error and rate of chronometers can be determined by the shipping in the Madras roads [1] In 1871 a fourth series of observations of Mars was made with the large equatorial, and signals were exchanged by the submarine cable between Madras and Singapore, in July, for the difference of longitude At the suggestion of Professor Oudemens, the Dutch Surveyor General in Java, a similar exchange of longitude signals had previously been made between Singapore and Batavia The central shadow path of another total eclipse of the sun across the Madras Presidency, on December 12th, 1871, led to the equipment of several expeditions to observe it The station selected for the Government Observatory was at Avenashy, in the Coimbator district, on the line of railway The Assistant Astronomer, aided by Colonel Ritherdon and Mr Doderet, obtained three successful photographic pictures of the totality, showing the corona and other phenomena of the eclipse Mr Winter rendered valuable service as polariscopist, and C Ragoonatha Charry was entrusted with the

[1] "Madras Administration Report for 1870-71," p 212

ordinary telescopic phenomena In 1872 the annular eclipse of the sun was observed on the 6th of June, and the phenomena known as "reversal of the lines," hitherto observed only at total eclipses, was also seen to great advantage with the spectroscope at both the formation and breaking of the ring

In December 1872, Mr Pogson detected the comet of Biela, at the Madras Observatory, under circumstances of extraordinary interest This comet was first seen in 1772, but in 1826 Mr Biela discovered it again, when the orbit was carefully calculated, and the results showed that it revolved round the sun in about $6\frac{3}{4}$ years In 1832 it returned with the utmost punctuality, and again in 1846 it separated into two, each complete, with a short tail of its own, 150,000 miles apart The phenomenon produced a profound sensation among astronomers It and its companion were again seen in 1852, but 1,250,000 miles apart

Mr Pogson represented that if an experienced European assistant had been granted him in 1863 there would have been no arrears in 1873 Meanwhile he has long had one labour in hand, the vast importance of which cannot well be over-rated, namely, the investigation of the constant of solar-parallax, by means of the planet Mars in opposition, which is one method of ascertaining the sun's true distance from the earth The transit of Venus offers the readiest and most immediate result, but the opportunity of observing it only occurs twice in a century In 1857, the Astronomer Royal[1] suggested and advocated the method by means of the planet Mars when in opposition, which is equally adapted to secure the same result The requisite observations for this method can only be made to the best advantage at a tropical observatory, and Madras was particularly named by the Astronomer Royal for the work Mr Pogson has now taken five series of opposition observations in 1862, 1864, 1869, 1871, and 1873, all of which await discussion The three last were made with the new equatorial, but still without all the proper appliances In 1874 telegraphic determinations of the longitude of Rurki were effected with reference to the observations of the transit of Venus at that station

In 1869, Sir George Airy, the Astronomer Royal, suggested that Colonel Walker should be called upon to draw up a document, to provide for the future administrative arrangements of the Madras Observatory, by prescribing certain definite duties for its future performance Accordingly a "*Code of Instructions to define the*

[1] "Monthly Notice, R A S," XVII, p 208–21

"*future operations of the Madras Observatory*" was drawn up by Colonel Walker, with the assistance and concurrence of Mr Pogson, the Astronomer, on February 26th, 1869 [1] The Code was amended on February 11th, 1870, and finally received the approval of the Government of India It is in nine sections

1st Meridian observations to be taken of a certain number of standard stars in the Northern and Southern Hemispheres, for the purpose of harmonizing and connecting together the positive determinations of the Greenwich, Madras, Cape of Good Hope, and Australian observations, with a view to the eventual preparation of an accurate catalogue of star's places, from the combined operations of all these observatories

2nd Meridian observations to be taken of all stars, down to the sixth magnitude, between North Polar Distance 60 and North Polar Distance 110

3rd Meridian observations to be taken of all stars used for geodetical purposes in the course of the operations of the Great Trigonometrical Survey

4th Meridian observations to be taken of all minor planets within range of the instrument (10 5 magnitude), whenever they are in opposition south of the equator

5th Equatorial observations to be taken of the planet Mars at every successive opposition, in continuation of the observations which have already been made by Mr Pogson for the investigation of the constant of solar parallax

6th Magnetic and meteorological observations to be continued on the system introduced by Mr Pogson in 1861

7th Provision for time determinations for shipping, and for notices of approaching stormy weather, &c

8th The publications should be issued in annual volumes, and annual Reports should be submitted to the Government of Madras, and sent to the Astronomer Royal, whose criticisms should be invited Monthly tabular statements of arrears of reduction and publication should also be submitted

9th Special investigations may be undertaken by the Astronomer, but they should not interfere with the regular routine of the observations, nor retard the work of reduction and publication

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[1] Colonel Walker to the Secretary to the Government of India, March 4th, 1869

In 1836 Mr John Caldecott, the commercial agent to the Travancor Government at Alepy, pointed out to General Fraser, the Resident, the advantages to science to be derived from the establishment of an observatory at Trivandrum The latitude is 8° 30′ 35″ N, and observations taken in such a position were considered likely to yield valuable results, owing to its proximity to the equator Trivandrum is, also, only about 70 miles south of the magnetic equator Rama Kermah, the late Rajah of Travancor, who was a learned and cultivated prince, entered warmly into the project, and appointed Mr Caldecott his astronomer, with authority to build an observatory at Trivandrum The building was planned and erected by Captain Horsley of the Madras Engineers in 1837, on a laterite hill two miles from the sea, and 195 feet above it, whence there is a magnificent view On one side is the sea bordered by groves of cocoa nut trees, on the other the rich undulating country, bounded by the many peaked ghâts Mr Caldecott went to England for instruments in December 1838, and returned in April 1841 with a transit instrument by Dollond, two mural circles, an equatorial, altitude and azimuth, and magnetic and meteorological instruments Mr Caldecott forwarded complete copies of his observations to the Court of Directors and the Royal Society, and in 1846, leaving the Rev Dr Spershneider in charge of the observatory, he came home to try and obtain the aid of some of the scientific societies in publishing them, but without success He returned to Trivandrum in 1847, and died there on December 17th, 1849

The observatory was in charge of Mr Spershneider for two years, and in 1851 the Rajah of Travancor appointed Mr John Allan Broun, who had been in charge of Sir Thomas Brisbane's observatory at Makerstown from 1842 to 1850, to be the astronomer at Trivandrum Mr Broun arrived on January 11th, 1852, but he found the astronomical instruments in so unsatisfactory a condition that he thought it best to devote his chief attention to magnetism and meteorology An account of his meteorological work, and of the establishment of an observatory on the summit of Agustia mulla, has been given in the section on meteorology [1] He also built a house adjoining the observatory at Trivandrum, with a row of Doric columns supporting an entablature imitated from that by Inigo Jones on the church in Covent Garden, and a terrace In July 1852 he commenced a series of lectures on the instruments, their objects,

[1] See page 282

and the results derived from them, and in course of time he succeeded in training a very efficient set of assistants In 1853 he built rooms for a new set of magnetic instruments which were obtained from England, and his magnetic investigations are of great value and importance He obtained a complete set of hourly magnetic observations at Trivandrum from March 1852 to March 1865, and at Agustia from June 1855 to July 1858, and during ten months in 1863 Mr Broun also made a short series of hourly magnetic observations simultaneously at three different stations, relative especially to the diurnal variation of magnetic declination One was as nearly as possible on the magnetic equator, about 30 miles north of Trivandrum, the other at the observatory, and the third at Cape Comorin In 1859-60 he made a magnetic survey of the west coast of India, for the purpose of ascertaining the position of the magnetic equator which passes through Travancor, and the variations of intensity about the line of no inclination Stations were chosen at intervals along the coast, which were eventually extended up to Bombay The horizontal intensity was found to be nearly the same from Bombay to Cape Comorin [1]

The present Rajah of Travancor resolved to discontinue the observatory establishment, and Mr Broun left Trivandrum in March 1865 But it was arranged that a limited series of observations should be continued by the two most experienced native assistants, who were to forward monthly reports and extracts of observations to Mr Broun, which are of great importance with reference to several questions of interest Mr Broun published the results of his labours in Travancor in 1874 [2]

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1 A history of the observatory, and a most interesting account of the establishment of the branch observatory on the Agustia mulla peak will be found in the "Report on the observatories of His Highness the Rajah of Travancore, at Trivandrum, and at the peak of Agustia on the Western Ghats,' by John Allan Broun, F R S, Director of the Observatories (Trivandrum, 1857)

2 In 1874 a handsome quarto volume was published by Messrs King, entitled "Reports on the Observatories, Public Museum, Public Park and Gardens of His Highness the Maharajah of Travancore, G C S I," by John Allan Broun, F R S, late Director of the Observatories It contains a reprint of the smaller volume of 1857, together with the second General Report covering the ground from 1857 to 1865, and short reports on the museum at Trivandrum Mr Broun has also contributed papers to the "Transactions of the Royal Society of Edinburgh" (vols xxii and xxiv, p 669), on horizontal force of the earth's magnetism, and on the bifilar magnetometer, on diurnal variation of the magnetic declination at Trivandrum, deduced from 12 year's observations, and on an examination of diurnal observations at nine other stations, for which he received the Keith biennial prize In the "Comtes Rendues" of the Academy of Sciences for July

The Bombay Observatory is confined to magnetic, tidal, and meteorological observations, and to observations for time to rate the chronometers in the harbour Major Jacob's desire that an astronomical observatory should be established in the Western Presidency has never been fulfilled

The transit of Venus was observed on the 9th of December 1874 by Mr J B N Hennessey, of the Great Trigonometrical Survey, at Masauri, a Himalayan station 6,765 feet above the sea His especial object was to observe the transit from a considerable height He used the equatorial of the Royal Society, having first fixed his latitude and longitude to observe for time, and rated his chronometers Fortunately he was favoured with exquisitely clear weather He watched for the first external contact of Venus, but did not detect it until it had made an indentation on the sun's limb The latter appeared jagged Venus was edged by a narrow ring of light, but Mr Hennessey could not discern the "pear-drop" or the "ligament" described by former observers Colonel Walker, who observed the transit at Dehra Dún, ten miles to the south and only 2,200 feet above the sea, saw the pear-drop and the ligament very distinctly So that they were visible at a height of 2,200, but not at a height of 6,500 feet The Rev H D James observed the transit at Chakrata, 7,300 feet above the sea An account of these observations of the transit of Venus were published in the "Proceedings of the Royal Society"[1]

Lieutenant Colonel J C Tennant had charge of two stations in India for the observation of the transit of Venus He himself, with Captains Campbell and Waterhouse, observed at Rurki, while Captain Strahan was sent to Lahore Colonel Tennant took charge of the new equatorial and of the time observations Captain Campbell observed with the new great theodolite, and Captain Waterhouse took above 100 photographs of the solar disc

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4th, 1870, Mr Broun s paper on the secular variation of the magnetic declination, as deduced from observations made at Trivandrum, 1853–70, is published In the "Philosophical Magazine" for July 1858 is Mr Broun's letter to Sir David Brewster on the results and views derived from his observations in Scotland and India. See also British Association Reports, ix, p 38, xv, p 22, xxiv, p 28, xxvii, p 30, xxix, p 20, 24, 27, 74, and "Proceedings of the Royal Society," xvi, p 59 See also a pamphlet printed at Edinburgh in 1877, "List, with some notices of the contents of scientific works and papers,' by J A Broun, F R S, &c &c They are 74 in number, chiefly on subjects connected with Mr Broun s magnetic and meteorological observations at Makerstoun and Trivandrum

[1] "Proceedings of the Royal Society," Nos 159 and 161, 1875

while the planet was on it, besides five showing the egress of the planet from the sun He was assisted by Serjeant Harrold, R E, who had charge of the photographic work during the Abyssinian Expedition During the transit Colonel Tennant observed the ingress, internal contact, and both contacts at egress, besides a large number of micrometer observations of the relative positions of Venus and the sun, and also of the diameter of the planet Captain Strahan observed the egress of the planet from the sun Colonel Tennant speaks strongly of the great service done by Colonel Strange's office in preparing the instruments, and against the proposal to abolish it

On the conclusion of the operations connected with the transit of Venus, Colonel Tennant[1] proposed that there should be a solar observatory at Simla, especially for observations with the spectroscope and by photography, and also for the observation of Jupiter's satellites This proposal was not sanctioned, but arrangements have been made for taking daily photographs of the sun's disc, during two years, by a trained observer under Colonel Walker's superintendence

The Madras Observatory is now the sole permanent point for astronomical work in India, and the only successor of the famous establishments founded by Jai Sing It has been presided over by a succession of six able and accomplished astronomers, it has produced results which entitle it to take rank with the observatories of Europe, and its present Director is engaged in the prosecution of labours which are of great importance to astronomical science

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[1] Colonel Tennant has received the appointment of Master of the Mint at Calcutta

# XIX

# PHYSICAL GEOGRAPHY OF INDIA

THE operations which have been enumerated in the previous sections are intended to furnish minute and exact information respecting the topography of every part of India, the heights, positions, and ramifications of its mountain masses, the courses of its rivers and streams, the nature of its coast line, the geological character and climate of its various regions, while a part of the object of an archæological survey is to investigate the physical changes that have taken place within historic times, by a comparison of the information supplied by ancient writers with the actual state of the country. Such is the material by the aid of which it is the task of the physical geographer to form a systematic view of the various regions, with reference both to the action of natural causes on their physical conditions, and to the changes produced by human means. It will be the object of the present section to supply information respecting the various attempts that have been made to utilize the material that has been collected, and to deduce generalizations from numerous classes of observations, as well as to point out where material is to be found for generalization, in regions or on subjects where nothing of the kind has hitherto been attempted. With this object some information will be given respecting the sources for the study of Indian comparative geography. The travellers who have explored portions of the Himalayan range will be enumerated, and an endeavour will be made to give an idea of the views some of them have enunciated respecting the physical structure of that great mountain mass. Some account will then be attempted to be given of the writers who have formed general views on the great river basins, and of those who have written on the physical geography of other parts of India. A sketch of the botanical geography, with an enumeration of the principal works on Indian botany, will then be given, and some information respecting the writers on the importance of forests and on forest conservancy will follow, with reference to the effect of human agency on physical geography. Finally there will be an allusion to the physical geography of the Indian seas, and to the value of maps showing the features which compose a physical and statistical atlas.

The various subjects which are treated of in this Memoir form one harmonious whole, each separate part of which fits into the others The archæological surveys are inseparably connected with comparative geography, while mastery of the latter study is essential for a due comprehension of the existing physical conditions of a country Hence the writings of Arrian and Ptolemy, of the Chinese pilgrims, and more especially of the Arab geographers, are most valuable to the student of Indian geography The work just completed by Professor Dowson ("The History of India as told by its own Historians Muhammadan Period') furnishes an invaluable mass of information respecting the early Arab geographers, consisting of notices of their lives and works, and extracts from their writings, with critical notes The authors treated of include the merchant Sulaiman, who flourished about A D 850, Ibn Khurdabda, Al Masudi, Al Istakhri, Ibn Haukal, Al Idrisi, and the compiler Al Kazwini, who wrote in A D 1263 Professor Dowson gives a geographical note in which he identifies many localities, at the end of his first volume, and in treating of later Muhammadan authors, in the subsequent volumes, he brings out much information which is valuable to the comparative geographer [1] No less important are such works as General Cunningham's "Ancient Geography of India," and others which discuss questions relating to the geography of places mentioned by Hwen Thsang and Fa Hian

The structure of the great Himalayan mass which bounds India to the north is the branch of the subject to which attention is naturally drawn in the first place, and it is that to which both travellers and systematic geographers have devoted the largest share of their labours

The reports of a long series of travellers necessarily preceded the first attempt at generalization Those who first penetrated into

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[1] See "The History of India as told by its own Historians The Muhammadan Period,' edited from the posthumous papers of the late Sir H M Elliot, K C B, by Professor John Dowson (8 vols Trubner Published between 1867 and 1877) The first volume contains the Arab geographers and the Sindi historians The second includes historians who treat of the inroads of Ghaznevides, Ghorians, and Slave Kings, down to A D 1260 It includes extracts from the *Tabakat i-Nasiri*, an important history, the whole of which is being translated by Major Raverty, with copious geographical and other notes The third volume brings the story down to Timur's invasion of India in A D 1398 The fourth volume embraces the period from Timur to Akbar The fifth and sixth treat of the Emperor Akbar, and the two last volumes of the later Mughal rulers It is hoped that arrangements will be made for the publication of two additional volumes treating of the Muhammadan dynasties of the Deccan, which will be specially interesting because they will include much that bears on the early connection of the English with India

the apparently inextricable labyrinth of snowy peaks, such as the Missionaries Antonio Andrada, Grueber and Dorville, Desideri and Freyre, and Horace della Penna,[1] were simply appalled at the horrid aspect of the mountains, and at the eternal winter The English officers who afterwards contemplated the mighty barrier from the plains became desirous of ascertaining the real height of the peaks and of exploring the hidden sources of the great rivers It was with these objects that Colonel Hodgson, Herbert, and Webb were ordered to survey the mountains between the Sutlej and the Kali, that Hardwicke penetrated to Srinagar, and that Baillie Fraser first crossed the range, on the southern slope of which the Jamna rises A few years later, Moorcroft and Trebeck explored the upper courses of the Indus and the Sutlej, and reached the Mansarowa lake, while Dr Gerard ascended the Spiti valley [2] Mr Bogle and Captain Turner were sent by Warren Hastings on embassies to the Lama of Tibet, and crossed the eastern Himalaya from Bhutan to the valley of the Sanpu ,[3] a feat which has only been achieved by one other modern European traveller,[4] though Dr Hooker penetrated some distance beyond the water parting Opportunities offered by embassies to Nepal enabled Kirkpatrick, Crawford, and Buchanan Hamilton to collect some information respecting the central portion of the great chain [5]

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1 See Introduction to Markham's "Mission of Bogle to Tibet," pp lvi to lx

2 Webb's Survey is in the *Asiatic Researches*, xi, p 447 See also a paper by Mr Colebrooke on the Sources of the Ganges —*Asiatic Researches*, xi, p 429 "Journal of a Tour through part of the Snowy Range of the Himalaya mountains," by James Baillie Fraser (London, 1820) "Travels in the Himalayan provinces," &c, by William Moorcroft and George Trebeck, in 1819–25 (2 vols, 1841) See also "R G S Journal," i, p 232 "Observations on the Spiti Valley," by Surgeon J G Gerard —*Asiatic Researches*, xviii, p 239 The original MS Journal of Herbert's Survey in 1818 is preserved in the Geographical Department of the India Office

3 "An account of an Embassy to the Court of the Teshu Lama in Tibet," by Captain Samuel Turner (London, 4to, 1800)

"Narratives of the Mission of George Bogle to Tibet, and of the Journey of Thomas Manning to Lhasa ,' edited with notes, an introduction, and lives of Mr Bogle and Mr Manning, by Clements R Markham, C B , F R S (Trubner, 1876 )

4 Mr Manning in 1811

5 "An account of the kingdom of Nepal, by Colonel Kirkpatrick, in 1793 (London, 1811), with a map by Colonel Gerard

"An Account of the kingdom of Nepal," by Francis Buchanan Hamilton, M D , 1802–3 (Edinburgh, 1819) At the end a table of the heights of 8 peaks, measured by Colonel Crawford is given The plants collected by Buchanan Hamilton were described by Don, in the "Prodromus Floræ Nepalensis"

Captain Herbert, whose writings deserve to be better known, was the first geographer who attempted to give a general view of the physical character of the Himalaya. Writing in 1818, his information was necessarily limited, but he had before him the results obtained by most of the travellers whose works I have enumerated, and he had some personal knowledge of the Western Himalaya from the Kali to the Sutlej. The physical features of Central Asia were unknown to him, and he laments the deep obscurity which then covered the geography of that interesting region. His conception of it was a vast central space from the circumference of which rivers flowed in all directions, and he perceived that a line connecting their sources must be of great elevation compared with other parts of Asia external to such a line. He knew also that this interior space was surrounded by mountains, and supposed it to be a very lofty plateau. But with part of the southern boundary, the stupendous mountains traversed by Webb, Turner, and himself, he was familiar. He was the first to point out that the line of water parting was by no means synonymous with that of greatest elevation. In exploring the Western Himalaya he could distinguish no continuous chain of elevations on a cursory glance. There seemed to be nothing to lend a clue to the development of the mountain masses, and there appeared an assemblage of elevated peaks confusedly heaped together. But he soon perceived that, by tracing the courses of the rivers and their tributary streams, a clue would be found to lead an observer out of this labyrinth. As regards the part of the Himalaya from the Sutlej to the Kali,[1] instead of a succession of parallel ranges rising one behind another in regular array, he made out a continuous chain forming an irregular curved line, with the Sutlej bounding it to the north, and bending round its convex side, while the sources of the Ganges rise within its concavity. He calls this the Indo Gangetic chain, and his description of it is precise and accurate. His next chain is that separating the sources of the Jamna and Ganges, which was crossed by Baillie Fraser. He adds, that the ramifications of ridges would almost bid defiance to any analysis, but for the assistance derived from observing the courses of the rivers. Herbert also observed that the ridge separating the Ganges and Indus basins was by no means the highest ground, and that the most elevated peaks were on a series of transverse ridges which

[1] A chief branch of the Gogra

ramify from the Indo-Gangetic chain, over which they tower several thousand feet He traced a connected line of peaks, not under 21,000 feet in height, and intersecting the watercourses, and both Webb and Herbert gave 27,000 feet as the height of Dhawala giri [1] In his valuable memoir, Herbert also speculates upon the relation between the height of the sources of rivers and the length of their courses, and gives a most interesting account of the Duns, the parallel chain of the Sawalakhs, the forest belt at their bases, and the Terai region beyond [2]

After the time when Herbert was engaged on his survey a number of able geographers and naturalists explored the Himalaya mountains Vigne [3] and Falconer penetrated into Balti and Ladak, Jacquemont [4] and Hugel [5] explored Kashmir, Cunningham [6] thoroughly examined the Ladak region, Dr Thomson [7] reached the summit of the Karakorum pass, Captain Gerard gave an account of Spiti and Kunawur,[8] and the Stracheys [9] surveyed Kumaun and Western Tibet The valley of Kathmandu had an able generalizer in Mr Hodgson,[10] who was for many years the British Envoy in Nepal, and in 1848 Dr Hooker [11] threw a flood of light on the geography of the Sikkim portion of the eastern chain

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[1] Actually 26,826 English feet

[2] "Report of the Mineralogical Survey of the Himalaya Mountains," by Captain J D Herbert, *J A S B*, xi, pt i, p x

[3] "Travels in Kashmir, Ladak," &c by G T Vigne (2 vols, 1835)

[4] "Voyage dans l Inde,' par Victor Jacquemont, 1828–32 (Paris, 1841)

[5] "Kaschmir und das Reich der Sick' Carl von Hugel (4 vols Vienna, 1840) Translated into English by Major Jervis (London, 1845) See also *R G S Journal*, vi, p 343

[6] "Ladak physical, statistical, and historical, by A Cunningham, Major, Bengal Engineers (1854)

[7] "Western Himalaya and Tibet, a narrative of a journey during the years 1847–48," by Thomas Thomson, M D (1852)

[8] "Account of Koonawur, in the Himalaya," by Captain A Gerard Edited by Lloyd (Map 8vo 1841)

[9] "On the physical geography of the provinces of Kumaon and Gurhwal in the Himalaya mountains, and of the adjoining parts of Tibet,' by R Strachey, Esq, of the Bengal Engineers —*R G S Journal*, xxi, p 57

"Physical Geography of Western Tibet, by Captain H Strachey of the Bengal Army —*R G S Journal*, xxiii, p 2 Published separately in 1854, and his "Journey to Lake Mansarowar' Published at Calcutta 8vo 1848

[10] "On the physical geography of the Himalaya," by B H Hodgson, Esq —*J A S B*, xviii, pt 2, p 761

[11] "Himalayan Journal,' by J D Hooker (2 vols 8vo 1854)

"Notes, chiefly botanical, made during an excursion from Darjiling to Tonglo —*J A S B*, xviii pt 1, p 49

Dr Forbes Royle discusses Himalayan geography in his great work illustrating the botany of the mountains [1]

Cunningham, in his work on Ladak, gives a general view of the physical features of the Western Himalaya Their most striking characteristic is the parallelism of the mountain ridges, which stretch through the country from S E to N W, their general direction determining the course of the rivers, and the valleys lying along the head waters of the Indus, Sutlej, and Chenab He divides the mountain region into six distinct ranges [2]—

1 The Karakorum range, from the sources of the Gilgit and Yasan, to that of the Shayok

2 The Kailas or Gangri range, traversing Western Tibet, along the right bank of the Indus from its source to its junction with the Shayok, and onwards to the junction of the Hunza and Nagar

3 The Trans Himalayan range branches off from Gangri to the south of Garo, and extends to Zanskar in an unbroken line Here the river rushes dark and turbulent through a vast chasm which human foot has never trod Thence the range continues to the Dras, where it is cut through by a narrow gorge called the wolf's leap, and thence to the great southern bend of the Indus, at the junction of the Gilgit

4 The Great Himalaya, which is the natural boundary between India and Tibet, is a mighty chain 650 miles long, pierced in three places by the Sutlej, its affluent the Para, and the Indus

5 The Mid-Himalaya, or Pir Panjal, consists of four distinct masses, the Bisakar, Lahul, Pir Panjal, and Swat

6 The Outer Himalaya This classification only applies to the portion of the system from the bend of the Bias to the Indus

Henry Strachey, in his general sketch of Western Himalayan geography, adopts the native Tibetan nomenclature He considers the general plan of the mountain system to be a series of parallel ranges running in an oblique line to the general extension of the whole, the great peaks being on terminal butt ends of the primary ranges The chief watersheds are often found to follow the lowest of the ridges, and the channels of drainage to cross the highest, deep fissures intersecting the mountains, often directly traverse to

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[1] "Illustrations of the botany and other branches of the natural history of the Himalayan mountains, by J Forbes Royle (London, 1839 2 vols 4to)

[2] Csoma de Koros says, that from the first range on the Indian side to the plains of Tartary the Tibetans count six chains of mountains —*J A S B*, i, p 121

the main lines of elevation No traveller, except the Pundit sent by Major Montgomerie in 1866, has ever visited any part of the great transverse watershed separating the Indus and Sutlej from the Sanpu, though the western shores of Lake Mansarowar were reached by Moorcroft and Hearsey in 1812, and by the Stracheys in 1846 and 1848 Henry Strachey describes the alluvial beds in the Himalaya, and the wonderful gorge where the Sutlej flows over bare rocks with walls of alluvium on either side upwards of a mile high Richard Strachey gives a very clear and interesting description of the Sawalakhs, rising abruptly from the plains along the whole southern edge of the Himalaya, with a steep outward face, and a gentle declivity sloping inwards, and forming the Dúns or shallow valleys, by meeting the foot of the next range of mountains He also explains the nature of the country at the base of the Sawalakhs, the waterless belt covered with forest, and the line of swampy Terai beyond, where the drainage of the higher country breaks out in copious streams in the country east of the Ganges [1] The fact of this Terai region terminating at the Ganges is accounted for by the slope being less to the eastward of that river The limit of the snow line on the different ranges is discussed by Cunningham, Richard Strachey, and Captain Thomas Hutton [2]

Dr Thomson, who was the first traveller, after the Chinese pilgrim Fa Hian, to reach the summit of the Karakorum pass, has discussed the physical structure of the Western Himalaya with great ability He considers that the only feasible mode of division is afforded by the courses of the different rivers If these be taken as guides, the mountains will be found to resolve themselves into two great systems Dr Thomson gives Herbert the credit of having first pointed out the impropriety of regarding the mountains as a single chain parallel to the plains He proposes to call Herbert's Indo Gangetic the Cis Sutlej, and the chain commencing at Kailas the Trans Sutlej range These would be the Mid-Himalaya and Great Himalaya of Cunningham's system Dr Thomson also described the alluvial deposits in the Himalayas, and the shells that are found in them

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1 The Terai and Bhabur regions are also admirably described by Colonel W H Greathed, C B, in his paper, "On the practice and results of irrigation in Northern India," read at the Institution of Civil Engineers, No 1350, Jan 1873

2 "J A S B,' xviii, p 954 The latter found its height to be 18,660 feet

The generalizations of Cunningham, the Stracheys, and Thomson refer to the Western Himalaya, and are not intended to apply to the ranges eastward of the Nepal frontier. Mr Hodgson, during a long residence at Kathmandu as Resident, thought much over the configuration of the mountains towering above the valley to which his personal observation was confined. In his paper on the physical geography of the Himalaya[1] he describes the Nepal division of the system as consisting of three river basins, those of the Karnali, Gunduk, and Kosi, separated by peaked ridges, parallel to each other, and at right angles with the main chain.

Sikkim has been explored by Dr Hooker and Dr Campbell, and the former traveller examined two passes in Eastern Nepal. As a physical geographer, Dr Hooker, combining his own acute observation with an intimate knowledge of the results obtained by others, has furnished his view of the composition of the great mountain mass. A prodigious chain traverses Asia from east to west, and south of it flow the Indus and Brahmaputra, in different directions, rising nearly together. The chain between these rivers and the plains of India is the Himalaya, connected with the Kuen-lun in rear, at the sources of the two rivers. The axis of the main Himalayan chain lies far back, and nearer to the two great rivers than to the plains, while from the central axis successions of secondary ranges descend on either side. These secondary ranges vary in direction, some being almost perpendicular to the main range, and others forming a very acute angle with it. All ramify very much, giving off chains of a third order, which separate the tributaries of the great rivers. Dr Hooker thus considers the system as consisting of a main range, with numerous secondary chains branching

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[1] "J. A. S. B.," xvii., pt. ii., p. 761. Mr Hodgson's scattered papers on the topography, ethnography, philology, and above all on the zoology of Nepal are very numerous. Besides four books on the Buddhist religion, on the aborigines of India, and on Indian education, Mr Hodgson has contributed no less than 170 papers to various periodicals, chiefly the "Journal of the Asiatic Society of Bengal," the "Transactions and Journal of the Agri-Horticultural Society of India," the "Proceedings of the Zoological Society of London," and McClelland's "Journal of Natural History." In the examination of the anatomy of the birds and quadrupeds of Nepal, Mr Hodgson received much assistance from Dr Campbell, who also resided 8 years at Kathmandu, before he commenced his career of more active usefulness at Darjiling.

In 1874 Mr Trubner published a collection of Mr Hodgson's "Essays on the languages, literature, and religion of Nepal and Tibet, together with further papers on the geography, ethnology, and commerce of those countries." 2 parts, 8vo, pp. 145 and 123.

from it, but all connected with the central axis, and not forming distinct mountain ranges. Most of the loftiest peaks are on the secondary chains. He compares the Sikkim Himalaya to Norway. The narrow valleys of Sikkim are analogous to the Norwegian fiords, the lofty snowy peaks to the islands on the coast, the broad rearward axis is the same in both cases, and the Sanpu valley occupies the relative position of the Baltic. Dr Hooker points out that Herbert's proposition of the line of great peaks intersecting the river basins, and not forming the true axis, was the first enunciation of a very important fact in physical geography.

Humboldt made his Russian expedition in 1829, and published his "Fragmens Asiatique" in 1831,[1] while his "Asie Centrale" appeared in 1843,[2] some years before the above explorers had completed their labours. But in 1833 Klaproth had produced his map of Central Asia, based on a great mass of Chinese material, and on the work of missionaries employed by the Chinese Government,[3] and Humboldt also obtained much information from Stanislas Julien, and Carl Ritter. From these data Humboldt formed his theory of the mountain system of Central Asia, as consisting of four great chains, the Altai and Tianshan on the north, and the Kuenlun and Himalayas on the south, issuing from the central knot of Bolor or Pamir. But he furnishes little information respecting the Himalaya, and refers his readers to the collections made by Carl Ritter.[4]

The complete topographical survey of the Western Himalaya, conducted under the superintendence of Major Montgomerie, the detailed accounts of its glaciers by Major Godwin Austen, and the examination of the structure of its southern portion by Mr H. B. Medlicott, have rendered our knowledge of that section of the region both accurate and complete. But, to the eastward of the Nepalese

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1 "Fragmens de Geologie et de Climatologie Asiatique" (2 vols. 8vo, Paris, 1831.)

2 "Asie Centrale, Recherches sur les Chaines de Montagnes et la Climatologie comparée" (3 vols. 8vo, Paris, 1843.)

3 Klaproth. "Carte de l'Asie Centrale, dressee d'apres les cartes levees par ordre "de l'Empereur Khian loung par les Missionaires de Peking, et d'apres un grand "nombres de notions extraites et traduites de livres Chinois." (1833.) The Missionaries were Fathers Felix d'Arocha, Espinha, and Hallerstein, who appear to have observed the latitude of Khotan.

4 "Une immense masse de materiaux dus aux dominateurs actuels de l'Inde, comme "aux courageux efforts de Jaquemont et de Hugel, a ete reunie et discutee recemment "dans l'excellent ouvrage de M. Ritter."—*Asie Centrale*, ii, p. 439. He alludes, of course, to Ritter's "Die Erdkunde von Asien" (9 vols.), the Himalayan part of which was published previous to the explorations of Cunningham, Hooker, Thomson, and the Stracheys.

frontier, little has been done since the days of Hodgson, Campbell, and Hooker

A systematic attempt to give a general idea of the physical structure of the Himalayan region will be found in the sketch map and memoir prepared by Mr Trelawney Saunders, after a study of all the foregoing authorities [1]

The Himalayan region is included between the plains of India and the upper courses of the Sanpu, Sutlej, and Indus, and extends from the gorge of the Indus to the gorge of the Sanpu or Brahmaputra, a distance of 1,400 miles Its general structure, according to the view of Mr Saunders, is briefly as follows —The Himalaya culminates in two parallel ranges running through its entire length, and these he would call the Northern and Southern Himalaya respectively Nearly all the great snowy peaks to the eastward of the Sutlej, which have been fixed and measured by distant triangulation, are in the southern range, while the same part of the northern range has so far received scarcely any attention It is, however, the northern range which forms the water parting between the Ganges basin and the Sanpu A series of valleys separates the two ranges, and through them flow the upper courses of the Jhelum Chenab, Spiti, Baspa, Ganges, and numerous affluents of the Ganges and Brahmaputra, in the direction of the Himalayan axis, until they break through the southern range to join the main streams in the plains of India The Indus, Sutlej, and Sanpu form a continuous trough in the same axial direction, and divide the Himalaya from the Karakorum and Gang ri mountains The Karakorum divides the Indus from the basin of Lake Lob The Gang-ri divides the Indus, Sutlej, and Sanpu from the extremely elevated plateau of Tibet, which is drained by inland lakes The northern limit of this very high plateau is formed by the Kuenlun mountains, which descend to the comparatively low plain of Gobi The Gang-ri and Kuenlun meet the Karakorum mountains at the head of the Karakash valley The Karakorum unites with the Hindu-Kush, and Bolor or Pamir mountains, in the central knot of Tagh Dumbash or Pusht i Khar

The southern range of the Himalaya, regarded as the culmination of the slope rising from the Indian plains, is, from that point of view, naturally connected with the ranges which skirt the Punjab and Sind, and terminate in the sea at Cape Monze The connexion

[1] "A Sketch of the Mountains and River Basins of India, in two maps, with explana tory memoirs," by Trelawney Saunders, Geographical Department, India Office 1870

may be traced from Kashmir, through Khagan and Swat, to the outer skirts of Kafiristan, thence, crossing the Kabul river, this southern chain is continued by the Karkacha range to the Sufid Koh, and thus reaches the Sulaiman and Hala mountains The northern chain of the Himalaya descends to the Indus from the peak of Nanga Parbat, and is taken up on the right bank of the river by the range which forms the southern boundary of the Gilgit basin From thence, crossing Chitral, it reaches the Hindu Kush at the Nuksan Pass, makes the backbone of Badakshan, and is probably connected with the high mountains which separate the Oxus from the Zarafshan

The general character of the highlands beyond the eastern extremity of the Himalaya and Assam, towards China and Burmah, has also been defined by Mr Saunders, from a combination of the scraps of intelligence which contain our present knowledge of this remarkable part of the Indian frontier

Although the scale is very small, the map by Mr Saunders shows these features with much clearness and precision, and the position of each peak and spur of importance is accurately defined

Since 1870 new works of geographers and travellers have very materially increased our knowledge of the great Himalayan system The most important is Colonel Yule's edition of Marco Polo, the the first edition of which appeared in 1871, and the second in 1875 [1] The notes by Colonel Yule are indispensable to the student of the mediæval geography of central and eastern Asia, and form an inexhaustible mine of sound learning and research Colonel Yule also contributed to a new edition of Wood's "Journey to the source of the river Oxus" in 1872, an essay on the geography of the valley of the Oxus,[2] and in 1875 Sir Henry Rawlinson furnished a large contribution to our geographical knowledge of Central Asia in a series of papers published under the title of "England and Russia in the East"[3] Colonel MacGregor was actively engaged for several

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1 "The book of Ser Marco Polo the Venetian," newly translated and edited, with notes and other illustrations, by Colonel Henry Yule, C B Second edition revised (Murray, 1875) 2 vols, 8vo

2 "A journey to the source of the river Oxus," by Captain John Wood, Indian Navy New edition, edited by his son, with an essay on the geography of the valley of the Oxus by Colonel Henry Yule, C B, with maps (Murray, 1872)

3 "England and Russia in the East, a series of papers on the political and geographical condition of Central Asia," by Major General Sir Henry Rawlinson, K C B, F R S, with map (Murray, 1875)

years, with the assistance of other officers in the Quarter-Master General's Department, in preparing a gazetteer of Central Asia and the border countries of British India The volumes for Persia and Afghanistan were printed in 1871, and those on the North West Frontier of India, Baluchistan, and Kashmir have appeared in subsequent years [1] These gazetteers are compilations of the information contained in accessible published works and in official records There are full separate accounts of tribes, rivers, mountains, provinces, and towns, with authorities at the foot of each article An excellent account of Bannu was published, in 1876, by Mr Thorburn [2]

Among recent Himalayan travellers the work of Mr Shaw, and that of the officers attached to Sir Douglas Forsyth's mission to Yarkand and Kashgar are the most important Dr Henderson published an account of the mission of 1870 with descriptions of its botanical and zoological results,[3] while the more important geographical results of the mission of 1853 are recorded in a large volume containing contributions by the different officers attached to the mission,[4] in the valuable Reports of Captain Trotter,[5] and in a book on the Pamír table land by Colonel Gordon [6]

In 1871 Mr W T Blanford, of the Geological Survey, explored the upper valley of the Tista in the footsteps of Dr Hooker, and reached the Donkia pass,[7] and in 1874 Mr Edgar wrote a report on the Tibetan frontier of Sikkim [8] Another important book on

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[1] "Central Asia," Part I (North West Frontier of India) in 3 vols pp, 657, 618, by Lieut Colonel MacGregor (Calcutta 1873) Part II (Afghanistan), pp 869 Part III (Baluchistan), pp 560, by Colonel MacGregor (Calcutta, 1875) Part IV (Persia), pp 801, compiled for political and military reference by Lieut Col C M MacGregor, Assistant Quarter Master General (Calcutta, 1871) Part VII, Section I (Kashmir), pp 306, by Major Bates (Calcutta, 1873)

[2] "Bannu or our Afghan Frontier, by S S Thorburn, I C S' (Trubner, 1876), 8vo, pp 480 and map

[3] "Lahore to Yarkand,' by George Henderson, M D, F R S, with an account of he birds by Allan O Hume, C B (Lovell Reeve, 1872)

[4] "Report of a Mission to Yarkand in 1873, under command of Sir T D Forsyth, K C S I, C B, pp 873 Numerous photographs (Calcutta, 1875)

[5] "Report on Trans-Himalayan Explorations during 1873 to 1875," by Captain Henry Trotter (Calcutta, 1875)

[6] "The Roof of the World,' by Lieut Col T G Gordon, C S I, with 66 illustrations (Edinburgh, 1876)

[7] "J A S B,' x, pt ii, p 367

[8] "Report on a visit to Sikkim and the Tibetan frontier in 1873," by G J Ware Edgar, C S I (Calcutta, 1874)

the Himalayas, entitled the "Abode of Snow," was published by Mr Wilson in 1875,[1] and Mr Calvert's beautifully illustrated account of Kulu, is a further contribution to Himalayan literature [2] But the work which, through its exquisite illustrations and charming narrative, gives the best idea of the mighty mountain masses, is that entitled the "Indian Alps, and how we crossed them," by a lady pioneer, which was published in 1876 [3]

The discovery of the manuscript journals and correspondence of George Bogle, the envoy sent by Warren Hastings to Tibet in 1774, and of the journal of Thomas Manning, an adventurous traveller who reached Lhasa in 1811, led to their publication in 1876, with editorial notes and an introduction by the present writer The introduction contains a geographical sketch of the Himalayan system, in which it is described as being composed of three chains, the northern range or Nyenchhen tang la, the central range bounding the valleys of the Indus, Sutlej, and Sanpu on the south, and the southern range consisting of a line of stupendous peaks broken by the gorges of several rivers, yet forming a distinct and continuous chain of mountains [4] In January 1877 an article appeared in the "Calcutta Review," in which my description of the Himalayan system was attacked, the old exploded notion that the principal peaks were not on a continuous chain but were merely spurs was maintained, and the existence of the great southern chain of the Himalayas was denied In consequence of the appearance of this article I published a reply in the "Geographical Magazine," in an article entitled "the Himalayan System"[5] Mr Trelawney Saunders also published a further and more exhaustive reply to the "Calcutta Review" in a valuable article illustrated by maps, and also by a list of peaks, with their altitudes, taken from the manuscript records of the Great Trigonometrical Survey [6]

The latest, and not the least important discussion of the Himalayan system, is contained in the first volume of Baron Richthofen's great

1 "The Abode of Snow,' by Andrew Wilson (Blackwood, 1875)

2 "Vazeeri Rupi, the silver country of the Vazeers in Kulu, with numerous illustrations, by J Calvert, M I C E (Spon, 1873)

3 "The Indian Alps, and how we crossed them, by a lady pioneer" Illustrated by herself (Longman, 1876) 4to, pp 612, with coloured illustrations

4 See the introduction to the "Narrative of the Mission of George Bogle to Tibet, pp xxiii to xl

5 Number for May 1877, p 113

6 "Geographical Magazine" for July 1877, p 173

work on China, a third of which is taken up by the interesting introduction on Central Asian Geography[1]

There is still a great field for exploration in the Himalayan region The whole of the Nepal portion of the ranges for a distance of 500 miles, and the greater part of Bhutan, the valley of the Sanpu eastward of Lhasa, and the mountain region still further to the east, where the Irawadi, Salwin, Cambodia, and Yangtse rise, are entirely unknown

The rivers flowing from the Himalaya, and forming the two great systems of the Indus and Ganges, have been studied with minute attention Upon the water supply brought down by these streams from the Himalayan snows the very existence of millions of people inhabiting the plains of India depends The physical laws regulating the direction and volume of the rivers are of such practical importance that they have formed the subject of close investigation for many years, and this great section of Indian physical geography has thus been minutely and elaborately examined

The best general account of the Indus and its five tributaries, before they enter the plains, will be found in Cunningham's Ladak He traces them from their sources, and describes the peculiar knee-bends in each, at the points where, after flowing down the long lateral valleys in the Himalaya, they burst through the chain, and alter their courses to reach the plain He also gives an account of the tremendous cataclysms which periodically take place, especially in the valleys of the Indus and Sutlej These floods appear to be caused by the fall of huge masses of rock, or of parts of a glacier, which block up the rivers until at length the pent up waters burst forth with irresistible fury Dr Falconer considered the Indus cataclysm of July 1841 to be one of the most remarkable natural catastrophes hitherto recorded as having occurred on the continent of India[2] A great flood is also recorded of the Sutlej, which took place in 1819 The shoulder of a mountain gave way at Seoni, about 20 miles north west of Simla, where the river flows between precipitous cliffs The fallen mass choked the bed for a height of 400 feet, the river ceased to flow for 40 days, when it burst the obstruction, and rushed down in an irresistible wave a hundred feet high

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[1] "China" Ergebnisse eigener Reisen und darauf gegrundeter Studien, von Ferdinand Freherrn von Richthofen Erster Band (Berlin, 1877) 4to, pp 750, and 11 maps

[2] "J A S B," x, pt 2, p 615, and xviii, p 231, Vigne, ii, p 362

It is in tracing the alterations that have taken place in the courses of rivers, and in studying the physical causes which have given rise to these changes, that archæology has rendered most useful service to physical geography By a careful study of the historians of Alexander's campaign, of the Chinese pilgrims, and of the A'in-i Akberí, General Cunningham has collected most interesting evidence respecting the former history of the Punjab rivers and of the Lower Indus The Punjab rivers have frequently shifted their channels Thus, in the time of Akbar, the Chenab and Indus united at Uch, now the junction takes place 60 miles lower down, at Mithankot Multan was once on two islands in the Ravi, it is now 30 miles from that river The confluence of the Bias with the Sutlej only dates from about 1790, and the old bed is now part of a complicated network of dry channels [1] A very complete knowledge of the present aspect of the Punjab and its rivers may be obtained from a study of the reports of irrigation officers [2]

The course of the Indus from Mithankot to the sea has been the subject of equally close study with reference to the improvement of irrigation in Sind At the time of Alexander's invasion, and down to the visit of the Chinese pilgrim, Hwen Thsang, the Indus flowed to the eastward of its present course, down the bed now known as the Eastern Narra But it is believed by many geographers that a gradual westing of all rivers flowing north and south is the natural result of the earth's revolution from west to east, which gives their waters a permanent bias towards their western banks [3] At last the Indus turned the northern end of the Aloi range, and cut a passage for itself through the gap in the limestone rocks between Rori and Bakhar, in about 680 A D Sind is described by Sir William Baker and Colonel Fife as an alluvial plain, almost every portion of which has, at some time or other, been swept by the Indus or its branches The land is always highest at the river banks The silt with which the waters are charged is deposited during the season of overflow most abundantly near the edge of the stream, thus forming a natural glacis, the crest of which is on

[1] General Cunningham's "Ancient Geography of India"

[2] "Selections from the Records of the Government of India"—*Punjab Reports*, 1849–56

"Agricultural resources of the Punjab," by Lieut R Baird Smith (1849)

Memorandum on the Bari Doab Canal, by Colonel Crofton April 3rd, 1868

Colonel Napier's Report on the inundation canals Sept 11th, 1852

"On the rivers of the Punjab," by W Purdon, C E 1860

[3] This fact, in physical geography, was first enunciated by the Russian naturalist, K E von Baer

the river bank, while the slope falls away gradually towards the boundary of the valley A continuance of this process raises the level of the river bed until, during some extraordinary flood, at intervals of many centuries, it bursts its embankment, and takes to one of the lower tracts Thus the bed and banks are continually rising [1]

The changes in the valley of the Indus have also been effected, to a great extent, by earthquakes, which entirely destroyed the great city of Brahminabad some centuries ago,[2] and threw up the Allahbund in more recent times [3] But a discussion of Indian earth quakes, as a branch of physical geography would, of itself, occupy a volume

The physical features of the Thurr, or desert, to the eastward of the Indus valley, of the Rann of Kach, of the valley of the Loni, and of the Aravalli hills, protecting the Ganges basin from the encroach ments of the sand-drifts, were first fully described by Colonel Todd,[4] who was followed by Alexander Burnes,[5] and a most interesting paper on the Rann of Kách and neighbouring region by Sir Bartle Frere appeared in the "Journal of the Royal Geographical Society

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[1] Lieut Postans —*J A S B* (1838), p 103

An excellent account of the geography of the Indus within the province of Sind will be found in the "Gazetteer of Sind,' by Mr A W Hughes, which was published in 1874 The introduction contains a comprehensive account of its physical geography, soil, irrigation canals, and climate A good general index adds to the completeness of this ably compiled and very useful work See also papers by Capt McMurdo —*J A S B*, i, p 33

Capt McMurdo —*Journ R A S*, i, p 223

Capt Del Hoste —*J A S B* (1840), p 913

"On the canals and forests in Scinde' Report by Colonel Walter Scott

Baker's Report on the Eastern Narra Oct 14th, 1844

Merewether on the Bigari Canal Oct 1856

Colonel Fife on irrigation in Scinde Oct 1855

[2] Bellasis on the ruins of Brahminabad —*Journal of the Bombay Branch of the Asiatic Society*

[3] "Remarks on the Alla Bund and drainage of the eastern part of the Scinde basin," by Captain W E Baker —*Bombay G S Journal*, vii, p 186

See also Lyell s Principles of Geology

"Memoir on the eastern branch of the Indus, giving an account of the alterations caused by the earthquake ' also, "A theory of the formation of the Runn, 1827–28," by A Burnes —*Trans R A S*, iii p 550

[4] "Annals and antiquities of Rajasthan,' by Lieut Colonel James Tod (2 vols London, 1829)

[5] 'Countries on the N W frontier of India,' by Alexander Burnes —*R G S Journ*, iv, p 88

"Description of the saltworks at Panchpadder, in Marwar," by Alexander Burnes —*J A S B* ii, p 365 for 1870"[1] In 1876 Mr W T Blanford explored the great Indian desert, and wrote a memoir on its physical geography with especial reference to the former existence of the sea in the Indus valley, and to the origin and mode of formation of the sand hills He describes very fully the physical character of the desert, with its botany and zoology, the distribution of its sand hills, and the evidence of recent marine action He then discusses the former existence of an inland sea covering the Rann of Kách and eastern Sind, and also extending up the Loni basin, but notices the want of evidence of marine denudation elsewhere in the desert His conclusions are that within very recent geological times, the sea covered the Rann of Kách, and the area now occupied by the Indus and Loni basins, but that the central part of the desert was not covered by the sea The sand is mainly derived from the old sea coast, and its transport into the interior is due to the south west wind[2]

The vast plain of India, including the lower parts of the basins of the Indus and Ganges, extends uninterruptedly along the base of the Himalaya, and nowhere attains a greater height than 900 feet, from the Arabian Sea to the Bay of Bengal But, at its highest point, where the water parting separates the Jumna from the Sutlej, there is an interval where the floods of the classic Saraswati once watered the land of Kuru, on their way to the Indus, but where now the streams have ceased to be perennial, while the desert fast encroaches on the once rich kingdom of Sthaneswara The causes of the physical changes in this interesting tract of country have been discussed by several able writers[3] In 1840 Sir William Baker ran a line of levels across it from Karnul to Ludiana, finding the greatest elevation above the Jumna and Sutlej to be 68 feet, and he afterwards carefully surveyed the courses of its river beds Captain Brown, of the Revenue Survey, also examined and described the water-parting region between the basins of the Indus and Ganges[4]

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1 "Notes on the Rann of Kách and neighbouring region, by Sir H Bartle Frere —*R G S Journ*, xl, p 181

2 "J A S B," xlv, pt ii 1876

3 Colvin, Fergusson, Baker, Cunningham

4 "General Cunningham's Ancient Geography of India

Captain W Brown (Revenue Surveyor) on the Bhatiana States

Report on the Cuggur and Soorsooty, by Captain W Brown

Baker's Report on the Cuggur, Sept 17th, 1841

"Report on a line of levels between the Jumna and Sutlej rivers,' by Lieut W E Baker —*J A S B*, ix, p 688

Report on the Bangur lands of Bhawulpur, by Mr Barns 1870

An old channel, being the dry bed of a large river, can still be traced from near the Himalaya, through Bhatiana, Bikanir, and Bháwalpur, into Sind, and is 600 miles in length In different parts of its course it is known as the Naiwal, Sotra, Hakra, Wahind, Dahan Scattered mounds mark the sites of cities and towns along the course of this lost river The Saraswati lost itself in the sands in the time of Menu But the Hakra, lower down, to which the Saraswati was a tributary, was flowing as late as the 13th century Dr Oldham, in some most interesting notes on the lost river of the Indian desert, has conclusively shown that the Hakra or Sotra is the ancient bed of the Sutlej, while the Bias flowed in an independent course to the Indus He also holds that the Sutlej had an independent course clear of the Indus, by the channel now known as the Eastern Narra, to the sea The researches connected with the courses of these rivers show the intimate connexion between the studies of the historian and archæologist, and those of the geographer [1]

The basin of the Ganges, with its tributary rivers and their peculiarities, has been minutely examined and described by the officers who have constructed those irrigation works which will be the proudest and most enduring monuments of British rule in India, and the lower part of the valley of the Brahmaputra has been almost as fully treated of in the published reports of officers on Assam and the north eastern frontier, from the time of Bedford and Wilcox But the physical laws which regulate the great Indian river systems have been most ably discussed by Mr Fergusson in his paper on recent changes in the delta of the Ganges [2] He points out the law by which all rivers oscillate in curves, the tendency of rivers in alluvial soils to raise their banks, and so confine themselves in their beds, and the mode in which deltas are gradually raised On the first point Mr Fergusson shows that all rivers oscillate in curves whose extent is directly proportionate to the quantity of water flowing through them, any obstruction or inequality causing oscillation, which goes on increasing until it reaches the mean between the force of gravity tending to draw it in a straight line and the force due to the obstruction tending to give it a direction at right angles with the former, the extent of the curves being

[1] "Notes on the lost river of the Indian desert," by Surgeon Major C F Oldham An article in the "Calcutta Review" for July 1874

[2] "Quarterly Geological Journal," xix, p 321

proportioned to the slope of the bed. With reference to the tendency of rivers in alluvial soils to raise their banks, he calls attention to the important fact that water resists water far better than earth does. A river can attack its banks in detail, and carry the bits away, but still water, by producing a state of rest, forces a river to deposit its silt exactly where it is most useful in forming a barrier against further incursions, and so finally repels its advance. In India these expanses of still water, called jhils, are at about the same level as the river. In the rains they rise with it, so that, when it overtops its banks, it meets this body of still water, and deposits its silt along the limits between the moving and the stationary mass. The mode by which it now appears that deltas are raised is by a river flowing through some low part of the country, gradually embanking itself, then raising its bed until the body of its water is higher than the country round. Into this it eventually falls, and commences a similar process of embanking itself, till, in the course of time, it is forced to seek a lower bed. Thus the whole delta is gradually raised by continual shifting of the plains of the rivers. Mr. Fergusson forms the conclusion, from a long and careful study of these Gangetic phenomena, that from 4,000 to 5,000 years ago, the sea, or at least the tide, extended as far as Rajmahal, and that Bengal proper was a vast bay or lagoon. The gradual raising of the delta, which caused the lower part of the Ganges basin to become inhabitable, is indicated by the positions of the capital cities, which were first on the water parting between the Ganges and Indus basins, and were established lower down the Ganges valley by successive dynasties as the progress of the physical changes rendered the former lagoons and swamps fit places for the abodes of men. The first cities really in the plains were Hastanapura on the Ganges and Ayodya on the Gogra, which flourished from 2,000 to 1,000 B.C. Then Canouj was built; at a later date Palibothra or Patna; the early Muhammadans made Gour, opposite Rajmahal, their capital; and finally Dacca was built in 1604 near the mouth of the river. Thus, in 3,000 B.C. the only practically habitable part of the alluvial plain of India was the water-parting between the Sutlej and Jumna. The rest has only become fit for man's occupation within the historical period, and hundreds of square miles of the delta have become habitable since the days of Clive. Great changes have taken place since Rennell's survey. In 1785 that great geographer found the Brahmaputra flowing through Silhet with a width of a mile and a half in the dry season Now the same bed is a mere creek, or rather chain of ponds, while the volume of water has passed into the Jennai (then an insignificant stream), some 70 miles further westward than the bed it occupied in the beginning of the century Then the Tísta joined the Ganges at Jaffierganj, now it flows into the Brahmaputra Earthquakes have aided the more gradual action of water in effecting changes in the delta In 1762, in the great earthquake at Chittagong, a large tract was submerged, and now forms the Silhet jhils, through which Dr Hooker sailed, while other parts were elevated[1] Mr Fergusson points out another important hydrographic law, namely, that the mouths of tributaries shift upwards along the main stream in consequence of the decrease of slope caused by the rise of the delta, which obliges the tributaries to increase the angle at which they fall into the Ganges Careful observation of the rate at which this takes place would show the progress of the rise in the delta "Hitherto," says Mr Fergusson, "dipping tumblers from the sides of budgerows" (to ascertain the quantity of silt in suspension) "has been supposed to be sufficient "to gauge the growth of continents, but the safest test of the "elevation of the delta is the progress of the retrocession of the "tributaries"

Several special memoirs on districts within the Gangetic basin have lately appeared in anticipation of Dr Hunter's final Gazetteer Among these are Mr Westland's Report on Jessor containing an interesting description of the river system and its changes during the last century, and of the progress of the formation of the delta[2] Dr Oldham's first part of a Memoir on Ghazipur contains notes on the changes in the course of the part of the Ganges which flows through that district[3] In 1876 Mr Beveridge published a history of the district of Bakarganj, the geographical portion of which contains an excellent account of the rivers, lakes, and swamps in that deltaic region[4]

It has been seen that both in the Indus and Ganges basins

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[1] 'Phil Trans,' lviii, p 251, "Hooker's Journal," ii, p 256

[2] "A report on the district of Jessore, its antiquities, its history, and its commerce," by James Westland (Calcutta, 1871)

[3] "An historical and statistical memoir of the Ghazeepoor district," by W Oldham, B C S, I L D (Allahabad, 1870)

[4] "The district of Bákarganj, its history and statistics," by H Beveridge, C B (Trubner, 1876), 8vo, pp 459 and map

earthquakes have formed an important element in the changes that have taken place This branch of the subject has received much attention, and descriptive lists of earthquakes in India have been drawn up by Colonel Baird Smith, and more recently by Dr Oldham [1]

South of the Ganges valley, long, flat-topped spurs descend towards the Jumna, and almost reach the river to the eastward of Gwalior But further east they recede, and form an amphitheatre of precipices, shaping the plain of Bandalkhand into a bay surrounded by sandstone cliffs, which again advance to the Jumna near Mirzapur This is the northern face of the plateau of Malwa, and highland of Bandalkhand and Rewah, which is bounded to the south by the valleys of the Narbada and Son These two valleys form a continuous and almost straight line of depression across India, from the gulf of Cambay to Patna on the Ganges Thus the plateaux of Malwa and Bandalkhand, or as it may more properly be called with reference to physical geography, the Vindhyan table land, forms a great triangle, with the line of the Narbada and Son as one side, the Ganges valley as another, and the Aravalli mountains separating it from the Luni basin and the desert, as a third To the south the great rock escarpment of the Vindhyan hills terminates the table land, and overhangs the valley of the Narbada, presenting the appearance of a weather beaten coast line From its summit there is no abrupt descent to the north, corresponding to their southern declivity, yet the northern slope, though slight, commences at the very edge of the escarpment above the Narbada, where the Betwa, Dessan, and Sonar rivers rise, and flow northwards to the Ganges The escarpment of Vindhyan rocks, here called the Kymor hills, continues along the north flank of the Son valley It is said that on the remarkable hill of Amarkuntak, the three rivers Son, Narbada, and Mahanadi rise from one tank This is not true, but their sources are really only a few miles from each other This region has been best described by Dangerfield,[2] Franklin,[3] Jacquemont,[4] Oldham,[5] and Medlicott,[6] while Dr Hooker crossed and described the Kymor hills

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[1] See also the paper on earthquakes, and especially on that in the N W part of the Bombay Presidency, on April 29th, 1864, by D J Kennelly, Esq —*Bombay G S J*, xviii, p 288

[2] Malcolm's "Central India"

[3] "Geological Society, Trans," III 2*d* S

[4] "Voyage dans l'Inde"

[5] "J A S B," xxv, p 249

[6] 'Geological Memoirs

The Narbada itself forms one of the most important and interesting features of the physical geography of Western India To the north of its valley are the flat-topped cliffs of the Vindhyan hills, from 300 to 800 feet high, and to the south is the Mahadeo or Satpura range, sloping gently towards the Narbada, and with its abrupt face to the southward, forming the northern boundary of the Tapti valley The Satpura hills have been described by Rigby,[1] and the Tapti valley by Edwards [2] Both the Vindhya and Satpura ranges are abrupt and scarped to the south, and slope off gently on their northern sides Dr Impey wrote a full description of the physical character of the Narbada valley in 1855, [3] it was reported upon by Evans, Keatinge, and Del Hoste,[4] and has since been carefully examined by the Geological Surveyors

The extensive region bounded by the Ganges, the Son, the Mahanadi, and the Bay of Bengal, and drained by the Damudar and other streams, has received very close investigation on its northern side, where the mineral treasures of the Rajmahal hills have long attracted attention, [5] but the southern and western parts of the tract are less known A party of the Topographical Survey has been engaged for some years in the exploration and mapping of part of this region

The plateau of the Deccan has been best described by Colonel Sykes, and no account of Mysor has yet appeared entirely to supersede the admirable work of Dr Buchanan This officer (who afterwards took the name of Hamilton) was deputed to report upon the dominions of the Rajah of Mysor in the year 1800, and he completed his tour in 1801 His work was published in 1807,[6] and every page teems with valuable information, but it is written in the form of a journal, and this makes it difficult to consult Dr Buchanan's work on Mysor was reprinted at Madras in 1870 [7] The new "Gazetteer of Mysor," by Mr Lewis Rice, the Director of Public

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1 "Journ Bombay G S," xi, p 69

2 " " G S, xi, p 16

3 "Bombay Selections ' No xiv N S

4 "Journal, Bombay G S" viii, 119 and 174, and i 174

5 See "Notes upon a tour through the Rajmahal hills,' by Capt Sherwill, R E J A S B xx, p 544 the 'Geological Memoirs," and Dr Hooker s Journal, and his paper in the 'J A S B," xvii, pt 11, p 355

6 "A Journey from Madras through the countries of Mysore, Canara, and Malabar," by Francis Buchanan, M D (London, 1807) 4to, 3 vols

7 Second edition, with a memoir of the author, 8vo, 2 vols (Higginbotham, Madras, 1870)

Instruction, was published at Bangalor in 1877 [1] The schemes for navigation and irrigation, and the works already executed, have led, more recently, to frequent and minutely detailed examinations of the basins through which flow the rivers which traverse the penin sula, and fall into the Bay of Bengal

The Mahanadi, rising in the mountainous region which bounds the Chatisgarh plateau, has a comparatively short course, and numerous tributaries converging from a limited circumference to a common centre Thus a single storm will often affect the whole area of the basin This peculiarity has caused those destructive floods in Cattack which necessitate a system of carefully constructed embankments Captain Harris, from his position in charge of these works, has studied the meteorological phenomena of the Mahanadi basin with close attention, but the best general description of the region is by Sir Richard Temple [2]

The basin of the Godavari is very fully described in the reports of Colonel Haig, the Krishna and Kaveri, with the smaller streams along the coast, have also been minutely described in numerous irrigation reports, [3] and the eastern hills of the peninsula have been for several years the scene of the labours of Mr King and his col leagues of the Geological Survey

The Western Ghâts, extending from the Tapti to Cape Comorin, with one remarkable gap at Palghat, and the peculiarities of their western drainage system, would require a large volume for their satisfactory description

No general work of the kind exists, and the different portions or districts can only be studied in detail

The northern portion is included in various accounts of the Deccan, but I know of no detailed geographical description of Nagar and Munjerabad, nor of Coorg and Wynaad, apart from the manuscript memoirs of the old surveys The best general account

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1 "Mysore and Coorg A gazetteer compiled for the Government of India," by Lewis Rice, Director of Public Instruction, Mysore and Coorg Vol I, Mysore in General, pp 658 Vol II, Mysore by districts, pp 504 and maps Vol III, Coorg

2 "Selections" (India P W D), No xliii, "Journal, R G S,' xxxv, p 70, (1865)

3 See, on these subjects, Major Orr s Report on the Works of the Madras Irriga tion Company at Karnúl, dated January 8th, 1861, Sir William Denison s Minute of March 2nd, 1861, and Colonel Ludlow s Report of October 1862 For an excellent general account of the works on the deltas of the Godavari, Krishna, and Káveri, see Colonel Baird Smith s Report (London, 1856) For the Krishna, see also Major Ander son's Report of January 6th, 1863

of Coorg is given in Colonel Sankey's interesting report on the roads, and I have myself reported upon the Wynaad district [1] Ouchterlony's report gives details of the geographical features of the Nilgiri and Kundah hills,[2] and the first account of the Anaimalais appeared in Dr Cleghorn's "Forests and Gardens of Southern India" The Palnais have been described by Captain Ward, Captain Beddome, Dr Wight and by myself, and I have also reported upon the mountainous region between Travancor and Madura [3] Yet wide tracts of the Western Ghâts are undescribed, and others are still unexplored Malabar was explored, early in this century, by Dr Buchanan, and his is still the standard work on the subject, but the system of back waters along the coast, and all the phenomena connected with the western drainage of the ghats, is a branch of physical geography which would still repay careful study [4]

The distribution of plants, and their influence upon the climate, and through the climate upon the physical character of a region, is one of the most important branches of geographical science, and it is one which, in India, has been studied from a very early period The first Indian herbalists, however, collected and examined plants without reference to any such general views It was to learn their healing virtues that the holy sage Agastia explored the wonders of the vegetable kingdom,[5] that Ibn ul Bakhtar came all the way from distant Spain to collect the plants of India,[6] and even that the Portuguese physician Cristobal da Costa made his botanical observations [7] The first great Indian work on plants was the "Hortus Malabaricus," undertaken under the auspices of Henry van Rheede, the Dutch Governor of Malabar The specimens were collected by Brahmans between 1674 and 1676, and sent to Cochin, where drawings were made by the missionary Mathœus, and descriptions in

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[1] "Chinchona Blue Book, (1870) pp 61–93, "Travels in Peru and India, p 402 "Madras Journal,' vi, p 280, v, p 280, and 1857, "Forests and Gardens of South India, p 289–302

[2] See also the earlier report on the Neilgherries by Messrs Keys and Turnbull—*Bombay G S J*, iv, p 9

[3] "Chinchona Blue Book,' (June 1866), p 283

[4] "On the inland navigation of Travancore'—*R G S Journ*, xxxvi, p 195 (1866) See also Mr Kennedy's interesting report to the Madras Government on the back water navigation, and the works required at Cochin, dated Oct 9th, 1862

[5] "Aghastier Vytia Anyouroo" A medical Sastrum frequently quoted in Ainslie's "Materia Medica"

[6] Escurial, MSS Casiri

[7] His observations form the basis of "Clusius Exoticorum libri decem' (Antwerp, 1563)

Malayalim were translated into Latin by Hermann van Doulp, the secretary to Government at Cochin. The work was published at Amsterdam in 12 folio volumes, with 794 plates, between 1686 and 1703, and a commentary on it, by Dr. Buchanan Hamilton, has since been printed in the "Transactions of the Linnæan Society."[1]

William Roxburgh was born at Underwood, in Scotland, on June 29th, 1759. He entered the Madras medical service in 1786, and John Kœnig[2] of Courland came out to India in the service of the Danish Government in 1768. These two eminent men, with Sir William Jones, Buchanan Hamilton, Hunter, Carey, and Rottler, formed themselves into a society for the promotion of botany, and Roxburgh was the first to reduce the plants of the east to the form of a flora. In the early part of his career he resided at Samulcottah in the Northern Circars, and wrote some valuable papers for Dalrymple's "Oriental Repository," on the cultivation of rice, sugar, and pepper. In 1793 Roxburgh became the first Superintendent of the botanical gardens at Calcutta,[3] where he remained until 1814, when he went home, and died at Edinburgh in April 1815. Roxburgh caused 2,000 coloured drawings of plants to be made, 300 of which were published by the East India Company in three large volumes entitled "The Plants of Coromandel," between 1795 and 1816. The published plants were selected chiefly for their useful qualities, and included the sandal wood tree, catamaran, nux vomica, teak, areca catechu, mimosa arabica, and terminalia chebula. Roxburgh's "Flora Indica" (3 vols. 8vo.) was published between 1820 and 1832.[4]

Wallich received Dr. Roxburgh's mantle, and succeeded him as the leading Indian botanist. Nathaniel Wallich was a Dane born

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[1] Vols. xiii., xiv., xv.

[2] Kœnig's herbarium and MSS. are in the British Museum.

[3] The gardens were commenced by Captain Kyd in March 1786.

[4] The first and second volumes of Roxburgh's "Flora Indica" were edited by Drs. Carey and Wallich, and published in 1820 and 1824 respectively. Dr. Roxburgh's sons republished both these without Wallich's additions, together with the third, completing the work in 1832. These three volumes have been textually reprinted in Calcutta in one large 8vo. volume, under the care of C. B. Clarke, with a preface, together with a reprint of Roxburgh's India Ferns from a number of the Asiatic Society's Journal, and an index to the Latin, English, and various native names. Copies of all Dr. Roxburgh's unpublished drawings were made by the late Sir William Hooker, on a reduced scale.

In the "Hortus Bengalensis" a list of all the plants described in Roxburgh's Flora is arranged according to the Linnæan system, with native names, habit, time of flowering, and references to the plates in Van Rheede's "Hortus Malabaricus."

There is an obituary notice of Dr. Roxburgh, with a portrait, in the 38th volume of the "Transactions of the Society of Arts."

at Copenhagen on the 28th of January 1786 He went out to India as surgeon of the Danish settlement of Serampur, and was taken prisoner when that place was captured by the English His great attainments as a botanist soon secured for him the transfer from a prison to the charge of the Government gardens at Calcutta, as Dr Buchanan Hamilton's successor, in 1815 Dr Buchanan Hamilton had taken Dr Roxburgh's place for a year During the next thirteen years Wallich added enormously to the extent of the collections In 1820 he made a botanical excursion to Nepal, and in 1824 he commenced the publication of his "Tentamen Floræ Nepalensis" In 1825 he was sent to inspect the timber forests of Oudh and Rohilkhand, and made large collections of plants, and in 1826 he enjoyed further opportunities as a member of the mission to Ava He also employed many collectors in various parts of India In 1828 Mr Wallich came to England with an enormous collection of plants, which he distributed among the principal botanists of the day He lithographed with his own hand a catalogue, consisting of 253 folio pages, of the specimens retained at the India House (7683), together with their localities and collectors' names In 1832 Wallich's original herbarium was presented to the Linnæan Society by the East India Company It consists of about 7,000 species, and has become a standard work of reference [1] While he was in England Dr Wallich also completed his "Plantæ Asiaticæ Rariores," a magnificent work in 3 folio volumes, containing 300 coloured plates, which was published by the East India Company in 1832 In 1833 Dr Wallich returned to India, and resumed his labours at the gardens with unremitting zeal From 1836 to 1840 he distributed no less than 189,932 living plants to 2,000 different gardens In 1841, ill health, the result of his extraordinary labour, compelled him to visit the Cape of Good Hope, where he made extensive collections, returning to the Calcutta gardens in 1844 He was engaged in examining the capabilities of Assam for tea cultivation in 1845, but in 1847 was obliged to go home from ill health, and this most zealous and able public servant died in London on the 28th of April 1854, aged 69 His successors at the Calcutta gardens have been Drs Falconer, Thomson, Anderson, and King

William Griffith must be mentioned as one of the leading Bengal

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[1] There is also a set of the Wallichian Herbarium at Kew Dr Hooker, in 1858, rescued 12 or 14 waggon loads of chests of dried plants from the cellars of the India House, consisting chiefly of Griffiths, Helfer's, and Falconer s collections, and arranged and distributed them to the principal museums in Europe and America

botanists, and was a pupil of Dr Lindley He was born in 1810 He arrived at Calcutta as assistant surgeon in 1835, was appointed to accompany Dr Wallich to Assam, and for a short time assisted in the distribution of the gigantic herbarium mentioned above He traversed the unexplored tracts near the Mishmi mountains, between Sudiya and Ava, collecting fishes, insects, and plants, and in February 1836 he made a journey from Assam to Ava, and down the Irawadi to Rangoon Next, as surgeon to Pemberton's embassy, he traversed 400 miles of the Bhutan country, returning to Calcutta in June 1839 In November of the same year he joined the army of the Indus in a scientific capacity, and went from Kabul to Khurasan, making large collections of plants In 1841 he was appointed on medical service to Malacca, from which he was recalled in 1842 to take the charge of the Calcutta Botanic Garden during Dr Wallich's absence at the Cape At the end of 1844, after Wallich's return, he went again to Malacca, where he died in February 1845, worn out by fatigues and sicknesses due to exposure during his remarkable and protracted journeys

Dr Griffith was unquestionably the most learned botanist and acute investigator of the many that British India can boast His various papers communicated to the Linnæan Society of London, and other publications, are models of scientific research, and his drawings, microscopic analyses and descriptions of plants and their organs, made chiefly during his travels, always in hot and often in malarious regions, and preserved at the Royal Gardens of Kew, are evidences of astonishing industry and great knowledge The fruits of these labours have been edited in five volumes, 8vo, by his friend Dr McClelland, late of the Bengal Medical Service [1] The great object of his life was the preparation of a general scientific Flora of India He devoted 12 years of unremitted exertion to this work, collecting 2,500 species from the Khasia hills, 2,000 from Tenasserim, 1,000 from Assam, 1,200 from the Mishmi country, 1,700 from Bhutan, 1,000 from the neighbourhood of Calcutta, and 1,200 from the Naga hills, besides large collections in the Malay peninsula and Borneo

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1 "Posthumous papers bequeathed to the H E I C, and printed by order of the Government of Bengal, being journals of travels by the late William Griffith, Esq, arranged by John McClelland, M D" (Calcutta, 1847–54, 5 volumes 8vo, with a 4to volume of illustrations) They include his journals of travels in the Mishmi country, Upper Assam, to Ava, Bhutan, Candahar, and Kabul

The public garden at Saharunpur was established in 1779 by Zabita Khan, who appropriated the revenues of seven villages for its maintenance, Gholam Kadu, and the Mahratta chiefs after him, continued the grant, and in 1823 Lord Hastings ordered the establishment to be converted into a botanical garden of 400 acres, to which was afterwards added a nursery of trees for the canal banks [1] Dr Forbes Royle was the first Superintendent, and, in his "Illustrations of the botany of the Himalayan Mountains," he was the first to attempt to demonstrate the prominent features of the geographical distribution of North Indian plants, in reference to the elevations and climates they inhabit, and to the botany of the surrounding country In his paper on the geographical distribution of the Flora of India, Dr Royle makes some most interesting remarks on the vegetation of Indian lakes, and suggests the process by which the coal formations have been deposited The lakes are often covered with numerous stems, leaf and flower stalks of a variety of plants closely interlaced and matted together, and cattle are even said to graze upon the grasses with which the lakes become covered, the matted growth being strong enough to bear their weight [2]

Dr Royle was succeeded at Saharunpur successively by Drs Falconer, Jameson and latterly by Mr Duthie, F L S

Dr Wight stands at the head of the botanists of the Madras Presidency His "Prodromus Floræ Peninsulæ Indiæ Orientalis" is pronounced by Dr Hooker to be the most able and valuable contribution to Indian botany that has ever appeared [3] In 1853 Dr Wight returned to England with an enormous collection of plants, chiefly from the hill districts, which he presented to the Herbarium of the Royal Gardens, Kew, whence the duplicates have been distributed

In 1830 Dr Graham made a catalogue of the Bombay plants,

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[1] "J A S B,' i, p 41

[2] "General observations on the geographical distribution of the Flora of India, and remarks on the vegetation of its lakes, by Dr Forbes Royle —*Reports of the British Association*, xv, p 74 (1846)

[3] By Robert Wight and G A W Arnott (2 vols 1834) Dr Wight has also published, "Illustrations of Indian Botany,' commenced in 1838 "Icones Plantarum Indiæ Orientalis," (2,101 plates,) and "Spicilegium Neilgherrense' (coloured plates) Dr Leschenault, the director of the botanic gardens at Pondicherry, and Mr Gardner of Ceylon, also explored the Flora of the Nilgiris

and he has been followed by Law, Dalzell, Gibson, Birdwood,[1] and others.

The "Flora Indica" of Drs. Hooker and Thomson was intended to combine all the information that has hitherto been collected on the subject of Indian botany. In 1851 the Court of Directors refused to promote this great national object, though strongly memorialized by the British Association; yet a first volume, with a most valuable and interesting preliminary essay, was published in 1855.

After enumerating the works of previous botanists, and the labours of various collectors,[2] the essay furnishes a lucid sketch of the physical features and vegetation of the provinces of India.

The authors, in giving a comprehensive view of Indian botany, divide the country into 18 botanical provinces, including Ceylon, with reference to physical features.[3] The total number of Indian species is from 12 to 15,000, but there is almost a total absence of absolutely local plants, while India contains representatives of almost every natural family on the globe. The general physiognomy of the greater part of the flora approximates more to that of tropical Africa than to any other part of the world. The plains are very poor in species, and there are few countries in which the vegetation presents so little beauty, or such short seasons of bloom. In the

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[1] "The Bombay Flora, or short descriptions of all the indigenous plants in the Bombay Presidency," by N. A. Dalzell and A. Gibson. (Bombay, 1861.)

"Catalogue of the economic products of the Presidency of Bombay," compiled by Assistant Surgeon Birdwood, M.D. (Bombay, 1862.)

[2] Richard Strachey collected 2,000 species in the Himalaya, and distributed them to several European museums. Munro made a large collection in Madras, Coorg, Agra, and Simla; Falconer in Tibet; Schmidt in the Nilgiris, Coorg, and Canara (named by Miquel); Lobb in Kasyah and Malabar; Law in Bombay; Dalzell in the Konkan; Sykes and Gibson in the Deccan; Stocks in Sind; Madden in Simla and Kumaun; Vicary in the Punjab and Sind; Edgeworth in Multan and Bandalkhand; Fleming in the Salt Range; Jameson at Masauri; Thomson 3,000 species in Rohilkhand, Kashmir, Tibet, and the Punjab, and in the Himalaya; Hooker 1,000 in Bahar and the Gangetic valley, 3,500 in Sikkim, 3,000 in the Kasyah hills, 1,000 in Cachar and the Sundarbans. Griffiths' collection has been described above. A very few of Jacquemont's plants were published by Cambessides and Decaisne, in a 4to volume with 180 plates (Paris, 1844.)

[3] Namely,

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|---|---|---|
| 1 Ceylon, | 7 Khandish, | 13 Gujrát, |
| 2 Malabar, | 8 Berar, | 14 Sind, |
| 3 Konkan, | 9 Orissa, | 15 Rajwara, |
| 4 Carnatic, | 10 Bahar, | 16 Punjab, |
| 5 Mysor, | 11 Bandalkhand, | 17 Upper Gangetic plain, |
| 6 Deccan, | 12 Malwa, | 18 Bengal, |

besides the Himalayan region.

Carnatic, where the flora has been thoroughly investigated, the vegetation is neither rich nor varied, and there are no forests except on the flanks of the mountains. In Malabar, where there is abundant rainfall, the luxuriant vegetation is Malayan, while in the Konkan, further north, where the country is more open, and heavy forests are rarer, there is a mixture of African types. On the Deccan the flora is not extensive, and in Berar and Khandish little is known of it. On the Vindhyan table land the flora resembles that of the Eastern Ghâts, but the Malwa flora is scarcely known. In Sind, where there are about 400 species, nine tenths are indigenous to Africa, and the vegetation of the Punjab is very like that of Sind. There is nearly complete identity of vegetation between Sind and Egypt.

The Himalayan region, as regards its botany, is divided longitudinally into east, central, and west, latitudinally into exterior, interior, and Tibetan, and altitudinally into tropical, temperate, and alpine. In the eastern portion Dr Hooker explored the dense forests of Sikkim, which extend up to 12,000 feet, collecting 2,770 species of flowering plants and 150 ferns, besides many cryptogamic plants. Many European types do not reach beyond the Western Himalaya, while others, such as walnuts, ivy, junipers, and yews, extend over the whole range. As many as 222 British plants are found in India, but to the eastward of Kumaun the European types rapidly disappear. The *deodara* or cedar of Himalaya (a variety of that of Lebanon) is only found to the west of Nepal. Very few European plants extend into that central part of the region, and fewer still into Sikkim. This is probably connected with the gradually increasing rainfall and damp heat to the eastward. The phenomena of vegetation are less dependent upon the mean temperature of the year than upon that of the season of growth, and it is therefore important to know the mean temperature of each month.

In 1872 the Secretary of State for India in Council (the Duke of Argyll) gave instructions for a Flora of British India to be prepared under the editorship of Sir Joseph Hooker, and satisfactory progress has already been made in this work. It comprises all the plants of India from the Indus to Burma, Malacca, and Ceylon, an area computed at a million and a half of square miles, and believed to contain upwards of 12,000 species of plants, from all elevations up to 19,000 feet. The first volume was completed (in three parts) in 1875, and contains 740 pages, with 44 natural orders, and 2,258 species The first part of the second volume is also published with 608 species The whole is in English, and will be comprised in four thick octavo volumes, and be issued at the very moderate cost of 31*s* 6*d* per volume

The effects of human action on the physical condition of the earth's surface have been very great, and the planting and destruction of forests have been among the chief agents in the changes thus caused [1] It is true that too much importance has been attributed to the influence of forests, as if they were the principal causes of the moisture of a climate Lieutenant W H Parish, in a very interesting paper on this subject, has well pointed out that temperature, the pressure of the atmosphere, and its electrical state are the chief agents towards the formation of rain, and that mountain chains and forests are merely local causes Humboldt considers that forests exercise a triple influence on climate, by protecting the soil against the rays of the sun, producing a constant evaporation, and increasing the radiation through the leaves The entire destruction of many forests has certainly rendered India liable to those dreadful calamities which always follow a deficiency of rain, and, during the troubles attendant on the fall of the Muhammadan empire, many districts were denuded of their trees, and converted into dreary wastes The attention of the English rulers was first turned to the subject by the rapid failure of the supply of timber for ship building in the Malabar forests, and Dr Gibson was appointed as conservator of the forests in the Bombay Presidency Broader views, however, soon began to be entertained, and a regularly organized system of forest conservancy is now established throughout India Much valuable information on this subject will be found in the work of Dr Cleghorn, to whose skill and ability as an administrator the present success of forest conservancy in India is mainly due, in the reports of Dr Brandis, the present accomplished Inspector General of Forests, and in the writings of Dr Balfour, of the Indian Medical Service, Colonel Heber Drury, and others [3]

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[1] The best and most instructive work on this subject is "Physical Geography, as modified by human action," by George P Marsh (London, 1864 )

[2] "J A S B" xviii, p 791

[3] "Forests and Gardens of Southern India," by Hugh Cleghorn, M D (London, 1861 )

"Timber Trees of India," by Dr Balfour (Madras, 1862 ) A third edition appeared in 1870

The want of forest handbooks led to the preparation of three works, namely the "Flora Sylvatica" of Madras, by Lieut -Colonel Beddome, Head of the Forest Department in that Presidency, which was commenced in 1868 and completed in 1873,[1] the "Forest Flora of British Burma," by Sulpiz Kurz, Curator of the Herbarium at Calcutta, and the "Forest Flora of North West and Central India,' commenced by the late Dr J Lindsay Stewart, and completed in 1874 by Dr Brandis [2] The three works comprise most of the trees a description of which is needful to foresters in British India In 1873 Dr Brandis wrote an article on the distribution of forest in India, for the "Geographical Magazine," which was illustrated by a tinted map showing the amount of rainfall in the different regions [3] Since July 1875 the "Indian Forester, a quarterly magazine of forestry edited by Dr Schlich, Conservator of Bengal forests, has been published at Calcutta [4] It contains many valuable articles on forestry, several of which are also interesting to the physical geographer

On the Western Ghats, owing to the introduction of coffee cultivation, many thousands of acres have been cleared of forest, and it is impossible to exaggerate the importance of ascertaining the nature of the changes caused by these clearings, and the

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"Useful Plants of India,' by Major Heber Drury (Madras, 1858 )

A new work, based on the same plan, was published at the Travancore Sircar Press in 1864 "Hand book of the Indian Flora, being a guide to all the flowering plants hitherto described as indigenous to the continent of India, by Lieut Colonel Heber Drury 3 vols A second edition entitled "The Useful Plants of India with notices of their chief value in commerce, medicine, and the arts,' by Colonel Heber Drury, was published by Messrs Allen in 1873, pp xvi 512

"Index to the native and scientific names of Indian plants and products, by Dr Forbes Watson (India Office, 1866 )

"Timber Trees of India, by George Bidie, M B (Madras, 1862 )

"Timber Trees of Upper Assam —*Journal Ag and Hort Socy of India*, iii, pt ii, p 6–10

[1] "The Flora Sylvatica for Southern India, by Major R H Beddome, Conservator of Forests,' 3 vols 4to (Madras) This work contains 325 plates of trees with full descriptions, and a manual giving a systematic account of 76 natural orders

[2] "The Forest Flora of North West and Central India a handbook of indigenous trees and shrubs of those countries, commenced by the late J Lindsay Stewart, M D, continued and completed by Dietrich Brandis, Phil D (Allen, 1874 )

[3] "Ocean Highways October 1873, p 200

[4] "The Indian Forester, a quarterly magazine of forestry, edited by W Schlich, Ph D Conservator of Forests, Bengal Vol I (July 1875 to April 1876), Vol II (July 1876 to April 1877), and Parts 1, 2, and 3 of Vol III (Calcutta Central Press Company 1876, 1877 )

best means of obviating the evils that may arise from them, for on the water supply from the ghats depends the irrigation of a large part of the peninsula. Among other measures, I believe and trust that the chinchona plantations, formed within the last sixteen years on most of the mountains of India, will be as useful as the trees they have supplanted, in preventing evaporation, regulating drainage, and receiving the moisture which is wrung out of the passing clouds [1]

The nature of the soil is another cause which produces modifications in climate, owing to greater or less power of radiating heat. Sandy soils become rapidly and intensely hot, and when the rays of the sun are withdrawn they readily radiate to the atmosphere the heat they have acquired. Clayey soils, on the other hand, become slowly heated, and as slowly part with heat. Swampy ground chills the air; thus, if marshes are drained or forests cleared, the temperature is raised.

The changes that take place along the coasts, and are still in progress, have only been partially investigated. For this purpose the examination of charts of the same places, made at different periods, is very important. At Cochin, for instance, round the Vaipin point, the action of the S W monsoon and of the back-water produces incessant change [2] Such phenomena as the Alepy mud bank, and others connected with the relations between the Malabar back-waters and the ocean, require further study and examination, [3] as do also the bores in the Gulf of Cambay, and at the mouth of the Salwin, and other tidal phenomena, the changes at the mouths of rivers, and the so-called "swatches of no ground" off the mouths of the Indus and Ganges. A complete and thorough investigation of the evidence of upheaval and depression round the sea shores of India is also a desideratum. Indeed "the physical geography of the Indian Seas" is a valuable and important volume which has yet to be written.

In September 1870, Mr Robertson, C E, was appointed to prosecute inquiries with a view to the improvement of some of the

1 "On the effects of the destruction of forests in the Western Ghauts of India, on the water supply," by C R Markham, "R G S Journal," xxxvi, p 180 (1866) see also Chinchona Blue Books, presented to Parliament, *passim*

2 See Kennedy's Report, Oct 9th, 1862

3 See on this subject, "On the Inland Navigation of Travancore in account of the Alepy mud bank and the Wurallay Barrier," by C R Markham, "R G S Journal," xxxvi, p 195 (1856)

harbours on the coast of India, and he published a report in 1871,[1] which gives detailed descriptions of the anchorages at Aden, Mangalur, Cananor, Calicut, Cochin, Narakal, Alepy, Paumben, Tutikorin, Negapatam, Madras, Blackwood's Harbour, and Cocanada, with suggestions for the improvement of some of them His remarks on the encroachments of the sea at Cochin, on the alteration in the Gurpur Gap at Mangalur,[2] on the changes at Negapatam, and on the siltings at Cocanada, place the necessity for periodical surveys in a very strong light

An attempt has been made in this section to give a general idea of the points of chief interest that have been discussed by physical geographers in connexion with India, with references to their writings It is of course only possible to furnish a cursory view of so vast a subject, within such narrow limits A great mass of accurate and well digested observation has been accumulated, to all of which it has not been possible to refer, but very rich veins of good metal will reward the explorer who searches among the selections from Government Records, the volumes of the Asiatic Society of Bengal, and those of other societies established in India There is ample material already garnered to enable a physical geographer to follow up and form generalizations on any branch of his science, while fresh stores are constantly being collected by the Topographical and Geological Surveyors and by other observers Surveyors are expected to send in a full account of the geographical features of the districts under survey, with notes on their aspect, climate, superficial configuration, forests, rivers, soils, and productions[3]

Mr Henry F Blanford, in 1874, published at Calcutta a text book on the rudiments of physical geography for the use of schools in India, with a sketch of the structure and climate of India[4] Its preparation was suggested by the senior Board of Examiners in Arts of the Calcutta University, who felt that elementary text books treating of natural sciences for use in India, should deal more

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[1] "Report to the Government of India on Indian Harbours," by George Robertson (Edinburgh, 1871)

[2] See also, on this subject, an article on "The Extension of the Malabar Coast," by E W Pringle with a map, in the number of the "Geographical Magazine" for September 1877, p 230

[3] "Manual of Surveying for India," p 634

[4] "The Rudiments of Physical Geography for the use of Indian schools, together with "a sketch of the physical structure and climate of India, and a glossary of the techni" "cal terms employed," by Henry F Blanford, F G S (Calcutta 1874), 8vo, pp 169

especially with objects familiar and interesting to the Indian learners. The illustrations in Mr Blanford's little work are, therefore, taken as much as possible from Indian localities, and the three last chapters are entirely devoted to the geology and climate of India, forming the only popular description that has yet been offered of these interesting subjects. Mr Blanford, who was formerly on the geological survey, and is now Director General of the Meteorological Department, is specially qualified to prepare such a text book, and the results of his labours are so excellent that it is much to be desired that they should be republished in England.

Few attempts have hitherto been made to produce really good maps to illustrate the physical geography and statistics of India. In 1833 Mr Walker brought out a set of maps to show the European connexion with India, but these are merely skeleton maps, giving the political boundaries, and those for military, revenue, and judicial purposes. A second edition, with five additional maps, was published in about 1848.

The best series of illustrative maps is that prepared by Mr Edward A Prinsep, the settlement officer in the Sealkot district of the Punjab. Their design is admirable, and they display both taste and skill in their execution. They are invaluable, as far as they go, and it is much to be desired that similar maps should be prepared in other parts of India. These are confined to the Sealkot district, and the series of sixteen shows at a glance the details of every branch of information required by a revenue officer, and much that is most useful to a general inquirer.[1] Mr Prinsep also made a map of the Amritsur Division of the Punjab, showing the general features of the hills and plains, rivers and canals, the roads, and limits of fiscal and civil divisions. There are also lines showing the zones of rainfall, and the depth of wells throughout the division.

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[1] I. "Report on the revised fiscal settlement of Sealkote district in Amritsur division," effected by E. A. Prinsep. (Lahore, 1865.)

II. "Statistical account of the Sealkote district," geographically sketched by E. A. Prinsep, settlement officer, 1855–60. The maps show the agricultural tribes arranged according to occupancy of land; political and fiscal divisions; rent free aspect of the district; physical features and zones of fertility; productive power as influenced by rain or aided by irrigation; different kinds of soils; acres under different kinds of produce; police divisions, and haunts of criminal races; roads and lines of traffic; statistical aspect of area, agriculture, and population; and prevailing tenures and modes of assessment. The maps were lithographed at the Surveyor General's Office at Calcutta.

[2] Scale 4 inches to the mile. Lithographed by Walker in 1863.

In 1870 Mr Prinsep published a very interesting series of maps of the Punjab, showing the State canals acting on improvable waste lands, the depth of wells, the rainfall and zones of drought, and the parts of the country already irrigated [1]

A series of skeleton maps of the Central Provinces has been lithographed to accompany the Administration Reports, showing, very roughly, the lines of railways, mineral resources, and positions of forests They are quite of a different character from Mr Prinsep's maps, both as regards design and execution, yet they are welcome as showing the interest that is taken in these matters

A plan was formed, in the Geographical Department of the India Office, for gradually securing the cartographic illustration of various subjects relating to Indian administration, and a commencement was made in the "Moral and Material Progress Reports" of 1873 and 1874, the latter containing sixteen such maps But after 1874 these arrangements were discountenanced and the work was stopped Yet I trust that we may look forward, hereafter, to seeing general maps of India, as well as those of particular districts, with strictly accurate outlines, prepared for the purpose of illustrating various branches of physical geography, forest tracts, areas of cultivation, irrigation works, systems of communication, population, and other features which compose a physical atlas, as well as vital and administrative statistics, and revenue details

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[1] At the end of his "How to make State Canals without borrowing' being a few suggestions by Edward A Prinsep, Settlement Commissioner, Punjab (Lahore, 1870)

# XX

## THE STATISTICAL SURVEY OF INDIA

THE Statistical Survey of India, organised from the first and conducted throughout by Dr W W Hunter, Director General of Statistics, has now been in progress upwards of seven years, and the statistical accounts of the different presidencies and provinces had so far approached completion as to enable the "Imperial Gazetteer" of India to be commenced in the first half of 1877 Dr Hunter has prepared an interesting report[1] on the subject, which deserves a somewhat extended notice

The organisation of a Statistical Survey of India was sanctioned by Lord Mayo in 1869, but during the preceding century there had been numerous efforts towards the same object, and the results of these different surveys formed a vast storehouse of unpublished information scattered over different provinces In Bengal the first attempt of this sort, dated from 1769, or precisely one century before Dr Hunter's investigations commenced For Madras a magnificent series of 200 manuscript folios, known as the Orme Collection, was compiled between 1740 and 1770, and, with the exception of portions utilized in Orme's two printed volumes, remains inedited to this day The Bombay Government created a distinct department, and Colonel Sykes, as Statistical Reporter, drew up a mass of papers, which, with previous documents, furnish a continuous picture of that presidency since the establishment of British rule In the case of minor provinces like Mysor, Travancor, and Cochin, the investigations had been even more carefully carried out In fact each conspicuous period of administrative improvement or reform has left behind it the traces of a fresh inquiry into the state of the country

For instance, in 1769, when English officers were first appointed to the Bengal districts, the President in Council issued an elaborate circular, calling for information respecting the political, ethical, and social history of the province, after which an investigation of

[1] Quinquennial Report on the Statistical Survey of India By W W Hunter, LL D, of the Bengal Civil Service, Director General of Statistics to the Government of India, 1876

the land tenures was to follow, together with a list of the products of the country, an account of its commercial capabilities, and a report on the means of developing its internal resources. The administration of Warren Hastings, which followed, was characterised by great activity. Surveys were made in every part of the dominions, and isolated documents of great value were left behind. The next conspicuous period of inquiry was during the years which preceded the permanent settlement of 1793, and the consolidation of the company's rules of business into the Cornwallis Code. Unfortunately, these and the preceding researches remain inedited and unprinted.

The modifications which the Cornwallis Code shortly required, and the revenue settlement of the North West Provinces during the early years of the present century, again forced on the Court of Directors the necessity of a comprehensive investigation, and the instructions drawn up by the Government of India on receipt of the Court's despatch show that the plan was well conceived. An account of each district was to be first prepared, with a notice of its topography, history, and climate. The condition of the people was next considered, the natural productions of the country—animal, vegetable, and mineral—the modes of tillage, implements of husbandry, breeds of cattle, and safeguards against floods. The size of the farms, the rates of wages, and, above all, the land tenures are selected for review, and the list concludes with the arts, manufactures, and commerce of Bengal. No attempt was made to cramp or confine the operations within a specified time, and a man of learning and ability was selected for the work. Yet the net result was that, after seven years, 30,000*l* are said to have been spent, only a fragment of a single province had been surveyed, and not one page had been printed. The records of this survey form a series of 28 volumes, containing at least 10,000 pages of MS., which, with the exception of Martin's *rechauffee,* remained unutilised until 1872.

During the next 40 years the work in Bengal seems to have been taken up at intervals by individual investigators, such as district officers. The only organised attempt during this period was made between 1836 and 1840 by the Medical Department, 21 separate branches of inquiry being laid down. Several of the papers thus obtained, such as Dr. Taylor's Dacca and Dr. John McCosh's Assam, were for many years the standard authorities on the districts of which they treat. This period of isolated efforts may be fitly concluded by the reports of several district officers in Eastern Bengal, which were embodied, in 1868, into a volume, entitled "Principal Heads of the History and Statistics of the Dacca Division"

In the meantime, the Court of Directors having failed to obtain from their Indian servants any comprehensive account of the territories under their care, had set on foot a distinct series of efforts of their own They liberally encouraged works bearing on the subject, and as far back as 1828 a fair compilation, under the name of the "East India Gazetteer," in two volumes, by Walter Hamilton, had reached a second edition Ten works of this class in all were examined by Dr Hunter, comprising such works as "Thornton's Gazetteer," "Pharaoh's Gazetteer of Southern India," and "Balfour's Cyclopædia" "Thornton's Gazetteer of the Territories under the Government of the East India Company and of the Native States on the Continent of India" appeared in 1854, and though there are many grave defects in it, which now render it untrustworthy and altogether inadequate, Dr Hunter expresses his opinion that it has done more than any other work to impart to the English people a knowledge of their Indian dominions, and that it has supplied the source from which successive compilers have drawn, sometimes with scanty acknowledgment, the materials for more modern encyclopædias and gazetteers

But "Thornton's Gazetteer" had one inherent and irremediable fault It was not based on a systematic account of each of the geographical or political divisions of India, compiled district by district, and, in the absence of systematic materials, the author had to depend upon the chance topography of tourists and historians He brought great industry to bear on the subject, but the practical result is that while some petty hamlet, in which a traveller had halted a night, or any locality which formed the subject of official correspondence, stands out in bold relief, important features of great districts are passed over without a word The results being thus less satisfactory than had been hoped, interleaved copies of "Thornton's Gazetteer" were circulated in 1856 among the district officers, who were requested to supply all omissions It was soon perceived, however, that to conduct a proper revision involved a complete re writing of the work, for since 1854 a new history has been enacted in India, a new political geography has been formed, and a new system of government has been reared Perceiving this, the local administrations began to strike out new plans for drawing up a statistical and geographical account of their territories In March

1862 the Madras Government issued orders for a series of district manuals to be compiled by the local officers, which should exhibit that presidency in minute detail. Five of these Madras manuals have already been published[1] for the districts of Madura, Vizagapatum, Bellari, Cuddapa, and Nellor. Similar efforts were made in the Central Provinces and in Bengal, and in October 1867 the local governments were addressed with a view to the extension of the operations throughout India. It soon, however, became evident that as there was no uniform system, and no central supervision, the expenditure might eventually be considerable without the desired results being obtained, especially with regard to securing comparable statistics. The Council of the Asiatic Society forcibly urged this view, which was concurred in by the Government of India, and Dr Hunter was accordingly directed to make arrangements for the systematic conduct of the future statistical operations, which were designed to extend over a territory of 1,556,836 square miles, inhabited by a population of 240 millions.

The previous operations, from 1807 downwards, had endeavoured to attain *per saltum* a goal which could only be reached by many weary steps. Dr Hunter's system started by laying down, and circulating to all district officers, a carefully planned series of "Heads of Information required for the Imperial Gazetteer," thus ensuring a fair amount of uniformity of treatment and subject matter. These materials have been gathered in, almost without cost, by enlisting the unpaid co operation of district officers and heads of departments throughout India. By appointing a provincial editor in each of the presidencies and provinces, central control has been localised, while as Director General, by means of regular tours, Dr Hunter has been enabled to exercise inspection and secure steady progress and fairly uniform execution of the whole.

By this means provision was made for the statistical survey

[1] I "The Madura Country. A Manual compiled by order of the Madras Government, by J H Nelson, M A, M,C S, in five parts. (Madras, 1868.)

II "A Manual of the District of Vizagapatam in the Presidency of Madras, compiled and edited by D F Carmichael, M C S. (Madras, 1869.) Pp 398, and map.

III "Manual of the Bellary District, compiled under the orders of Government, dated September 9th, 1869, No 2646, by John Kelsall, M C S. (Madras, 1872.) Pp 390, and map.

IV "A Manual of the District of Cuddapah in the Presidency of Madras, compiled and edited by J D B Gribble, M C S. (Madras, 1875.) Pp 369, and map.

V "A Manual of the Nellore District in the Presidency of Madras, compiled and edited by John A C Boswell, M C S. (Madras, 1873.) Pp 863, and map.

of the whole of British India, the Native States being alone excepted. The results are briefly as follows. As regards Bengal, which comprises 47 districts, the accounts of the whole 47 have been compiled, and were issued in twenty volumes during the year 1877. Of Assam, which now forms a chief commissionership consisting of 12 districts, the whole has also been compiled and will be issued in 1878. In these two provinces Dr. Hunter has himself acted as provincial compiler. In the North-West Provinces Mr. E. J. Atkinson has acted as compiler. Here five volumes, comprising 16 out of the 35 districts, have been printed, and the remainder are expected in 1879–80. The Punjab comprises 32 districts, of the whole of which the accounts have been printed. In Oudh the manuscript accounts of all the 12 districts have been completed, and the whole will probably be published in 1878. The "Gazetteer of the Central Provinces" was published in 1870, before the Census of 1872 had taken place. The more accurate statistics supplied by this enumeration are being incorporated under Dr. Hunter's eye. In Bombay, as in the North West Provinces, the scale of the operations has been enlarged, so that the time of completion of the whole of the statistical accounts is a matter of some uncertainty. The "Gazetteer of Sind," by Mr. Hughes, was published in 1874,[1] comprising five out of the 24 districts of the Bombay Presidency. Mr. Campbell is provincial editor as regards the rest of Bombay, and has issued several district accounts.

In Mysor and Coorg volumes comprising all the nine districts were issued before the end of 1876.

The system adopted in Madras dates as far back as 1862. Here each district is done separately, and there is no central officer or provisional editor appointed. The preparation of the "District Manuals," as they are termed, thus proceeds but slowly, only five[2] out of the total 21 having been as yet published in the course of 11 years. Of these the Vizagapatam Manual by the Hon. D. F. Carmichael, is pronounced by Dr. Hunter to be a model of administrative information and local research. But much repetition is involved by the scheme of decentralisation thus adopted, and Dr. Hunter has found it necessary to stipulate for the supply of short digests or abstracts of the outstanding manuals, so as to enable him to proceed with the "Imperial Gazetteer" without interruption or delay.

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[1] See note, page 356.

[2] See note on preceding page.

In British Burmah the operations are somewhat of a tentative character, as many years must elapse before the information here permits of the elaborate completeness of the statistical accounts of the older British provinces But the volumes embracing the whole of the 15 districts are expected in 1878–79, the MS having been already completed Mr La Touche completed a statistical account of Ajmir and Mhairwara in 1874

Thus of the 233 districts of British India with which the operations deal, the statistical accounts of 200 have been already compiled, while out of the 12 provinces into which British India is divided, the work in 10 is either completed or so far advanced as to hold out a fair prospect of completion within two years

No provision was made for the survey of Native States, but as they must be dealt with in the "Imperial Gazetteer of India, Dr Hunter has taken measures for obtaining accounts of them Those under the local governments, such as the groups of Native States under the Bengal, North West Provinces, Punjab, Madras, and (more especially) the Bombay Governments, are now in active preparation Those under the Foreign Office are more difficult of access, but for these Dr Hunter purposes to base his accounts on the forthcoming edition of Aitchison's "Treaties and Engagements," as amplified and revised in the Calcutta Foreign Office Special narratives have already been prepared for the Rajputana States A collection of administrative reports by the political officers will also be placed at Dr Hunter's disposal, and these, combined with other papers compiled by his deputy in the Foreign Office, will enable him to give a far more complete account of the Native States of India than has hitherto been attempted As regards the French and Portuguese possessions, important materials have been discovered by Dr Hunter in the course of his visits to Goa and Pondicherry, and recent statistics will be derived from the *Annuaires* and official publications of their respective governments

The condensation of all these provincial accounts into the "Imperial Gazetteer of India' commenced in the spring of 1877 This work will be designed primarily for the use of the controlling body in England, in the second place, for the use of Indian officials, and thirdly, for the public at large The general plan will be that of alphabetical arrangement of articles varying from a few lines to about twenty pages in length The period of time which the preparation of this important work will occupy will probably be four years from 1877 Owing to the great expense of literary compilation in India as much as possible of the work will be done by assistants working under Dr Hunter's supervision in England The cost is estimated at an aggregate of 12,000*l* as against 30,000*l*, which would have been the cost in India

The "Imperial Gazetteer of India" will represent a series of local inquiries and comparative statistics spread over an area but little less than that of all Europe excepting Russia It forms the necessary complement of the great Indian surveys, trigonometrical and topographical, which have been in operation for nearly a hundred years

The great difference between it and "Thornton's Gazetteer" (the only work in any way comparable with it) has been indicated above, and the elaboration and care bestowed on the preparatory arrangements, as well as the abilities and experience of the editor, afford a guarantee that the execution of the work will be commensurate with its importance The Government has published in the "Gazette" its high approbation of the large sections of the Statistical Account already issued by Dr Hunter

# XXI

## ORTHOGRAPHY OF INDIAN PROPER NAMES

A UNIFORM system of spelling native names formed one of the essential preliminaries of the "Imperial Gazetteer," and has at last been authoritatively adopted by the Government of India. Thus a serious official attempt is to be made to finish the great battle of Indian orthography, which has now been raging for upwards of a hundred years.

There are two systems of exhibiting Asiatic words in our own letters, "founded," as Sir William Jones said, "on nearly opposite "principles, but each of them with advantages. The first proposes "to regard chiefly the pronunciation of the words intended to be "expressed, the second consists in scrupulously rendering letter for "letter, without any particular care to preserve the pronunciation." In after years the second has received the title of the "*scientific system*," and the first that of the "*phonetic system*." Each has had a succession of able and persistent advocates, and during the century that the battle has raged, there has existed a complete state of anarchy as regards the spelling of Indian names, the confusion and absurdities of which have every year become more intolerably inconvenient.

In the first years of English occupation of India, proper names were written down by ear, without any attempt at correctness, and according to the fancy of each writer. Thus we have "Sir Roger Dowler" for Sirájuʼd daulah, "Crotchy" for Karachi, and "Isle of bats" for Allahabad. For the word Khan, the historian Orme has Cawn, while Dow adopts Chan. But the greatest variety of these barbarisms will be found in the speeches of Burke, a very fitting casket for such gems.[1]

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[1] Incorrect spelling is sometimes the cause of very serious errors. A striking instance is mentioned by Mr. Eastwick. The popular form of spelling *Cawnpore* led to the notion that it was a town founded by some Muhammadan Khan or *Cawn*. Hence it was supposed to be a place of no antiquity, and accordingly Thornton, in his "Gazetteer," says that it is quite modern. But the correct spelling is said to be Kanhpur, the city of *Kanh* or Krishna, and it is a place of primæval antiquity.—Dr

The first advocate of any system at all was Major Davy, an officer who studied Persian in India just a century ago. He prided himself on his pronunciation, and was a strong supporter of the *phonetic system*. Major Davy instructed Professor White, the editor of the "Institutes of Timour," to use his plan of exhibiting the pronunciation of the Persian language in our characters, and the plan is retained, with minute care, throughout the work, which was published in 1784.

But Major Davy had a contemporary who advocated the *scientific system*, and was the first to give the Nagari and Bengali alphabets accurately in English characters. This was Mr Halhed, whose method is given in the preface to his code of Hindu law, compiled under the orders of Warren Hastings in 1775. Mr Halhed made no distinction between the hard and soft *d*, *dh*, *t*, and *th*, but every vowel in his system had its long or short mark above it.

Sir William Jones, not satisfied with the system of Mr Halhed, devised the alphabet which bears his name.[1] He gives an analysis of each Nagari letter separately, and provides for all the sounds used in Sanscrit, Arabic, Persian, and Hindu. He discarded the *phonetic system*, by which the pronunciation of Asiatic names was to be shown by English letters, because there are no consistent rules of orthography in English, and every vowel may be used to articulate one and the same sound. Sir William gives the following sentence, as an example,—"*A mother bird flutters over her young*—" in which every vowel and the diphthong *ou* have the sound of *u* in *but*. He, therefore, used the Roman or Italian sounds of vowels. This great scholar thus identified himself with the *scientific*, which is hence also called the *Jonesian system*. It was scrupulously adhered to by Colebrooke and Wilkins. It prevails in the "Asiatic Researches," in the "Journal of the Asiatic Society of Bengal," and in that of the Royal Asiatic Society, and it was adopted by Rottler in his Tamil dictionary, by Campbell in his dictionary of Telugu, and by Shakespear in his Hindustani dictionary.

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Hunter, however, adopted *Khanpur* as the correct form, to be spelt *Cawnpur*. He observes that Hindu Pandits give it *Kanhpur*, while Muhammadan Maulavis return it as *Khanpur*, and that local usage inclines to the latter form.

[1] "A Dissertation on the Orthography of Asiatic words in Roman Letters," by the President, 1788. In the "Researches of the Asiatic Society of Bengal,' vol. i. Also in the collected works of Sir William Jones, i, p. 176.

Dr John Borthwick Gilchrist soon afterwards became the great advocate and supporter of the *phonetic system*,[1] but the difference between his scheme, and that of Sir William Jones, lies entirely in the vowels. In the *Jonesian system* all distinct vowel sounds are represented by the same letters, and differences of length are shown by accents, while in the *Gilchristian system* one vowel sound, varying only in the accident of quantity, is represented by two distinct letters. The plan of Gilchrist became the more popular of the two. He used the short *u*, instead of *a*, for the silent unexpressed inherent letter of the languages of India, and substituted *oo* for the *u* of Jones. He also discarded the *au* of Jones (for *ow* in *how*) and substituted *ou* in its place. Dr Gilchrist clearly states that his method of rendering Asiatic words is studiously founded on the orthoepy rather than on the orthography of their respective characters and languages, and he urges that, as the work is designed for British subjects only, there is no necessity for attending to general or continental pronunciation.

Thus the names of Jones and Gilchrist became the watchwords of orthography and orthoepy, of the scientific and phonetic systems, and their disciples continued to argue, while absolute confusion and anarchy prevailed in the spelling of the general public. For 30 years they had a fair field and no favour, but, except among the learned, there was a decided leaning from the first in favour of Gilchrist's

[1] "A Grammar of the Hindoostanee Language, or part i of vol i of a System of Hindoostanee Philology, by John Gilchrist. (Calcutta, 1796.)

"Hindoostanee Philology, comprising a Dictionary, English and Hindoostanee, with a grammatical introduction, by John Borthwick Gilchrist, LL.D., Hindoostanee Professor in the College of Fort William. (London, 1810. Again 1835.)

| Halhed | Jones and Wilson | Gilchrist | English equivalents |
|---|---|---|---|
| ĕ | a | u | As *a* in *above*, or *u* in *up*, *fun* |
| ĕe | i | i | As *i* in *hill*, in *bit* |
| ēe | i | ee | As *i* in *police*, or *ee* in *heel* |
| oo | u | oo | As *u* in *push*, or *oo* in *wool* |
| oo | u | oo | As *u* in *rule*, or *oo* in *cool* |
| ai | ai | ui | As *ai* in *aisle*, or *ui* in *guide* |
| ou | au | ou | As *ow* in *owl* |
| o | o | o | As *o* in *note*, *pole* |
|  | a |  | As *a* in *art*, *father*, *tartan* |
|  | e | e | As *e* in *there*, *a* in *mate* |

system At last, in 1820, the Government ordered an accurate record to be made in English, of the land tenures, and uniformity became an important object Dr Gilchrist's scheme, in a simplified form, was then adopted, and the same system was used for maps and revenue survey records The Record Committees succeeded in entirely reforming the orthography of names of places on this system,[1] and it continued to be that of all official correspondence for many years, while the Asiatic Society and scholars were faithful to Sir William Jones

This was only a lull The battle began to rage again, in 1834, with renewed fury Mr Thompson, a missionary at Delhi, had written an English and Urdi dictionary in Roman characters, which Dr Yates, another missionary, recommended to the Calcutta School Book Society Mr Prinsep protested against the innovation, while Dr Duff, a missionary, declared for the Roman alphabet Sir Charles Trevelyan, then a young civilian, vehemently supported the publication of vernacular books in the Roman character, and on the scientific system He allied himself with four missionaries, Duff,[3] Yates, Pearce, and Thomas, for the purpose of printing and circulating such books, and 57 had been published by the end of 1836[4]

Meanwhile a sharp controversy was carried on between Sir Charles Trevelyan, who upheld the scientific or Jonesian system, and Mr Henry T Prinsep, who maintained the superiority of the phonetic system of Dr Gilchrist Mr Prinsep said that the system of Sir William Jones was a style of writing to be reverenced and respected, but not imitated, and that it should be reserved for recondite science[5] Mr Trevelyan replied that the phonetic system of Dr Gilchrist was not a system of orthography, but of *kakography*, or of confusion, mystification, and absurdity While such was, he maintained, the

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1 Reports of Record Committee, Aug 6th, 1820, and May 12th, 1821

2 M H Thoby Prinsep's Minute, June 1834

3 "Dr Duff's Modification of the Jonesian system, as finally approved by the Committee of the Calcutta Bible Society, with an alphabet, is given by Colonel Thuillier in his "Manual of Surveying for India, (*third edition*) p 405 (note)

4 "Original Papers illustrating the History of the Application of the Roman Alphabet to the Languages of India,' edited by Monier Williams (London, 1859, 8vo, pp 276)

5 See "Journal of the Asiatic Society of Bengal,' iii, p 281 "On the Adaptation of the Roman Alphabet to the orthography of Oriental Languages," by H T P

plan of Gilchrist, the system of Sir William Jones, after having completely stood the test of learned criticism, after having gone through a probationary period of sixty years, and approved itself to the great body of scientific men throughout the world, was at last claimed for general use It was true, as Mr Prinsep had urged, that it had long remained unused except by scholars But that was no reason why it should continue to be so "The jewel," he declared, "must no longer remain shut up in a casket, but must be brought "forth to shine in the face of day The money must no longer "remain hoarded in the treasury, but must now pass into circu-"lation"[1]

Mr Trevelyan returned to England in 1838, and published his work on the education of the people of India,[2] but his missionary allies continued their labours, and in 1857 Mr Mather reported that the Roman character, with the Jonesian system, was universally used by the missionaries in the Upper Provinces

In 1845 Mr Crow, a deputy collector, published an ingenious treatise on the best mode of writing oriental words, in which he advocated the scientific system But in the same year Sir Henry Elliot published a work in which he "conformed to the system of "Gilchrist, or rather to that modification of it in use in our "Revenue Survey, which certainly has the merit of enabling an "Englishman to pronounce a word in such a manner as to make "it easily comprehended by the natives of Hindoostan, while Sir "William Jones' system is better suited to the learned"[3] Molesworth also adopted the system of Dr Gilchrist in his Marathi dictionary

In the directions for revenue officers in the North West Provinces,[4] they are instructed to convert Urdi and Hindu words into English according to an alphabet which is given in the Appendix This alphabet has the double *oo* and *ee*, and the initial *U* for the Jonesian A It is, therefore, on the Gilchristian system, and is the same scheme as that adopted by the Record Committee in 1820 It is recommended as "that which an Englishman "would naturally adopt, without aiming at great refinement or "accuracy"

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[1] August 27th, 1834

[2] Longman, 1838

[3] "Supplement to the Glossary of Indian Terms, by H M Elliot, B C S Sudder Board of Revenue, Feb 1844 (Agra, 1845)

[4] Published at Agra in 1849, para 7 of sec ii, p 28, and App No 1, p 89

In 1851 Colonel Thuillier published his "*Manual of Surveying for India*," in which he devoted a section to the question of orthography,[1] observing that surveyors of all persons must be most interested and concerned in such a question The rules he laid down were that all vowels were to have the Italian sound, no others being used, all consonants to have the ordinary English sound, the C being excluded and K or S always substituted, the reduplication of consonants to be dispensed with as much as possible, superfluous letters of all kinds to be dropped, and old established orthography of historical places not to be interfered with But he allowed the double *oo* to stand for *u*, and the *ee* for *i*, as a compromise which would enable the generality of people to attain a better pronunciation In his third edition of 1875 he of course adopted the official system of Dr Hunter [2]

Thus the phonetic system of Dr Gilchrist was the one that was officially adopted in the Revenue and Survey Departments of the Bengal Presidency from 1820, certainly until 1851, and, indeed, it appears to be the system which enjoyed official sanction up to the issue of the Government resolution of 1870 The new system will, therefore, be opposed to that used in all the official despatches and records during a long course of years, which will be one source of inconvenience

When Professor H H Wilson published his "Glossary of Indian Terms," he adopted the scientific system of Sir William Jones throughout, discussing the whole question in his preface, and he gives equivalents in Roman characters for every letter in nine alphabets used in India But a key is provided at the end of the book, in which the popular spelling is given, with a reference to the equivalent scientific form in the body of the work [3]

These controversies prevented any uniform system of spelling from being introduced, and there was such hopeless confusion on the subject, that Mr Thornton when he compiled the "Gazetteer of India," gave it up in despair He simply inserted the names as he happened to find them spelt in official documents [4] Thus Amritsur and Ambála are the one in the first, the other in the fourth volume,[5]

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1 Page 628

2 Page 404 (3rd edition) Dr Hunter's rules are given in the Appendix, p cxcii

3 "Glossary of Indian Terms," compiled by H H Wilson (London, 1855)

4 Thornton's "Gazetteer" Preface, p iv (1854)

5 The one "Umballa," the other "Amritsur"

though their initial letters are identical in the vernacular (the *a* of Jones and *u* of Gilchrist) A town and district having the same name are spelt quite differently The word *fath* is spelt in eleven different ways, all wrong Since the publication of this gazetteer the confusion has become worse and worse Such uniformity as may have been secured by the Record Committees fifty years ago, when the phonetic system was in the ascendant, has long since disappeared, and has given place to the most perplexing and deplorable anarchy, than which any system would be preferable

In 1858 the controversy broke out afresh, and was carried on with some spirit in the "Times" and other English newspapers, with Sir Charles Trevelyan, under the signature of Indophilus, and Mr Monier Williams on one side, and Professor Garrett on the other Sir Charles went out as Governor of Madras in the same year, and used his utmost influence to introduce the scientific system there in all official correspondence, but without any effect That system also found an advocate in Mr Eastwick, who edited Murray's Handbooks for India in 1859, and Keith Johnston adopted it for the maps of India in his atlas published in 1861 It was also adopted by Mr Thomas in his system of transliteration and application of diacritic marks to English type in the "History of India by its own Historians,' [1] and it is explained in a pamphlet issued by the Philological Committee of the Asiatic Society of Bengal It also forms the basis of the rules issued by Colonel Walker for the guidance of officers of the Great Trigonometrical Survey, in spelling names of places The Syndicate of the University of Calcutta, in 1859, published a key to Professor H H Wilson's system of transliteration as modified by that body [3] In this pamphlet it is observed that a general disregard of all fixed rules of spelling prevails, and it is hoped that the adoption of a fixed system by the Calcutta University and the Education Department in Bengal will have the effect of gradually securing a general uniformity of spelling throughout the country in public documents and in literary productions This key gives a complete and an optional form of Roman equivalents to be used for the letters of the

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[1] See page 342 [2] Dehra, Jan 27th, 1865, Dept Order, No 33

[3] "A key to Professor H H Wilson's system of transliteration as modified by the Syndicate of the Calcutta University, and ordered to be adopted in University proceedings and records' Calcutta, 1869 Pp 71

Sanscrit, Bengali, and Arabic alphabets. Every Indian letter must, in accordance with the rule of Sir William Jones, be represented by its fixed Roman equivalent. The vowels are to have powers as in Italian, but not as in English; diacritical marks attached to consonants may at option be omitted in writing proper names; but accents on long vowels must invariably be inserted.

The best system for the transliteration of Arabic and Persian names has also been much discussed. The following is a statement of the system adopted by the Rev. Dr. George P. Badger, D.C.L., one of the most accomplished of our Arabic scholars. He says:—

"My main object has been to convey the correct sound, and, as far as may be, to preserve the etymology of Arabic words, without resorting to unfamiliar expedients, such as the use of arbitrary diacritical points.

"Nobody can be more aware than I am that neither of these ends can be perfectly attained without the aid of devices of some kind to indicate the sound of those Arabic letters which are foreign to our language. But bearing in mind that persons unacquainted with Arabic would undoubtedly fail to pronounce such words correctly even with that help, I have eschewed resorting to it, resting satisfied at present with giving, through Roman letters, the nearest approach to the right sound practically attainable by the generality of English readers.

"I represent both the ح and ة—two radically different letters, the first a deep pectoral, and the second a slight aspirate—by our *h*. Whenever the latter occurs as the feminine termination of a word, and preceded by the vowel *a*, as in *Mekkah*, *Jezirah*, the *h* is nearly mute, as in our *heir*, *hour*. س, a sibilant, and ص, a faucial, I represent by *s*; ت and ط, the former our *t*, and the latter like the same letter as more emphatically enunciated by Irishmen, by *t*; and ق and ك—the first a guttural and the second like our *k*—by that letter only.

"The other Arabic letters, which have no equivalents in our language, are خ, ذ, ض, ظ, غ, and ع. The sounds of خ and ض are expressed nearly enough for all practical purposes by *kh* and *dh* respectively. ذ I write *dz* and ظ *zh*, by way of distinguishing them, and also for etymology's sake, rather than because the expedients convey any very clear idea of the proper native sounds. Those who are puzzled by the combinations may content themselves with pronouncing both as *z* In order, however, to prevent the bizarre appearance of four consonants coming together in the transliteration into English, whenever either of these four letters is double in the Arabic, I separate the combinations by a hyphen, thus, *fakh khâr*, *nadh dhâdh*, *kadz dzâf*, *munazh-zham* Fortunately, such words are of rare occurrence

"I adopt the same expedient with ش—adequately represented by *sh*—when that letter is doubled, thus, *hash-shâsh*, *fash shâr* Also, when it occurs at the end of a syllable and is followed by *h*, as in *Másh-had*, which, otherwise, English readers might pronounce *Ma-shad* And, again, when a syllable ends with *h* and the succeeding one begins with *s*, as in *Ah sâ*

"The guttural غ I express by *gh*, and the ع with an apostrophe *before* the vowels *a*, *i*, *u*, when they *follow* that letter in the Arabic, as *'Abd*, *Irâk*, *'Ulamá*, *Sana'â*, and *after* the vowels when it occurs at the end of a word or syllable, as *rabia'*, *Radha'*, *ez-Zaila*

"The remaining Arabic consonants correspond generally with those of the English alphabet The sound of our *c*, as in *cat*, being supplied by my use of *k*, I only resort to it, conjoined with *h*, to express the Persian چ, which is equivalent to our *ch* in *Charles*

"There are only three vowels in Arabic, in sound like *a*, *i*, *u*, in *far*, *pit*, *lunar*, respectively The Arabic equivalent of *a* takes, in some positions, the sound of *e* in *beg*—a grammatical nicety seldom correctly observed, and I should have preferred expressing the corresponding Arabic vowel sound always by *a*, but the use of the *e* has so long prevailed, especially in writing the definite article *el* (properly, *al*), and such words as *Ahmed* and *Jezirah* (correctly, *Ahmad*, *Jazirah*), that I have regrettingly retained it in such cases For the same reason I have retained the vowel *o* in names which have become familiar by long usage, such as Omar, 'Oman, 'Othmân, which should severally begin with 'U

"To indicate the prolongation of a vowel, I place over it the familiar circumflex (^), as in *Bukhâra*, *Tûrân*, *Baghdâd*, in preference to the acute accent ( ) recently sanctioned by the Government of India, whereby the hitherto universal use of that accent by English lexicographers to denote where a syllable should be accentuated is overlooked, and its utility lost I retain it with that object, which is one of great importance in the pronunciation of Eastern names. Thus, *Kajar*, *Maskat*, *Lâhej*, are severally marked as requiring the accentual emphasis to be given to the first syllable.

"The Arabic diphthongs are *ai*, *ei*, *au*, in sound like *ie* in *pie*, *ei* in *vein*, and *ow* in *how*. When doubled in the same word, I express the *au* by *aww*, as in *Tawwâm*.

"The Arabic suffix يّ, when used to denote an ordinary or gentilic adjective, I represent by *y*, which somewhat in the same way constitutes the formative of many of our English adjectives, as *windy* from *wind*, *stormy* from *storm*. I prefer this expedient to that which has recently been adopted, of expressing the suffix by a circumflexed *i* (as in *Hindi*), because that mark is generally used, as I use it, to denote a prolonged vowel, from which this adjective termination differs very essentially. The *y* in such cases should be pronounced with a ringing Italian *i* sound.

"I notice, lastly, that in addition to the use made of the apostrophe, as stated above, I avail myself of it, as in English, to denote the elision of a letter, as in *won't*. Its utility is great in this respect, especially in transliterating compound Arab names, which generally require to be put into the construct case. Thus, *'Abd el Majid*, *Nâsir-ed Din*, *'Abd-er-Rahmân*, should be written and pronounced *'Abdu 'l Majid*, *Nâsiru 'd Din*, *'Abdu 'r Rahmân*, the apostrophe representing the elision of the *e* of the article, in its different forms here presented of *el*, *ed*, *er*, and the junction in one syllable of the *u*, the final vowel denoting the nominative of the nouns *'Abd* and *Nâsir*, with the *l*, or second letter of the article, which remains. But however correct and desirable this style may be, I do not advocate its adoption in names which have become familiar to the ordinary English reader under a different form.

"I wish it to be understood that my system is tentative only, and designed to facilitate the introduction of a perfect transliteration of Arabic into Roman characters, which shall correctly represent not the sound only, but also the etymology of the former language."

Mr Thomas, for the "International Numismata Orientalia," has adopted a system both for Arabic and Persian, and gives a table showing the systems of Sir William Jones (1828), Mirza Ibrahim (1841), Mr F Johnson (1852), and M Chodzko (1852), in their Persian Grammars, Dr Wright in his Arabic Grammar (1874), Dr Fuerst in his Hebrew and Chaldee Lexicon (1867), Mr Lane in his Arabic Lexicon (1863–74), together with the Persian and Arabic methods adopted by himself for the "Numismata Orientalia."[1]

But the phonetic system, first advocated by Gilchrist, in spite of this great weight of authority against it, continued to have powerful supporters, chief among whom were Mr. Marshman,[2] and Colonel Meadows Taylor. It was advocated by the latter very high authority on the ground that the English language possessed phonetic equiva-

[1] Contrasted methods of transliteration variously advocated for Arabic and Persian, with the systems finally adopted for the "International Numismata Orientalia."

| — | 1 Sir W. Jones | 2 Mirza Ibrahim | 3 Mr. F. Johnson | 4 M. A. Chodzko | 5 Dr. Wright | 6 Dr. Fuerst | 7 Mr. Lane | 8 Numismata Orientalia: Persian | 9 Numismata Orientalia: Arabic |
|---|---|---|---|---|---|---|---|---|---|
| ا | a | a | a | o a | | | | a | |
| ب | b | b | b | b | b | b | b | b | b |
| پ | p | p | p | p | p | — | - | p | - |
| ت | t | t | t | t | t | t | t | t | t |
| ث | th or s | s | s | s | t | t θ | th | s | th |
| ج | j | j | j | dj | ǵ | g | j | j | j |
| چ | ch | ch | ch | tch | c | — | - | ch | |
| ح | h | h | h | hh | h | h | h | h | h |
| خ | kh | kh | kh | kh | h | h | kh | kh | kh |
| د | d | d | d | d | d | d | d | d | d |
| ذ | z | z | z | z | d | d | dh | z | d |
| ر | r | r | r | r | r | r | r | r | r |
| ز | z | z | z | z | z | z | z | z | z |
| ژ | j | j | j | j | j | — | - | zh | — |
| س | s | s | s | s | s | s | s | s | s |
| ش | sh | sh | sh | ch | s | s | sh | sh | sh |
| ص | s | s | s | s | s | s | s | s | s |
| ض | z | z | z | z | d | d | d | z | d |
| ط | t | t | t | t | t | t | t | t | t |
| ظ | z | z | z | z | z | z | dh | z | z |

| — | 1 Sir W. Jones | 2 Mirza Ibrahim | 3 Mr. F. Johnson | 4 M. A. Chodzko | 5 Dr. Wright | 6 Dr. Fuerst | 7 Mr. Lane | 8 Numismata Orientalia: Persian | 9 Numismata Orientalia: Arabic |
|---|---|---|---|---|---|---|---|---|---|
| ع | ع | a | ع | a | | | a | | |
| غ | gh | gh | gh | gh | g | g | gh | gh | gh |
| ف | f | f | f | f | f | f | f | f | f |
| ق | l | ck | k | q | k | k | k | k | k |
| ك | k | k | k | l | k | k | k | k | k |
| گ | g | g | g | g | g | — | - | g | |
| ل | l | l | l | l | l | l | l | l | l |
| م | m | m | m | m | m | m | m | m | m |
| ن | n | n | n | n | n | n | n | n | n |
| و | v w | v | w | v oû | w | v w û | w | v w | w |
| ه | h | h | h | h é | h | h | h | h | h |
| ي | y | y | y | y i | y | y i | y | y i e | y |
| ـَـ | a | a | a | e | a e e | a or e | a or e | a ă | a |
| ـِـ | i | i | i | i | i ĭ | i or y | i | i e | i |
| ـُـ | u | u | u | u | u o o | o or u | u or o | u | u |
| ـا | á | — | á | á | á | — | á | á | á |
| ـي | i or e | — | i | — | í | — | ee | í é | í |
| ـو | u or o | — | u | ôo or ou | ú | — | oo | ú | ú |
| ـَو | au or aw | — | au | ôou | au o | - | ow ó | au ó | au |
| ـَي | ai | - | ay | — | ai e | — | ey ei | ay ai | ay ai |

*The diacritical dots may be omitted at option, but preferentially where the original text accompanies the romanized version.*

[2] "Observations on the establishment of a uniform orthography of Indian names and places." (London, 1870.) A pamphlet by J. C. Marshman, Esq.

lents for all sounds in Indian proper names But, in the phonetic system, the sound rather than the othography of the Indian languages must be followed Colonel Meadows Taylor drew up and submitted to the Secretary of State a set of simple rules for the use of English equivalents for Indian phonetic sounds [1]

The scientific system is essential to the scholar The phonetic system is supposed to be better suited for the use of travellers, and of the general public

Mr Barton deprecated the notion that the claim of linguistic science and the necessities of popular usage were so opposed to one another as to be altogether irreconcilable He, therefore, proposed that in a gazetteer or other similar work the scientific spelling should follow the popular one in each case in brackets He thought that the requirements of popular utility might thus be reconciled with the claims of science [2]

The present action of the Government of India originated with a proposal which was made by the Bombay Geographical Society in 1868, for the preparation of a vernacular and English index of Indian geographical names On April 30th, 1868, the Government of India invited aid from the local governments in the preparation of such an index, and suggested the adoption of a uniform system of transliteration, at the same time drawing attention to Professor Wilson's modification of the system of Sir William Jones Dr W W Hunter, LL D, of the Bengal Civil Service, was appointed to compile the Gazetteer of Bengal, and he was instructed to use his exertions to secure uniformity of spelling in the preparation of the other gazetteers throughout India, the system of Professor Wilson being again recommended as a model Dr Hunter submitted a plan, on November 6th, 1869, in which he recommended a compromise The "scientific system," though admirably adapted for scholars, was allowed to be too elaborate for general use The diacritical marks were omitted in Dr Hunter's plan, and a certain freedom was allowed in spelling names which were familiar to the public, or had become historical, in an unscientific form He divided such names into two classes Some, such as Calcutta,

[1] With a letter dated Sept 26th, 1870 He also discussed the question in the preface to his "Manual of Indian History

[2] "Remarks on the Orthography of Indian geographical Names, with especial reference to the proposed new Indian Gazetteer," by the Rev T Barton, M A, late Principal of the Cathedral Mission College, Calcutta (Stanford, 1871)

Bombay, Lucknow, were to have remained unaltered Others were to have been brought a little nearer to the pitch of scientific accuracy without losing their popular identity Thus *Dinapore*, the correct form of which was said to be *Danapur*, was to be *Dinapur* *Cawnpore*, which should be *Kanhpur*, was to be *Cawnpur* *Oude*, which should be *Avadh*, was to be *Oudh* The Government must, Dr Hunter submitted, consider, not what is best, but what is practical He endeavoured to get rid of accents as much as possible, but at the same time he attempted to show the true pronunciation at a glance Dr Hunter's plan may be described as the nearest approach to the "scientific system" that it is believed the general public, in the present state of education, are able to endure [1]

The Government of India approved of Dr Hunter's plan for the Gazetteers on February 28th, 1870 A guide to the orthography of Indian proper names was prepared in 1871,[2] containing the spelling of 2,186 postal towns and villages of India according to Dr Hunter's system, and on February 28th, 1872, this guide was ordered to be circulated to all the local authorities A second guide was printed in 1872 [3] The plan of Dr Hunter, thus sanctioned by the Government, was adopted in legislation, in the gazetteers, by the Surveyor General, in the Post Office Guide, in the Railway Time Tables, in the Telegraph Department, by the East India Railway, by the Government offices, and by several

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1 The following are the powers of the vowels in Dr Hunter's plan They are identical with those of Sir William Jones and Professor Wilson

| | |
|---|---|
| Short *a* | as *a* in the second syllable of tartan, and as *u* in but |
| Long *a* | as *a* in the first syllable of tartan |
| *i* | as *i* in ravine |
| *u* | as *u* in rural |
| *e* | as *a* in mate, dare |
| *o* | as *o* in note |
| *ai* | as *i* in ride, size |
| *au* | as *ou* in cloud |

He omits *i* and *u* of Jones

2 "Guide to the Orthography of Indian proper Names, with a List showing the True Spelling of all post towns and villages in India, by W W Hunter, Esq, LL D Director General of Statistics to the Government of India (Calcutta, 1871) Folio, pp xiii and 146 Dated at Simla, Nov 10th, 1871

3 Dr Hunter prepared the second orthographical guide —"Standard Spelling of Indian geographical names, by W W Hunter, Esq, LL D, Director General of Statistics to the Government of India" (Calcutta, 1872), pp 162, octavo

It is arranged in three columns I Name as spelt in Dr Keith Johnston's Royal Atlas II Correct spelling III Column for local verifications from the vernacular newspapers Up to that time the spelling of the same place had varied in the different local gazettes The Postal Guide spelt the name of a town in one way, the Railway Companies in another Even two officials, dating their letters from the same place, often spelt it in a different way The well known province of Sind was officially spelt in no less than six different ways, namely *Scinde*, *Scind*, *Scindh*, *Sindh*, *Sinde* and *Sind*

On June 27th, 1872 the Secretary of State in Council, having considered the above proceedings of the Government of India, addressed a despatch to the Viceroy, "on the orthography of the "Roman character of Indian proper names" In this despatch assent was given to the measures which had been adopted, but it was suggested "that some extension should be given to that part of "the scheme which permits a departure from the new system, in "the case of those places of which the names have acquired a widely "recognized mode of spelling, either from popular custom or in "consequence of historical notoriety"

Vernacular lists were then prepared of the names of districts, towns, rivers, and places in the various provinces, and carefully translated, on the above basis, into the Roman character In the case of well known places which have obtained a popular or historical fixity of spelling, this customary spelling was to be retained For other names the correct transliteration was to be enforced In this way lists have been drawn up, approved, and published in the Gazette, for Assam, the North-Western Provinces, Oudh, the Punjab, the Central Provinces, the Berars, Bombay and Sind, Mysor, Coorg, and Bengal That for Madras has not yet been received, and for Burmah it is not known whether any list will be prepared Unfortunately the various compilers of lists have adopted no uniform rule in the selection of names which are to retain an old and incorrect spelling In some lists the number of instances in which old spellings have been retained is so large as to make the desired improvement a nullity It is to be hoped that these inconsistencies will be eliminated before a general and complete list is sanctioned

Dr Hunter states that through the agency of the Gazettes, official reports, the new maps, and the greater part of the Indian newspapers, the adoption of the scheme is gradually becoming general "But" (he continues) "the tangled growth of a century "cannot suddenly be transformed into order or cleared away A

" whole generation of Anglo Indians must pass before general " uniformity can be looked for, but meanwhile the old standing " difficulties in the way of a uniform orthography for the 'Imperial " 'Gazetteer' have been removed "

It is vain to hope that there will be a general agreement as to the best system of orthography for Indian proper names At the same time uniformity has become essential, especially between maps and gazetteers, and the official introduction of one uniform system, if there is a fair chance of its being generally adopted and becoming permanent, is undoubtedly a very great advantage A recension of all the names in the Postal Guide of India was a very formidable undertaking, and that Dr Hunter should not only have completed it, but also have achieved so large a measure of success in his efforts to secure the adoption of the new system, are striking proofs of how much good service may be done by the judgment, tact, and perseverance of one man, within a comparatively short time It is very important that an authoritative general list, giving the officially adopted spelling for all names in British India, should be published without further delay

# XXII

## THE GEOGRAPHICAL DEPARTMENT OF THE INDIA OFFICE

A Department for the systematic utilization of geographical work has been considered to be an important and indeed an essential element in the Home Government of a great Colonial Power, ever since Columbus first sailed from Palos. Bishop Fonseca was alive to its necessity, and as soon as the Royal Council of the Indies was formed, in 1524, for the Home Government of the vast trans Atlantic possessions of Spain, a Geographical Department was regularly organized. In those days it was called the Office of the Cosmographer of the Indies, but, allowing for the difference of time the duties were the same as those which should devolve upon a similar Department at the present day. The utilization of geographical knowledge was as important, and the value of science in all branches of administration was as great, then as now.

It was the duty of the Cosmographer's Department, in the Office of the Council of the Indies, to furnish geographical knowledge to officers and servants of the State, to supply instruments, to apprise officers in the Indies of the times for observing, to collect and enter in books all routes and journeys made in the Indies with care and accuracy, to construct maps and charts in accordance with the descriptions received, and to record all such descriptions, and other reports of a like nature. Finally, the Cosmographer was called upon to train up a class of efficient geographers, and this was one of the most important parts of his duty. He gave three yearly courses of lectures, which were attended by young officers and pilots. The course for the first year consisted of the four rules of arithmetic, the rule of three, extraction of square and cube root, fractions, and and Sacrobosco's "De sphæra mundi." The second year's course comprised the six first books of Euclid, arcs and chords, right sines tangents and secants, the tables of King Alfonso, George Purbach's theory of the planets, and the fourth book of the spherical triangles of Muller (or Juan de Monte Regio, as the Spaniards called him). The third year's course included the Almagest of Ptolemy, cosmo graphy and the art of navigation, the use of the astrolabe and its mechanism, the use and adjustments of other instruments, and the method of observing the movements of the heavenly bodies.[1]

This wise care for the instruction of their officers as geographers, on the part of the Council of the Indies, was one of the most admirable parts of their system, and one which would be well worthy of imitation. For the rest, the labours of their Geographical Department were of inestimable value, and a knowledge of them will always be indispensable to students in the wide field of research which they embrace. The one great fault of the Spanish officials was their love of secrecy, but even this arose, in great part, from their sense of the value of the information that had been collected, and it ensured, at all events, due care in the preservation of the records. All branches of knowledge connected with geography were not utterly neglected, nor were precious documents destroyed by cartloads, or left to rot and perish.

When the East India Company was first formed in London, its enlightened managers had not then a great empire to administer, like the Council of the Indies at Seville, but very few days had elapsed before they saw the necessity for a Geographical Department as part of their system of management. Correct geographical information was, they well knew, as necessary for a body of merchants as for the administrators of an empire, and two months after the incorporation of the Company we find Richard Hakluyt, the illustrious founder of the East India Geographical Department, preparing memoranda of the chief places where sundry sorts of spices do grow, gathered out of the best and latest authors, of the prices of precious stones and spices, of what is good to bring from the Indies by him that is skilful and trusty, of certain commodities of good request gathered out of authors that have lived and trafficked in those parts, and of other information of a like nature.[2] A few years afterwards Edward Wright was added to the Department, to

[1] "Ordenanzas del Consejo Real de las Indias, por el Rey Felipe IV, 1636, ccxxxviii to ccxliii. Also in the "Recopilacion de leyes de los reynos de las Indias, Carlos II." Lib. ii., Titulo xiii., Leyes i. to v. (Tom. i., p. 185.)

It should be remembered that the Cosmographer's Department of the Council of the Indies was quite distinct from that of the "Piloto Mayor" at the "Casa de Contratacion." The latter was analogous to the present Hydrographer's Department at the Admiralty.

[2] 'Divers Voyages, by Richard Hakluyt,' printed for the Hakluyt Society, and edited by Mr. Winter Jones (1850), p. 151.

compile the maps and charts, and the collection of geographical information in the form of logs and journals was commenced.[1] Wright was the first Englishman to publish the principle of Mercator's projection, in his "Correction of Errors in Navigation," 1599.

For a century and a half the labours of the Geographical Department were chiefly confined to the preparation of charts and the record of voyages, but with the acquisition of Bengal by Lord Clive commenced the land surveys of Rennell, "the Father of Indian Geography." When Major Rennell returned from his severe labours as a surveyor in Bengal, he devoted the remainder of his life to the interests of Indian Geography at home. He was the unpaid but most efficient head of the Geographical Department of the India House. His Bengal Atlas was already published by order of the Company in 1781,[2] but in March 1788 his famous map of India appeared, and the memoir followed in 1792. This is the starting point in the history of Indian Government map making, and the memoir furnished a complete account of the material upon which Rennell's map is based. The map of D'Anville, published in 1751 and 1752, was still the basis upon which the new work was to be founded, but Rennell collected much additional material. He had the route surveys of General Goddard from the Jumna to Poona, of Captain Reynolds through Malwa, of Colonel Fullerton in Coimbator, of Colonel Call in Tinnevelli, and those made in the wars with Haider and Tippu, besides the marches of Bussy in the Deccan. On the Bengal side he had his own admirable surveys, but D'Anville's map was still the best authority for the Punjab and the course of the Indus, as it was until very lately for the upper basin of the Brahmaputra. Rennell's interest was excited by the accounts he had obtained from the notes of Captain Kirkpatrick, of the remains of old irrigation works north of Delhi, the canal of Shah Firoz, and the new cut of Shah Jehan, and he regrets that the descriptions of them were so obscure. He also discussed in his memoir the question of the identity of the Brahmaputra with the Sanpu, advocating that view against a counter theory of D'Anville, and he identified some of the Punjab rivers with those mentioned by Arrian and Pliny. It is unnecessary to say that, though Rennell continued

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1 Calendar of State Papers (Colonial, 1513–1616), para. 284.

2 "Bengal and Behar Atlas," by James Rennell, 1781, published by order of the East India Company. The maps are dedicated to the memory of Lord Clive, to Warren Hastings, Sir Hector Munro, Mr. Verelst, &c.

to labour zealously in the interests of Indian geography for the remainder of his life, his works were by no means confined to the scenes of his active service. He welcomed all geographical material, and warmly supported all explorers. When the engineers who accompanied the Indian armies, in their various campaigns, produced new work, it was Rennell who promptly brought it to the knowledge of their countrymen at home.[1] In 1798 he was assisting Mungo Park in the arrangement of his African travels. His great work, the "Geographical System of Herodotus examined and explained," was published in 1800, and in 1816 it was followed by his "Geographical Illustrations of the Retreat of the Ten Thousand." He also devoted many years to the collation of the log books of the Indiamen for 40 years back, and his valuable results, entitled "Investigations of the Currents of the Atlantic," &c., were published by his daughter, Lady Rodd, with several large charts, after his death.

Rennell lived to a great age, and never ceased to devote his time to the interests of Indian geography. After he had reached his 87th year he possessed in full vigour all his intellectual faculties, and, though suffering little short of martyrdom from frequent attacks of the gout,[2] he still devoted many hours of each day to his favourite pursuit. There is but one thing to regret in the great geographer's career. His early prejudice in favour of route surveys led him to withhold from Colonel Lambton that hearty support which would have been invaluable, from such a quarter, when the Trigonometrical Survey was in its infancy. But he became convinced of the superiority of Lambton's method long before his death, and welcomed with joy the 6-sheet map of India by Walker,[3] which was partly based on triangulation. He was remarkable for true, patient, and persevering research; his critical judgment was seldom at fault, and his work is always reliable.

Rennell died on the 29th of March 1830, at the great age of 88, and was buried in Westminster Abbey, where there is a mural monument to his memory.[4]

Major Rennell never held any official appointment after his return

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1 "On the Marches of the British Army in India, during the Campaign of 1791,' by James Rennell. (1793.)

2 "Quarterly Review,' vol. xxxix. p. 179 (1829).

3 Allen's.

4 A memoir of Major Rennell, reprinted from the "Address of the President of the Royal Society, on November 30th, 1830, is given in *Gleanings in Science*, iii., p. 409 (Calcutta), 1830.

See also "Notice Historique sur la vie et les ouvrages de James Rennell, par M. le Baron Walckenaer." (4to. Paris, 1842.)

to England His great services to India were all rendered from motives of zeal His contemporary and active fellow labourer, Dalrymple, was the recognised official Hydrographer in those early days

Alexander Dalrymple, the seventh out of 16 children of Sir James Dalrymple, was born at New Hailes on the 24th of July 1737 He received little or no education, and it was not until after he had gone out to Madras as a writer in 1752 that he taught himself accounts and the French and Spanish languages In 1759 he was sent on a voyage to the Eastern Islands, and acquired much nautical experience In 1765 he returned to England, and published several charts and plans of coasts and anchorages He went back to Madras as a Member of Council, under Lord Pigot, in 1776, and finally went home in 1777 Two years afterwards he received the official appointment of Hydrographer to the East India Company Dalrymple was a most indefatigable collector of geographical materials Rennell acknowledges the assistance he received from the Company's Hydrographer in the preparation of his great map of Hindustan, and Dr Vincent was indebted to Dalrymple for the maps and charts to illustrate his great work, "The Voyage of Nearchus" Dalrymple was, indeed, a most industrious and untiring workman He translated and published several voyages from the Spanish,[1] and Admiral Burney, in the preface to his great work on voyages in the Pacific, says that the above translations of Dalrymple were his *vade mecum*, and that he was largely indebted to their author Dalrymple advocated the existence of a southern continent, and was anxious to sail with Captain Cook in the "Endeavour," but was prevented because he had not been bred in the navy He gave many tracts to the world on various subjects[2] In 1790 he made a useful suggestion to the East India Company, which was approved and the sum of 200*l* was granted for the purpose The scheme was to publish tracts from time to time on the geography, commerce, and products of the East The result was "The Oriental Repository," in two volumes, which contains several papers of considerable interest, especially those on the cultivation

[1] "A historical collection of the several voyages and discoveries in the South Pacific Ocean, being chiefly a literal translation from the Spanish writers, by A Dalrymple, London, 1770, 2 vols With an extraordinary dedication, stating to whom it is *not* dedicated He gives Magellan from Herrera and Barros, Juan Fernandez from the Memorial of Arias, Mandana and Quiros from Figueroa and Torquemada, Le Maire and Schouten, Tasman and Roggewein At the end there are many curious woodcut

[2] Bound up in three volumes in the Geographical Society's library

of various Indian products, by Dr Roxburgh Dalrymple's strictly official work is represented by 58 charts, 740 plans, and 57 views of coasts, in all, 855 plates, besides 50 nautical memoirs [1] In 1795 the office of Hydrographer to the Admiralty was created, and Dalrymple was the first to hold it, together with the same post at the India House He filled it until 1808, when he was suddenly called upon to resign by Lord Mulgrave He declined to do so, and was summarily dismissed on the 28th of May On the 31st he published "The Case of A Dalrymple," bitterly complaining of the treatment he had received It broke the old man's heart, and he died on the 19th of the following June [2]

On Dalrymple's death Captain Hurd succeeded him at the Admiralty, but his post at the India House remained for some time vacant, until an accumulation of nautical materials led to the appointment of Captain Horsburgh, who had made himself known by the publication of several valuable charts of the China Seas Sir Charles Wilkins, the librarian, had charge of the original maps, memoirs, and other records, while Horsburgh performed the duties of hydrographer

James Horsburgh was born of humble and respectable parents at the small village of Elie, on the south east coast of Fife He commenced his career as a cook and cabin boy, and eventually rose to be captain of the "Anna," East Indiaman, in which he sailed from England in 1802, returning in 1805 In a paper printed in the "Philosophical Transactions" he detailed his meteorological observations, and in 1806 he began to collect materials for sailing directions After some years of indefatigable research he completed his "East India Directory," which has gone through eight editions, and is still the recognised guide for the navigation of the Indian seas [3] Under Horsburgh's superintendence at the India House,

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[1] A large number of Dalrymple's charts and plans are bound up together in a volume preserved in the Geographical Department of the India Office The number is 454

[2] There is a memoir on Dalrymple prepared by himself in the "European Magazine, Nov and Dec 1802

[3] It was preceded by Laurie and Whittle's "Oriental Pilot The first edition of Horsburgh's Directory appeared in 1808, the second in 1817, the fifth in 1841, the eighth and last in 1864 See page 44

Captain Horsburgh became a Fellow of the Royal Society in 1806 In 1816 he published his "Atmospheric Register for indicating storms at sea In 1830 he contributed a paper to the Royal Society on "Icebergs met with in the Southern Hemisphere" which began in 1810, many valuable charts were compiled and published.

Dalrymple was more an industrious collector of materials than a compiler. The map of India which succeeded Rennell's was by that famous cartographer, Aaron Arrowsmith. This was the last great map based on route surveys. The materials were furnished from papers and drawings belonging to the Duke of Wellington, Sir John Malcolm, Dr Buchanan, and Colonel Colin Mackenzie. It was published in 1816, in nine sheets, on the scale of 16 miles to an inch.

But the labours of the topographical surveyors of the Madras Military Institute, based on the triangulation of Colonel Lambton, began to attract attention as soon as their results arrived in England, and the necessity for the publication of more accurate and detailed maps of India than had hitherto been produced was soon acknowledged. Aaron Arrowsmith was of course consulted. He constructed a projection for a new atlas of India, on the scale of four miles to an inch, and the Madras survey maps were placed in his hands. The result was the publication of his atlas of South India, from Cape Comorin to the Krishna, in 18 sheets, on the scale proposed, which appeared in July 1822.

The question of the publication of the results of the Great Trigonometrical and Topographical Surveys, which had now been in progress for upwards of 20 years, was carefully and anxiously considered by the Court of Directors, and Colonel Salmond, then Military Secretary, was, for some years, in consultation with Colonel Mackenzie, the Surveyor General at Calcutta, on the subject. Colonel Hodgson, Mackenzie's successor, returned to England, in the hope and expectation that the great work would be entrusted to him. It, however, would no doubt have been given to Aaron Arrowsmith, who had already made the projection, and, indeed, published several sheets in the best style of the day, but, just at that time, the veteran cartographer died. The East Indian Directors then appointed Mr John Walker to compile and engrave the sheets of the great Atlas of India.

Mr Walker came of a family of map engravers. His father had worked for Dalrymple, and his name appears on the maps in Vincent's Nearchus, on that in Salt's Abyssinia, on those in the Arctic voyages of Parry and Franklin, and on many others of that period. His name was also immortalized by Sir Edward Parry on a lofty cape in the far north, which is well known to many an Arctic traveller. The son was thoroughly trained, and the amount of judgment and ability he brought to the great task he undertook is shown by the often disputed but ever approved excellence of his work.

The Indian Atlas was designed to occupy 177 sheets, 40 inches by 27, and the globular projection and scale (4 miles to the inch), originally proposed by Mr. Aaron Arrowsmith, were adopted. The scheme embraces the region from Karáchi to Singapore, and includes Ceylon. From 1825 Mr. Walker combined the various documents sent home by the surveyors in India, prepared the sheets for publication, engraved them on copper, and issued them to the Surveyor General in India and to the London Agent.

Sir Charles Wilkins, the librarian who had charge of all geographical records, died in Baker Street, at the great age of 85, on the 13th of May 1836. Captain Horsburgh, the Hydrographer to the East India Company, died at Herne Hill, at the age of 74, on the 14th of the same month of the same year. Mr. Walker was then engaged to take charge of all the records that had previously been under the care of Sir Charles Wilkins, in addition to his other duties. As Captain Horsburgh's coadjutor and successor Mr. Walker produced nearly a hundred charts, many of which are of a large size, and the majority are still the chief authorities followed by navigators in the Eastern seas to this day. He also continued to engrave the sheets of the Atlas and other maps. Engraving was his special work. The care of records and conduct of geographical business required departmental agency for its efficient discharge. None was furnished. All geographical work ceased to be performed; the records were lost or left to rot, and even the correspondence book was destroyed. But Mr. Walker's duties as a cartographer were admirably performed.

The first sheets of the Atlas were of course those for which the Madras Topographical Surveys furnished the materials. The first was published in 1827. Then followed one of Bandalkhand from Captain Franklin's work, and the Himalayan region from Hodgson's and Herbert's surveys. These, however, have since undergone complete revision. In 1860, and again in 1863, remonstrances were received from India at the delay in the execution of the sheets after the materials for them had been sent home. With a view to obviating this delay, a proposal was made by the Surveyor

General in July 1864 that the sheets of the Atlas should henceforth be brought out in quarter sheets. Mr Walker concurred that this arrangement would expedite the work, and it was accordingly adopted. There has always been the highest testimony to the accuracy and excellent style in which Mr Walker has produced the Atlas sheets.

But Mr Walker's work is by no means confined to the sheets of the Atlas. He has engraved seven maps of the triangulations, including Lambton's operations, Everest's great Arc Series, and Waugh's N.W. Series, the last forming a chart of five feet by six in extent. Of general maps of India he has drawn and engraved one on six sheets for Messrs Allen, a skeleton map on six sheets for the Government, a map in two sheets, and some others. Simm's large plan of Calcutta, drawn in 1848–49, was reduced and engraved by Mr Walker in four sheets.[1] From 1846 to 1848 a number of maps of districts in the Bengal Presidency were required to be reduced from the Revenue Surveys to a ¼ inch scale, and lithographed. Those of the North-West Provinces were, as has been seen, prepared and published at Allahabad, under the orders of Mr Hugh M. Elliot, the Secretary to the Board of Revenue. But those of the Lower Provinces were sent home to be lithographed in England. Of these 31 were executed by Mr Walker, and a few appear to have been entrusted to Mr Wyld, in 1848. Mr Walker also executed a Revenue Map of the North-West Provinces, and one of the Ajmir District.

The most beautiful specimens of Mr Walker's lithography are his production of Colonel Robinson's remarkable survey of Jhelum and Rawal Pindi in eight parts, on 28 sheets, and his maps showing the results of Captain Montgomerie's surveys in Jumu and Kashmir. There are four sheets on a scale of two miles, and four on a scale of four miles to an inch.

A map of the Jalandur Division of the Punjab, maps for General Cunningham's and again for Mr Vigne's travels, the map for Wood's Oxus, one of Gwalior in four sheets, one of Nagpur and Wurdah, and a carefully compiled map of the North West Frontier of India on two large sheets, are also among Mr Walker's works.

The manuscript maps forming the results of the Haidarabad

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1 The manuscript is deposited in the Geographical Department of the India Office.

2 Balasore, Bijnur, Goruckpur, Ghazipur, Jounpur, Moradabad, Patna.

Survey were sent home and taken in hand by Mr Walker, and he completed 13 Circars on a scale of a mile to an inch. The rest remained to be done.

Mr Walker engraved the two sheets of Colonel Scott's excellent general map of the Madras Presidency, and another general map of the Bombay Presidency in three sheets. He constructed a map of Arabia in two sheets, one of the routes between Constantinople and Delhi, and engraved a series of elaborate maps illustrating the Assyrian Vestiges, by Captain Felix Jones, in four sheets, and the Surveys in Mesopotamia by Selby, Collingwood, and Bewsher, in two sheets. Add to this 87 out of the 200 charts published from surveys executed by officers of the Indian Navy.

Such is an enumeration of the work performed by the veteran geographer of the East India Company. It is work of which he might well be proud, and places him in the first rank of the geographers of the present century. Mr John Walker died, in his 86th year, on April 19th, 1873, having been in the employment of the East India Company and of the India Office for 48 years. He was the depository of official traditions extending over half a century, and his well-stored memory frequently proved of great value to his successors. Just before his death Mr Walker had received a complimentary letter, which was addressed to him by order of the Secretary of State, on the value of his long and zealous services.

In 1868 the question was raised whether the time had not come when the remaining sheets of the Atlas might with advantage be taken up by the Surveyor General himself, and engraved at Calcutta. Hitherto the difficulties in the way of such a course had consisted in the want of means and the absence of an efficient staff. These difficulties had to a great extent been surmounted during the time that Colonel Thuillier had been in charge, who had year by year increased the efficiency of the lithographic and drawing branches of his office, and continually introduced new improvements. The advantages of the arrangement were obvious. It was most desirable that the sheets should be compiled and prepared within easy distance of the surveyors who had made the original drawings, and to whom reference could at once be made for the solution of any point that might arise. Much time might also be expected to be saved. Even in an economical point of view the change would probably be advantageous, as soon as the natives of India had learnt the art of engraving and hill etching.

The change was accordingly sanctioned, and Colonel Thuillier was deputed to make the necessary arrangements in England during the year 1868. He arranged with Mr. Walker that all plates of sheets of the Atlas actually in progress, or for which materials had been sent to England, should be finished by Mr. Walker, and that the rest should be undertaken by the Surveyor General in India. Thus time was given for Colonel Thuillier to organise his increased staff at Calcutta. Up to that time Mr. Walker had completed the engraving of 84 of the Atlas sheets.

Colonel Thuillier returned to India with a staff of carefully selected English engravers, in January 1869, and a notice of their progress has already been given at page 177. The whole work from the preliminary reconnaissance for the surveys to the publication of the maps is now done in India under the immediate eye of one chief, while plenty of useful work remains to be performed in the India Office.

Since 1836 all geographical and kindred subjects had been deprived of separate departmental supervision, and the maps, journals, and other records had been cast aside to rot and perish. Those which were not lost were frayed and dust stained, and finally a quantity were sold as waste paper. Ancient journals of great navigators, abstracts of which alone exist in the Pilgrims of Purchas, have disappeared, and many of the later memoirs and surveys of the time of Colin Mackenzie, and even a volume of the Great Trigonometrical Survey Series, are missing.

Yet, after all these deplorable losses, there remained a most valuable collection of maps and records, and the re-constitution of a Geographical Department at the India Office, such as had been found essential to efficient administration alike by the Council of the Western Indies in Seville and by the founders of the East Indian Empire in London, was urgently needed. The Surveyor General, while he was in England in 1868, represented the necessity for such a step, and the great inconvenience that had long been felt from having no separate Department of the India Office in direct communication with the Survey Departments of India. Such a branch of the Home Government would attend to the hitherto neglected duties of receiving, analyzing, and arranging for general reference and use, all geographical and geological documents, of quickly disseminating all maps of a general character emanating from the great national surveys of India, and of transacting all business connected with the surveys and other scientific branches of the service. It was also represented to be essential, in order to meet the increasing demands for geographical information, that there should be proper arrangements for ready reference to, for the exhibition of, and for the immediate issue, for public purposes, of all geographical materials. The serious detriment to the public service caused by no Geographical Department having existed for several years was shown in the total loss of maps and memoirs representing recent surveys, which can never be replaced, in the long delays that had occurred in noticing important proposals for scientific purposes, and in the failure to make announcements of great moment to mariners or men of science, which had been duly reported from India.

In consequence of these representations the geographical and other kindred business of the India Office, which had been placed in charge of the compiler of this Memoir in June 1867, was formally organized, and Mr. Trelawney Saunders was appointed Assistant in the department in the autumn of 1868. Thus the labours of the reconstituted Geographical Department of the India Office extend over a period of ten years.

A perusal of the foot notes in the previous sections of this Memoir will give a general idea of the value and importance of the maps and records that have survived, and which are now preserved in the Geographical Department. They were found in a state of indescribable confusion, and undergoing rapid deterioration, and it occupied Mr. Saunders, whose experience at the Geographical Society had thoroughly qualified him for the task, for 165 days, six hours each day, to reduce the chaotic mass to anything like order. The arrangement of this valuable, and in some respects unique, collection of geographical records was completed in May 1869.

The next work was the establishment of a system for bringing the maps emanating from the great national surveys of India within the reach of geographers and other inquirers in Europe. Hitherto, it had only been possible to procure the sheets of the Atlas, and the numerous useful maps produced in India could not be obtained by the public, and indeed were unknown. In December 1869 three agents were appointed in London[1] for the sale of all maps published in the Surveyor General's Office at Calcutta, or in the office of the Superintendent of the Great Trigonometrical Survey, and the whole of these maps are now within the reach

[1] 1. W. H. Allen & Co., 13, Waterloo Place. 2. Edward Stanford, 55, Charing Cross. 3. Henry S. King & Co., 65, Cornhill. 4. Mr. Trubner, 57 Ludgate Hill, was added in October 1871.

of any purchaser Mr Saunders completed "A Catalogue of Maps "of the British Possessions in India and other parts of Asia, "issued by order of the Secretary of State for India," containing a synopsis of the political divisions of India, furnishing the key to the arrangement of the catalogue, an index map to the Indian Atlas, carefully and accurately constructed, the catalogue itself, giving the full titles of all the maps, and a general index The first edition of the present Memoir was completed and published in 1871

The valuable collection of manuscript maps and other documents, including many drawn by Rennell, Colebrooke, Mackenzie, Burnes, Wood, and other Indian worthies, is now open to inquirers for reference and inspection The study of comparative geography is a necessity for the historian and the antiquary It is also of practical importance to men of science and engineers The examination of a series of maps of a river or of a harbour, from the first ever drawn to the results of the latest survey, is a thing rarely to be obtained, but one of great interest, and often of practical utility Efforts have been made towards the improvement of the manuscript collection in this respect A complete set of copies of ancient Portuguese plans of towns and ports along the west coast of India,[1] the originals of which are in the British Museum, has been made for the Geographical Department There is also a very precious collection of 110 maps and charts of the Indian coasts, the dates of which range over a period of a century and a half, among the Royal Archives at the Hague The whole of these have been copied for the Geographical Department, through the kind intervention of Commodore Jansen of the Dutch Navy

Arrangements have been made for a regular exchange of maps with the Russian and Netherlands Governments in duplicate, one set being sent to the office of the Surveyor General at Calcutta, and the other being retained in the Department The advantage thus gained is twofold Geographical information is obtained, while, as the Surveyor General has observed, "the possession of such splendid "specimens of engraving and lithography, for the instruction of "members of his Department, is exceedingly valuable"

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1 The list of them will be found in the "Catalogo dos manuscriptos de Bibliotheca Eborense, Cunha Rivera,' i, p 302

2 The list of these Dutch maps of the coast of India is given in the "Inventaris der Verzameling Kaarten berustende in het Rijks Archief,' (1867,) pp 130–64

Exertions have been made to recover some of the lost treasures, and not wholly without success The original manuscript of a journal kept by Captain Knight during a voyage towards the North Pole in 1606 has been discovered amongst a heap of rubbish, and has been printed and edited in a volume of the Hakluyt Society's series[1] This interesting enterprize, which ended in the mysterious disappearance of Knight himself on the Labrador coast, was previously only known through a meagre abstract in Purchas

A like success attended an attempt to recover the results of Captain Selby's survey of the sea of Nejf, and part of the course of the Euphrates, which had been lost during the time that there was no separate Geographical Department The original maps and field books had fortunately been left at Baghdad They were sent for, 14 maps and 5 field books were duly received, and Lieutenant Collingwood was employed to reproduce the maps for engraving The ground they cover is most important, including the ruins of Birs Nimroud, Cufa, Mashad Ali, and Kerbela, and showing the region into which the waters of the Euphrates are being drained The loss of such a survey, executed at considerable expense and with uncommon zeal by the able officers in charge of it, would have been most serious Lieutenant Collingwood completed his work in June 1870 Like success has not attended efforts to recover Captain Selby's surveys of part of the Shattu-'l-Arab, nor the original drawings of the Red Sea survey for the Hydrographer of the Admiralty

The manuscript maps in the collection, many of them most precious relics of illustrious geographers and explorers, were never backed, nor adequately cared for During the period that no separate Geographical Department existed they were frayed and torn, stained with dust, and left in a most disgraceful state No blame whatever attaches to Mr Walker, who had not the means of providing against this destruction of the records The whole collection is now being gradually and steadily cleaned and backed

The map mounter was temporarily employed from January 1870, and received a permanent appointment in July 1873, with the assistance of an apprentice The total superficial area of maps mounted already covers 17,535 square feet

[1] In the volume containing Sir James Lancaster's Voyages (1877)

The Geographical Assistant has executed maps requiring much careful research, and has prepared several valuable geographical memoirs His "Memoirs of the mountains and river basins of India," with two maps, were published in the form of a quarto pamphlet early in 1870 The distinctive feature of the maps is, that the Himalaya mountains are given in a new form, the great peaks being represented in a culminating outer range, separated by a chain of elevated valleys from an inner range, which forms the water parting between the basins of the Ganges and Sanpu The Tibetan highland is also clearly defined, and the various elevations above the sea are admirably shown by varying depths of shading, and by sections The map of the river basins shows their extent at a glance, and the memoir is accompanied by a table of the areas of the basins, and lengths of the main streams His map of the central part of British Burmah, to illustrate the Journals of Captain McLeod, Dr Richardson, and subsequent travellers, is also a valuable addition to geographical knowledge, as it combines the routes of eight distinct explorers The collation of their observations, and the combination of different and sometimes conflicting authorities, is work which requires the experience and sagacity of a practised geographer for its satisfactory performance The completion of the lithography of the sheets of the Haidarabad Survey, left unfinished by Mr Walker, was also taken in hand[1] He prepared the admi-

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[1] Mr Walker had lithographed 13 of the Haidarabad circars in various sizes and styles namely—

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|---|---|---|---|
| Bassim, | Jaulna, | Maiher, | Patree, |
| Baythalwaddy, | Kowlas, | Nuldroog, | Purainda, |
| Dowlutabad, | Kullinnair, | Nurnulla, | Pyton |
| Gawilgurh, | | | |

The Department has since completed eight circars, in a uniform manner, on 92 sheets of imperial size (30 inches by 22), which are beautiful specimens of lithography They are—

| | | | |
|---|---|---|---|
| Bheer, | Nandair, | Warungul, | Eilgundel, |
| Daroor, | Beder, | Medduck, | Mullungore |

There are still 16 circars unpublished, namely—

| | | | |
|---|---|---|---|
| Koolburga, | Raichoor, | Koilkonda, | Kummumett, |
| Mullair, | Moodgul, | Gunnapoore, | Bonagheer, |
| Yedagherry, | Pangul, | Devercondah, | Hyderabad, |
| Suggur, | Ramgheer, | Nelgoonda, | Mahore |

But the drawings of these are treated differently from those already published, and they are often on different scales, and more or less imperfect The circars of Suggur, Raichoor, and Moodgul are altogether wanting at the India Office Among the circars rable maps for the "Moral and Material Progress Reports" of 1873 and 1874, and has compiled maps of the famine districts and several other pieces of work of a similar character from time to time, according to the requirements of the service.

In February 1872 the Department was so fortunate as to obtain the services of Colonel Walker, the Superintendent of the Great Trigonometrical Survey of India, for six months, to make a thorough investigation of the condition of the plates of the Indian Atlas remaining in England, and to decide what should be done with regard to each plate. The Department was thus furnished with an unerring guide for the future, in the conduct of a difficult and complicated part of the business.[1] Colonel Walker also prepared a memorandum on the projection and scale of the Indian Atlas.

There was urgent need for adequate space in the India Office for the priceless collection of maps. This collection is intended to serve two purposes: 1. The ready supply of information for official and general use; 2. The record and preservation of original documents. In order to ensure the first object there are orders that copies of every map of whatever kind that may be published in India shall be forwarded to England. Accordingly the Surveyor General arranged to send a box of maps to England every quarter. These maps are required in all Departments, and the efficiency of the collection can only be attained by the provision of adequate space. For the record and preservation of original documents space is of equal importance. After the millions of money spent on all the various surveys of India it is of paramount consequence that the results should be placed beyond the chance of loss, by

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executed by Mr. Walker are four which are now included in Berar. Two of these were published when the survey of them was unfinished, and all four have undergone considerable revision, besides being no longer actual administrative divisions of the Nizam's Government. In continuing the publication of the Haidarabad Survey it is, therefore, proposed to republish first the parts now included in Berar, with the revised and additional surveys relating to them, arranged according to the present divisions. These should be followed by Mahore and Ramghir, on the S.E. frontier of Berar, and bordering on the Central Provinces. The other parts of the 16 unpublished circars will be proceeded with as soon as the drawings are made complete.

[1] See Memoranda by Colonel Walker, on the present state of the arrangements for the publication of the sheets of the Indian Atlas in England, and on the projection of the Indian Atlas, in the Abstract of the Reports of the Surveys 1870–71, p. 72, and 1871–72, p. 47. These are also printed at the end of this section. See page 431.

keeping the originals or copies in England There has already been much loss, indeed, the loss of records in India represents a waste of money amounting to thousands of pounds The urgency for granting this space was frequently represented, and it has at length, in 1877, been provided, for the permanent collection, for the stock, and for the map mounter [1]

During 1872 the map mounter got through a vast amount of work Complete sets of maps were presented to the Royal Botanical Gardens at Kew, to the Privy Council Office for the use of the Judicial Committee, to the Royal Geographical Society, to the War Office, the British Museum, the Radclyffe Library at Oxford, and to numerous scientific and other bodies For Kew alone 175 maps were mounted, covering an area of 1,000 feet In order to show the economy that is ensured by the employment of a thoroughly efficient map mounter, I may mention that the time occupied in this work was 120 hours at 6*l*, and the materials cost 5*l* 10*s*, total 11*l* 10*s* The same work done outside would have cost 25*l* As many as 850 maps have been mounted, of which 500 belonged to the permanent collection

On July 25th, 1872, I received a letter from Mr Grant Duff, then Under Secretary of State for India, requesting me to undertake the preparation of the Annual Report on the Moral and Material Progress of India It was Mr Grant Duff who secured compliance with a clause in the Act creating the Indian Council which provided for the preparation of these annual reports It was his object that they should not be mere colourless official statements He desired that an interest should be aroused in Indian affairs by the annual presentation of a thoroughly readable document [2]

The graphic illustration of statistics brings the Moral and Material Progress Report into direct and harmonious contact with

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[1] This subject is more fully discussed in the "Abstract of Surveys for 1872, p 67 See also Despatch to India of November 25th (No 22), 1869, to Madras, July 22nd (No 1), 1869, and to Bombay, July 29th (No 2), 1869, also to India, January 5th (No 1), 1871, and to Madras, November 2nd (No 3), 1872

[2] The clause in the Acts is as follows —"And such account shall be accompanied by a statement prepared from detailed reports from each Presidency and District in India, in such form as shall exhibit the moral and material progress and condition of India in each such Presidency' —21 & 22 Vict cap 106, sec liii

geography Territorial limits are one of the bases of statistics, population comes next, and these two statistical elements necessarily rule all others Maps and diagrams both generalize and allow of abstraction They enable inquirers at once to detect and often to rectify errors, which, if undetected, would effect results and throw everything into confusion In the Geographical Department there is the efficient means of employing this method to advantage, and almost all statistical facts can be treated on the basis of geographical distribution Population may be illustrated with reference to the physical aspects of a country Agricultural statistics may be shown, not only with reference to the yield and area of crops, but also to the proportion of that yield to population Fiscal arrangements, as regards India, may be very clearly explained on a map, better indeed than by any system of tabulation Manufactures, commerce treated from various points of view, institutions, languages, ethnology, religion, education, crime, medical statistics, political questions, and distribution of troops are all capable of cartographic illustration Not only is this method a necessary part of statistical work, but it serves to give aid, supply checks, and detect errors in tabulation The two methods are necessary to each other

In designing the new series of Moral and Material Progress Reports I considered that the usefulness of reports of this kind depends on the systematic classification of facts in appropriate groups, such as every accurate thinker or careful historian necessarily adopts for his own use The Report of 1873 was divided into fifteen sections, each treating of a special administrative subject or group of subjects as they affect the whole of India, the aim being to include in each section those subjects which have more characteristics in common with one another than any of them have in common with any other subject not in that section The Report was prepared on this plan, with fifteen maps, and, as commencing the series, a retrospective history of each subject was given for facility of reference

The Report was completed in good time, and was presented to Parliament in April 1873 Its object, which was the promotion of a general interest in Indian affairs, was gained The plan was good and only needed further development At the same time it was a first attempt at real improvement and was very defective It is no easy task to reach a point anywhere near perfection in a report embracing so wide a range of subjects It requires the close attention of several years, each year producing its special improvement, before such a document can be made satisfactory, and to this task the energies of the Geographical Department were now directed

In the year 1873 the Department did much useful work, including assistance to Sir Frederic Goldsmid and the other officers who then returned from Eastern Persia, in preparing the results of their work in the field, and especially to Major St John in the compilation of his important map of Persia

In this year also the fruits of the action of the Department with regard to Marine Surveys were fully reaped [1] The subject received careful consideration, and a despatch from the Government of India was received, dated June 30, 1873, which led to the establishment of a Marine Survey Department at Calcutta, under the able management of Captain Taylor, and to the restoration to efficiency of this important branch of the public service

In July 1873 a special permanent appointment was sanctioned of a "Clerk in the Geographical Department"

At the same time the increasing transactions with the agents, and the requirements of the auditor, necessitated the introduction of a proper system of book keeping, and for this service a temporary clerk was appointed

Thus, in 1873, the Geographical Department was for the first time supplied with a sufficient staff, and a suitable organization It consisted of six members, including myself The Geographical Assistant has charge of the collection of maps, supplies geographical information when required, prepares maps, and also has the duty of passing the general catalogue through the press The specially appointed clerk was my personal assistant in many ways, but particularly for correspondence There was also a very efficient temporary clerk, and a map mounter and apprentice who also perform other multifarious duties

The "Moral and Material Progress Report for 1874" was arranged to be a revised edition of that for 1873 Many improvements were introduced, the different sections were re written, and sixteen maps were prepared Among them there is one showing all the divisions

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[1] See page 42

[2] Parliamentary Papers East India (Marine Surveys) Return, 21st March 1877 General Report on the operations of the Marine Survey Department, 1874–76 with Appendices

of India, which is quite unique, and has received almost unqualified praise from the leading geographers of this country and of Germany In addition to the maps, an appendix was introduced, consisting of a series of statistical tables The India Office is indebted to Mr Prinsep, who has for many years prepared the tabular statements, for the conception and annual improvement of the Statistical Abstract presented to Parliament, consisting of a series of useful tables But it was considered desirable that the cartographic and tabular illustration of statistics should be combined, and that both should be comprised in the "Moral and Material Progress Report"

For the Report of 1874 the subjects selected for tabulation were first the two statistical bases of area and population, next the financial statement, then the trade returns, and, finally, tables showing the progress of education, and the number and distribution of troops These might perhaps be added to, but in selecting subjects for tabular illustration those only should be chosen that are adapted for that method It is also a great point to include as much as possible in one glance, and to avoid any unnecessary multiplication of tables, especially on the same subject I paid very special attention to the latter point in the preparation of the statement of Indian exports and imports

The "Moral and Material Progress Report of 1874" was presented in good time, and received even more general and hearty commendation than the former one It was an improvement, but it did not deserve the praise that was bestowed upon it The plan for the future was that the succeeding Reports should only contain the transactions of one year, as a rule, but that in each year one particular subject should receive special elaboration, while attention was also given to the improvement of the Report as a whole Thus, when at the end of a fixed period a new edition of the more complete Report of 1874 was produced, it was hoped that it would make some approach to perfection, and would really deserve the praise which its predecessor received My plans for future years were as follows For the Report of 1875 special attention had been given to the Education Section There would have been a general review of Indian literature on the plan of the annual pamphlet brought out by M Garcin de Tassy, and more complete information respecting missionary work In 1876 the Census would have been thoroughly discussed, with a careful map It had been pointed out to me that the Reports lost much of their value to real students from not being furnished with those copious references to authorities which make the publications of Justus Perthes so useful. A system of references would, therefore, have been commenced with the Report of 1876, and a copious index would have been added. That of 1877 would have contained a completely re-written section on agriculture, with such a system of illustrating agricultural statistics as I sketched in a paper read before the Society of Arts.[1] Thus each Report would have contained some one specially elaborated subject, until the time came for the second edition of the complete Report of 1874, when the whole would have been condensed and combined together in one harmonious work. Meanwhile the most important consideration was the preservation of exactly the same arrangement of the sections, in the successive Reports. Any departure from the original arrangement destroys continuity, and thus mars the usefulness of the Reports for purposes of reference.

The year 1875 was one of much departmental activity. Among other things the collection of charts, maps, and books for exhibition at the Paris Geographical Congress had to be prepared for Colonel Montgomerie, and a catalogue was drawn up in a compact form which served its purpose admirably. In this year also the Auditor called for a detailed account of the stock of maps on hand, and the staff of the Department applied themselves with vigour to the laborious task, necessitating the opening of every parcel, and the counting of its contents.

The discovery of the journals and other papers of Mr. George Bogle, who was sent on a mission to Tibet by Warren Hastings, and of Mr. Manning, the only Englishman who ever visited Lhasa, furnished a good deal of useful work for the Department during the year 1876. The preparation of an official work on Tibet was sanctioned, which afforded an opportunity of bringing together much useful geographical information. The maps were prepared by the Geographical Assistant, who was also indefatigable in identifying names of places, and in conducting difficult bits of research. The specially qualified clerk gave assistance in many ways, besides translating the narratives of Grueber, Desideri, and Della Penna

1 "Agricultural Statistics of India." Paper read at the Society of Arts, May 21st, 1875. No. 1174, vol. xxiii., p. 599.

from the Italian The temporary clerk's great experience in the business of printing was most useful in all matters connected with passing the work through the press, and in securing economy [1]

The Department also had much work, in 1876, connected with the Special Loan Collection of Scientific Apparatus at South Kensington Two sections of the Official Handbook, one on Geographical Instruments and Maps generally, and the other on the Collection of Maps of India, were prepared in the Department, [2] but the heaviest work fell upon the map mounter He had to frame and prepare for exhibition a large collection of maps illustrating every period from the time of Portuguese ascendancy to that of the most recent issue from the office of the Surveyor General The rough plans of the Portuguese and Dutch were succeeded by more elaborate charts, these by military route surveys, early topographical maps, sheets of the Atlas, and finally by elaborate topographical and revenue maps adapted for all the wants of a complicated system of government The exhibition of this series of Indian maps excited great interest

The want of a simplified catalogue of the maps on sale had been felt both for public and official purposes, and, as the stores were kept under reference numbers, it was thought advisable to combine that system with alphabetical order, instead of adopting the elaborate geographical arrangement This catalogue was compiled and passed through the press by the temporary clerk, whose experience was invaluable in the economical publication of such a work The catalogue is in a tabular form, with columns for the reference numbers, titles of the maps alphabetically arranged, dates, scales, size in inches, and price It also has an index map to sheets of the Atlas, with a key index By the use of this excellent catalogue any member of the Department can readily find any map in store It has passed through two editions In future a supplement will be issued every quarter, on the arrival of each consignment from India, which will be incorporated at the end of the year

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1 "Narratives of the Mission of George Bogle to Tibet, and of the Journey of Thomas Manning to Lhasa, edited, with notes, an introduction, and Lives of Bogle and Manning, by Clements R Markham, C B, Geographical Department, India Office" (Trubner, 1876), pp clxi and 354, Maps, &c

2 "South Kensington Museum Handbook to the Special Loan Collection of Scientific Apparatus, 1876" Prepared at the request of the Lords of the Committee of Council on Education, pages 230 to 277

The year 1877 has been a time devoted to completing all the tasks that remain unfinished One of the chief of these tasks is the publication of the General Catalogue Much labour has been encountered in the classification and arrangement for the press of articles filling more than 600 pages, and the work has been much hindered by the incorporation of additional materials which have accrued from time to time from various official quarters The exclusion of these acquisitions would doubtless have expedited the publication and prevented complaints on the score of delay, but the practical value of the catalogue would have suffered materially from such omissions, and as several years must elapse before a work of this kind is reprinted, it was determined to make it as complete as possible With this view, also, the Contents and Alphabetical Index are carefully elaborated, so that reference may be guided to the collateral illustration which articles under various titles and heads reflect on one another This General Catalogue contains every geographical document in the India Office, including the original manuscript work of Rennell, and many other famous Indian surveyors Among the treasures preserved from destruction are the original manuscript reports of the trigonometrical operations of Colonel Lambton, Sir George Everest, and Sir Andrew Waugh The collection also contains a valuable series of maps of the Ganges and other rivers of India, most of them in manuscript, by Rennell, Colebrooke, Wood, Hodgson, Bedford, and Wilcox There are also manuscript maps of Rennell and Buchanan Hamilton, the maps and memoirs of Mysor by Colin Mackenzie, the reports and papers of the mission of Sir Alexander Burnes, and the manuscript maps and field books of Lieutenant Wood, the discoverer of the source of the Oxus, the maps and routes of Kirkpatrick, Crawford, and Ochterlony in Nepal, and many other valuable documents, including memoirs, journals, and field books

It is anticipated that the India Office Geographical Catalogue will be of great service, not only to geographers and map makers, but also to Government Departments, and to inquirers into almost all classes of Indian subjects It will convey a vast amount of information as to the existence of precious manuscript materials, both in the shape of maps and of memoirs, which have hitherto been buried and unknown A very complete idea can thus be formed of the existing materials for the compilation of general maps, and for use in the study of special subjects

Another task for 1877 has been the preparation of this second edition of the "Memoir on the Indian Surveys" In each of the five years that have intervened since the publication of the first edition, an Abstract of the Surveys for the year, exactly on the plan of the Memoir, has been prepared and published The two last were very ably compiled by the specially appointed clerk There has been a good demand for these Abstracts, and the early ones are out of print, so that they have served a useful purpose The information they contain has now been embodied in this second edition of the Memoir

One more task has been completed in the present year, namely, the preparation of an edition of the voyages of Sir James Lancaster, the commander of the first venture of the East India Company, followed by a calendar of all the logs or journals which have escaped destruction, and are preserved in the India Office, from 1607 to 1700 inclusive[1] This work will be a slight contribution towards the proper record and arrangement of the priceless though sadly mutilated and neglected collection of early historical documents

The year 1877 will see the end of my work as Head of the Geographical Department of the India Office It has extended over a period of ten years, from 1867 to 1877 It has been pleasant work, because it has borne fruit it has yielded results, and has secured several steps in advance which cannot well be lost again But the pleasure has been mainly caused by the zealous and efficient co operation of the staff which has worked under me

The uses of the Geographical Department will in future be to keep up direct communication with the survey and other scientific branches of the service in India, and to transact all business connected with them, to disseminate and utilize the results of their work, to keep on record, and ready for the use of all inquirers, what remains of the once magnificent collection of geographical materials, and to add to it, and to produce all geographical and other kindred work that is required to be executed in England The public service and the interests of science will be furthered in no small degree by the careful performance of these duties There

[1] "The Voyages of Sir James Lancaster, Kt, to the East Indies, with abstracts of "journals of voyages to the East Indies during the seventeenth century, preserved in "the India Office and the voyage of Captain John Knight (1606) to seek the North "west Passage Edited, with an introduction, by Clements R Markham, C B, F R S (Printed for the Hakluyt Society, 1877)

is, I sincerely trust, a long and useful career before the Department, during which all existing work will be kept up, and many plans for improvements, which I strove vainly to carry out, will eventually bear fruit In watching its continued prosperity, my hopes will, I trust, be justified, and all my hard work and anxiety during the last ten years will be fully repaid

CLEMENTS R MARKHAM

December, 1877

## POSTSCRIPT

Since the above sheets went to press the Survey Departments of India have had to mourn the loss of three of their most distinguished ornaments, Sir Andrew Waugh, Colonel Robinson, and Colonel Montgomerie.

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SIR ANDREW SCOTT WAUGH was the son of General Gilbert Waugh, the Military Auditor General at Madras, and was born in 1810. He entered the corps of Bengal Engineers in 1827, became Garrison Engineer at Allahabad in 1830, and, when still a very young man, joined the great Trigonometrical Survey, then under the able direction of Colonel Everest. His nomination was dated the 2nd of July 1832, and his friend and contemporary was Thomas Renny, now Major Renny Tailyour, of Borrowfield, co. Forfar. The first work which was entrusted to the two zealous young officers, Waugh and Renny, was the exploration of the wild, jungly country between Chunar and the sources of the Son and Narbada, up to Jabalpur. They completed this service, and submitted a very interesting topographical and geological report in 1834, with coloured sketches of their route, the manuscript of which is still preserved in the Geographical Department of the India Office.

Their next work was of a far more difficult character. It was to assist Colonel Everest in the important operation of measuring the most northern base for the Great Arc Series, which was commenced in the end of 1834. The region selected for this measurement was the Dehra Dun, a beautiful valley between the Sawalakh hills and the Himalayas. As soon as the base was measured, it was re-measured in reverse order by Waugh and Renny, the error being 2·396 inches in 7·42 miles. On the 1st of October, 1836, Colonel Everest took the field with both the large theodolites, dividing his staff into two distinct parties, under himself and Andrew Waugh. After two years of incessant work, Lieutenant Waugh was sent, in October 1838, to revise the angles in the Deccan, and he completed a series of triangles over a meridional distance of 260 miles, returning to Dehra in June 1839. To show the wonderful accuracy of these observations, it may be mentioned that the difference between the length of the Dehra Dun base as measured, and as computed by triangulation from the Sironj base, was 7 inches. In 1840, Waugh was engaged in fixing latitudes at stations on the Great Arc by observations of stars, and in 1841 he proceeded to remeasure the Bidar base. This brought to a close the operations for measuring the Great Arc Series of India, which extends from Cape Comorin to the Himalayas.

When Sir George Everest retired, in 1843, he recommended that his able and indefatigable assistant, Andrew Waugh, should succeed him. In doing so, Everest thus spoke of his successor:—"He is beloved and respected by all the subordinate members of my department, and held in honour and esteem by all who know him personally. His talents, acquirements, and habits as a scholar, a mathematician, a gentleman, and a soldier, are of a high order." In 1843, Captain Andrew Waugh was appointed Surveyor-General and Superintendent of the Great Trigonometrical Survey of India. His first work was to complete Sir George Everest's project for the triangulation of the important region between the Great Arc Series and Calcutta, and until 1848 he was engaged in the supervision of this work, and especially in fixing the heights of the Himalayan peaks. The heights of 79 peaks were fixed, the loftiest of which, 29,002 feet above the sea, was well named by Colonel Waugh after his old chief, Mount Everest. It is still the loftiest measured peak in the world.

After the completion of this series, Colonel Waugh was free to undertake a work originated by himself, and the acquisition of Sind and the Punjab offered a vast field for fresh operations. He conceived a project for forming a system of triangulation to the westward of the Great Arc Series, to include the newly acquired territory. His old friend and companion, Renny Tailyour, was with him when this work was begun, but he retired in 1849, on succeeding to his father's estate of Borrowfield. In 1851, Colonel Waugh superintended the measurement of the Chuch base in the Punjab, and in 1854 he saw the base at Karáchi completed. He took special pains in the preparation of the volume recording the measurement of the Chuch and Karachi bases, and drew up a memorandum to serve as a guide for measuring future base lines. This volume, in manuscript, is preserved in the Geographical Department of the India Office. In 1856, Colonel Waugh instituted a series of levelling operations to determine the height of the base lines in the interior, commencing in the Indus valley in 1858, and he also ordered the commencement of the survey of Kashmir

Great progress was made in the Topographical and Revenue Surveys during the administration of Sir Andrew Waugh, who was admirably supported by Major Thuillier from 1847 In 1861 Sir Andrew published his "Instructions for Topographical Surveying," and besides the Kashmir Survey, under Montgomerie, that of the Sind Sagar Doab, under Robinson, was due to the initiative of the Surveyor General

Sir Andrew Waugh became a Major General and was knighted in 1861, and he retired in March of the same year, after having held the appointment for 17 years When he returned to England, he took with him the appreciative thanks of his Government, and the attachment of a splendid staff of surveyors who had been trained under his auspices The whole staff, 191 in number, presented him with a service of plate in 1862 He had pushed forward the great work with such ability and energy that his successor, Colonel Walker, can see his way to its completion within a limited number of years His labours were brought to public notice in several of the annual addresses of the Presidents of the Royal Geographical Society, and in 1857 he was awarded its Gold Medal A history of the operations of the Great Trigonometrical Survey down to the time of Sir Andrew Waugh's resignation, compiled by H Duhan, will be found in five articles in the "Professional Papers on Indian Engineering" (vol ii, pp 285 and 398, and vol iii, pp 94, 305, and 402)

On his return to England, Sir Andrew Waugh became an active and useful member of the Royal Geographical Society, where his advice was most valuable in all matters relating to instruments and to Asiatic geography He became a Fellow in 1857, and was a member of the Council from 1861 to 1872, holding the office of Vice President during the last five years In 1862 he was elected a member of the Geographical Club He was also a Fellow of the Royal Society

Sir Andrew Waugh was twice married, and had one son by his first wife, Gilbert William Renny Waugh, who entered the army in 1867, and is now a Lieutenant in the 78th Highlanders For the last five years the health of the veteran surveyor had been failing He was missed at his seat at the Council table of the Geographical

Society, and still more was the absence of his genial smile and kindly greeting regretted by the Geographical Club. But his friends had the pleasure of seeing him at the Athenæum almost to the last. He died at his house, 7, Petersham Terrace, Kensington, on the 21st of February 1878, at the age of sixty eight.

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THOMAS GEORGE MONTGOMERIE, the third son of Colonel Montgomerie, of Annick Lodge, and nephew of the twelfth Earl of Eglinton, was born at Ayr on the 23rd of April, 1830. Whilst at Addiscombe he gained the "Pollock Medal," awarded to the most distinguished cadet of the season, and he entered the East India Company's service, as a Lieutenant in the Bengal Engineers, on the 8th of June 1849.

Very soon after his arrival in India, young Montgomerie joined the Great Trigonometrical Survey, in October 1852, and in 1853 we find him assisting in the measurement of the Chuch base, near Attock. In 1854 he accompanied Sir Andrew Waugh to Karachi, and took part in that base measurement from December 1854 until its completion on January 20, 1855.

As soon as this work was done, the survey of Kashmir, and of the mighty mass of mountains up to the Tibetan frontier, was commenced. Captain Montgomerie was only in his twenty fifth year when this important and most difficult service was entrusted to him by Sir Andrew Waugh. He began work in the spring of 1855, and during the first season he carried the series across the Pir Panjal range into Kashmir. Two of the stations were 13,000 and 15,000 feet above the sea. Building materials had to be dug out of the snow for the station pillars, and the observers were detained at one station for twenty-two days, owing to snowstorms and foggy weather. Afterwards, as the party penetrated into the mountains, the height of the stations averaged 17,000 feet, and luminous signals were used from peaks 19,000 and even 20,000 feet above the sea. Between 1855 and 1861, young Montgomerie extended the triangulation over 93,000 square miles. One member of the party took observations from a station which was 20,600 feet above the sea, and marks were erected on peaks as high as 21,480 feet. Montgomerie fixed the height of a peak in the Karakorum range, temporarily called K 2, which is second only to Mount Everest, having a height of 28,290 feet. This most difficult and laborious survey is remarkable for its accuracy, and in a circuit of 890 miles, only a discrepancy of $\frac{8}{10}$ of a second in latitude, and of $\frac{1}{10}$ in longitude, was found The topographical filling in by plane table advanced with the triangulation, both being under the superintendence of Captain Montgomerie

After ten years of uninterrupted labour in Kashmir, Montgomerie went home on leave, and on the 22nd of May 1865, Sir Roderick Murchison presented him with the Founders' Gold Medal of the Royal Geographical Society The President said to him, on the part of the Council —"When we reflected upon the remarkable facts that you had passed from the hot plains of Hindustan to the loftiest region on the face of the globe, and that there, amidst enormous glaciers, you had made accurate scientific observations at stations, one of which was 5,000 feet higher than the summit of Mont Blanc, we could not fail to applaud and reward such noble feats, displaying, as they did, the great abilities and energy with which you conducted so arduous a survey"

On May 1st, 1867, Captain Montgomerie resumed his labours in India, conducting the Kumaun and Gurhwal survey, and executing a specially accurate survey of the hill sanatarium of Ranikhet

But the work by which Colonel Montgomerie is most generally known among geographers, is that comprised in his system of employing native explorers to make discoveries in the unknown regions beyond the northern frontiers of British India He hoped that by this means the whole country between British and Russian territories would be laid open Natives are permitted to travel without molestation, as traders or in other capacities, through countries where Europeans would certainly be regarded with suspicion, and most probably would be murdered Montgomerie's plan was to employ Pathans to explore the Hindu Kush, the valley of the Oxus, and Eastern Turkistan, while for the exploration of Tibet he engaged Bhutiyas and inhabitants of the upper valleys of the Himalayas within British territory He taught them to make route surveys by taking bearings with a compass and pacing the distances to take meridian altitudes with a sextant to determine latitudes, and to observe with a boiling point thermometer But he did not teach them how to reduce their observations, and they were not supplied with astronomical tables, in order that they might not be able to fabricate fictitious work

There was great difficulty in training these native explorers, and there were many disappointments Out of six or eight men that were instructed for years, only two or three turned out first-class observers Nevertheless, this system resulted in the acquisition of a large amount of new information, and the work of "Montgomerie's Pundits" is well known to all geographers They penetrated to Lhasa and the interior Tibetan lakes on one side, and to the unexplored regions of the Upper Oxus on the other On his return, each explorer brought his crude work to Montgomerie, who reduced the observations, prepared the journals for publication, compared the work with all that was previously known, and finally completed a series of invaluable reports

Colonel Montgomerie was senior Deputy Superintendent of the Great Trigonometrical Survey, when ill-health obliged him to retire, to the great regret of the Department, in 1875 An appreciative notice of his services—by his colleague, Mr Hennessey—appeared in the Annual Report for 1875–76, which was reprinted at page 123 of the Geographical Magazine for May 1877 Colonel Montgomerie became a Fellow of the Royal Geographical Society in 1865, and a member of the Geographical Club in 1873 He was elected a Fellow of the Royal Society in 1872

The last time that he was officially employed was in 1875, when he acted as Her Majesty's Commissioner at the Geographical Congress in Paris But his long and severe service had shortened his valuable life He never seems to have really recovered after his return to England, and he died at Bath on the 31st of January 1878, leaving a widow and three children to mourn his loss Their sorrow will be shared by many friends and admirers, both in this country and in India The Indian Survey Department has lost one of its brightest ornaments, and all geographers will feel that a life has been cut short, which, had it been spared, would yet have done much precious service in furthering the objects of their science

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By the retirement of MAJOR GODWIN AUSTEN the Survey Department has sustained another serious loss

Henry H Godwin Austen, son of Robert A Godwin Austen, Esq, of Shelford House, near Guildford, the eminent geologist, received his first commission in December 1851 He served in the Kashmir Survey, under Montgomerie, and sketched some most difficult ground with great taste and skill, including the enormous glaciers of Little Tibet, one of them 36 miles long His notes on the valley of Kashmir, and on the glaciers of the Mustakh Range were published in the "Transactions of the Royal Geographical Society, 1861," p 30, and 1864, p 19 He next accompanied Mr Eden's Mission to Bhutan, serving afterwards with the Duar Field Force He then headed the sixth topographical party for the survey of the forest covered and pestilential Garos, the Khasia and Jayanta hills, Naugong, and N Cachar In 1873 he was engaged in the Naga hills, and in 1875 he accompanied the Duffla military expedition, producing an out town of work representing 1,705 square miles of entirely new topography This work on the northern frontier of Assam is of great geographical importance, as throwing light on the vexed question of the course of the Brahmaputra, and Godwin Austen has contributed to our knowledge a map of the Duffla Hills and the course of the Subansiri He retired from the service on the 12th of June 1877

Reference to Colonel ROBINSON's surveying services will be found in the Index

# APPENDIX

## MEMORANDUM ON THE STATE[1] OF THE ARRANGEMENTS FOR THE PUBLICATION OF THE SHEETS OF THE INDIAN ATLAS IN ENGLAND. BY COLONEL J. T. WALKER, SUPERINTENDENT GREAT TRIGONOMETRICAL SURVEY OF INDIA.

In Section XVII of the 'Memoir on Indian Surveys' by Mr. Markham, the arrangements are described which were made in 1868 for having the remaining sheets of the atlas engraved at Calcutta under the immediate superintendence of the Surveyor-General. An engraving office was to be organised in India by Colonel Thuillier, who had been given a staff of English engravers selected by himself in this country to form the nucleus of the new office and train natives of India in the art of engraving and hill-etching on copper plate. To prevent any delay in the publication of the atlas while the new office was being organised at Calcutta, it was arranged that all the plates of the atlas which were actually in the hands of engravers in England, or for which geographical materials were available, should be finished in England. This work was necessarily to be performed under the superintendence of Mr. John Walker, the Geographer to the India Office, by whom the atlas had been commenced in the year 1826, and had been carried on ever since during a period of more than 40 years, in a highly satisfactory manner, but who had now attained a great age, and wished to retire from business as soon as the engraving arrangements in Calcutta were sufficiently matured to permit of his services being dispensed with.

In fact it was the circumstance that Mr. Walker could not naturally be expected to be physically able to carry on his work much longer, which had shown the necessity for making some other provision for the completion of the atlas, and thus led to the formation of the engraving office in India. The new arrangements were not made a day too soon; Mr. Walker very shortly afterwards became unable to attend to any further details of business; his communications to this office became more and more intermittent, and at last ceased altogether; very few of the atlas sheets which in 1868 he had undertaken to complete were rendered to this office, and nothing was known of the condition of the remainder, for latterly his medical attendants have not permitted him to be spoken to on the subject.

In January last I was asked to move in the matter, and to ascertain the state of affairs. I found that very little more had been done than what had already been rendered to this office, and that much the greater portion of the work had not yet been commenced. It soon became evident that the collapse had arisen

[1] This was written in 1872.

See 'Memoir' (first edition), p. 283.

mainly from the circumstance that Mr John Walker had been in the habit of constructing the projections and compiling the materials of the atlas sheets with his own hands He alone knew anything about the theoretical principles or the practical details of the system of projection on which the atlas had been constructed hitherto, and which necessarily would have to be adhered to in completing it When his health broke down there was no one to take his place consequently most of the new sheets had not yet been commenced for he had not been able to construct the projections and put the materials together On the other hand, the completion of the copper plates which were actually in the hands of the engravers was progressing very slowly for want of funds to pay the engravers Mr Walker had been in the habit of paying all the expenses of the engraving from his private means in the first instance, and sending in bills to this office after the completion of the work, but, for upwards of ten years, he had not taken any steps even to reimburse himself for the large advances which he must have made, and hence the operations languished for want of funds

Thus it appeared that a work which is of great national importance though neither very difficult nor very costly, was almost at a standstill for want of some one to initiate the successive stages of the operations and to exercise a general supervision over the whole and also for want of the moderate funds which were required to defray the current expenses [1]

Out of deference and regard to the great family of geographers and engravers, by one of the members of which the atlas had hitherto been brought out so admirably I proposed that an arrangement should be made with Mr John Walker's younger brother, Charles who had once been in partnership with him but had long retired from business, for the completion of the plates actually in the hands of the engravers, but Mr Charles Walker died very suddenly and unexpectedly while the arrangement was under discussion, there was no other member of the family who was in a position to take his place, and thus the connexion of the Walker family with the great geographical work with which its name has been associated for a period of nearly half a century became dissolved

On Mr Charles Walker's death the copper plates and geographical materials were collected together and made over to this office

I was then on the point of returning to India, but in consequence of

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[1] In connexion with this subject the following paragraphs of a letter dated 18th June 1828 from the Court of Directors to the Madras Government are of much interest Noticing an announcement by the Surveyor General of India (dated 29th March 1823) that a map of the Peninsula was being constructed by his deputy at Madras on the scale of Arrowsmith's large map the Court writes —

"We desire that such a work be not persisted in To the attempts which have been made at differ
' ent times by the Surveyor General at the several Indian presidencies to construct maps embracing
' a large extent of country and the consequent retention of documents in India we impute the little
' progress that has yet been made in the formation of a general Indian atlas All projects of that
' nature begun in India have failed from the supervening sickness or death of the projectors or from
' other obstructions occurring in the progress of the work whilst the requisite documents having been retained in India contrary to our reiterated orders, we have been prevented from taking the
" necessary measures for the completion of a general Indian atlas in this country

Colonel Thuillier's earnest representations of the inadequacy of his engraving office in Calcutta to undertake all the arrears of work which had been accumulating in England, as well as to keep pace with the operations of the field surveys in India, I was detained in England for a few months in order to make arrangements for the completion in this country, not only of the copper plates which were in the hands of the engravers, but of several new plates for which geographical materials were available For this purpose it was necessary that I should ascertain the principles on which the projections had hitherto been based and this was not a very easy matter for there was no one who could give me any information on the subject, excepting Mr Walker who was too ill to be spoken to Eventually, I came across a manuscript memorandum book in Mr Walker's office in Castle Street, Holborn containing tables and other data on which the projections must have been based, as appears from internal evidence, though there is nowhere any statement to that effect This book was lent to me for a short time, after which it had to be returned to Mr Walker's family, but meanwhile all the most important portions had been transcribed, sufficient to permit of the projections of the remaining atlas sheets being constructed in such a manner as to be in exact correspondence with those of the sheets already completed, provided only that the scale or unit of length from which all the measurements had been hitherto laid off on the copper plates could be procured After considerable difficulty and delay I succeeded in obtaining this scale from Mr Walker's family, but only on loan and under a promise that it should be soon returned These difficulties, I am persuaded merely arose from a natural feeling of hesitation on the part of the family to do anything which Mr John Walker might—for aught that was known to the contrary—have disapproved, there can be no doubt they would not have occurred had he been well enough to be consulted, for it was afterwards ascertained that he had allowed Colonel Thuillier to take a copy of the manuscript memorandum book above specified, and had furnished him with an exact copy of the scale

It is desirable that some more permanent record should be made than at present exists of the details of the construction of this great geographical work which has already been going on for nearly half a century and is still far from complete I have therefore, drawn up the following memoranda regarding the principles of the projection, the data on which it is based, and the practical details of its application, and also on the unit of the adopted scale of measurement

## *The Projection*

This is one of the numerous modifications of the conical development, it represents the parallels of latitude by concentric arcs but the meridians by arcs concave to the central meridian, and not by straight lines as in the true conical development A cone is assumed to roll over the spheroid tangentially to an adopted central parallel of latitude the distance from the vertex of the cone to this parallel (= normal × cotan latitude) is the radius of projection of the parallel, and may be considered as the fundamental radius of the pro jection, for the radii for all other parallels are determined by adding to or subtracting from it the distances between those parallels and the central parallel

The angle subtended at the vertex of the cone by a longitudinal arc of 1° in length is called the "angle of the projection" for the parallel of latitude to which the arc appertains, as this angle varies with the latitude, its value is computed for each parallel

These data constitute the fundamental elements of the projection, and are given in the following table —

TABLE OF THE ELEMENTS OF THE PROJECTION

| Parallel of Latitude | Radii of Projection | | Angle of Projection for 1° of Longitude | Length in Fathoms of 1° of Longitude |
|---|---|---|---|---|
| | In Fathoms | Logarithms | | |
| ° | | | ′ ″ | |
| 7 | 8723613 | 6 940696 | 23 48 | 60406 |
| 8 | 8663149 | 6 937675 | 23 55 | 60268 |
| 9 | 8602682 | 6 934630 | 24 1 | 60112 |
| 10 | 8542212 | 6 931570 | 24 7 | 59938 |
| 11 | 8481739 | 6 928468 | 24 13 | 59746 |
| 12 | 8421263 | | 24 18 | 59535 |
| 13 | 8360779 | 6 922246 | 24 23 | 59307 |
| 14 | 8300286 | 6 919092 | 24 27 | 59060 |
| 15 | 8239793 | | | 58796 |
| 16 | 8179300 | 6 912700 | 24 35 | 58514 |
| 17 | 8118820 | 6 909493 | 24 39 | 58214 |
| 18 | 8058311 | 6 906243 | 24 41 | 57896 |
| 19 | 7997796 | 6 902970 | 24 44 | 57561 |
| 20 | 7937275 | 6 899671 | 24 46 | 57208 |
| 21 | 7876747 | 6 896347 | 24 48 | 56838 |
| 22 | 7816212 | 6 892997 | 24 50 | 56451 |
| 23 | 7755670 | 6 889640 | 24 51 | 56047 |
| 24 | 7695121 | 6 886215 | 24 51 | 55625 |
| 25 | 7634564 | 6 882786 | 24 51 | 55187 |
| 26 | 7574000 | 6 879325 | 24 51 | 54732 |
| 27 | 7513428 | 6 875837 | 24 49½ | 54260 |
| 28 | 7452847 | 6 872322 | 24 48 | 53772 |
| 29 | 7392258 | 6 868777 | 24 46 | 53267 |
| 30 | 7331660 | 6 865201 | 24 44 | 52746 |
| 31 | 7271053 | 6 861597 | 24 41 | 52210 |
| 32 | 7210437 | 6 857962 | 24 38 | 51657 |
| 33 | 7149812 | 6 854293 | 24 34 | 51088 |
| 34 | 7098117 | 6 851147 | 24 27 | 50504 |
| 35 | 7037473 | 6 847418 | 24 25 | 49905 |
| 36 | 6976819 | 6 843657 | 24 17 | 49290 |
| 37 | 6916155 | 6 839861 | 24 11 | 48660 |

The elements of the figure of the earth which are here employed are not stated, but there can be no doubt that they must have been those which were determined by Colonel Lambton from his measurements on the great Indian Arc, and are given in vol xiii of the 'Asiatic Researches' This will be seen by comparing the differences between the lengths of the radii of projection with the lengths of Colonel Lambton's meridional degrees, and also by comparing the lengths of the longitudinal degrees of the projection with those of Colonel Lambton as in the following table —

| Parallel of Latitude | Differences between Radii of Projection | Lengths of Colonel Lambton's | |
|---|---|---|---|
| | | Meridional Degrees | Longitudinal Degrees |
| 7 | 60,464 fathoms | 60,467 5 fathoms | 60,406 4 fathoms |
| 8 | 60,467 " | 60,470 1 " | 60,268 6 " |
| 9 | 60,470 " | 60,473 2 " | 60,112 6 " |
| 10 | 60,473 " | 60,476 5 " | 59,938 4 " |
| 11 | 60,476 " | 60,480 3 " | 59,746 1 " |
| 12 | 60,484 " | 60,484 3 " | 59,535 6 " |
| 13 | 60,493 " | 60,488 7 " | 59,307 1 " |
| 14 | 60,493 " | 60,493 4 " | 59,060 6 " |
| 15 | 60,493 " | 60,498 4 " | 58,796 3 " |
| 16 | 60,480 " | 60,503 8 " | 58,514 1 " |
| 17 | 60,509 " | 60,509 4 " | 58,214 2 " |
| 18 | 60,515 " | 60,515 4 " | 57,896 6 " |
| 19 | 60,521 " | 60,521 6 " | 57,561 4 " |
| 20 | 60,528 " | 60,528 2 " | 57,208 8 " |
| 21 | 60,535 " | 60,535 0 " | 56,838 9 " |
| 22 | 60,542 " | 60,542 0 " | 56,451 6 " |
| 23 | 60,549 " | 60,549 4 " | 56,047 2 " |
| 24 | 60,557 " | 60,557 0 " | 55,625 8 " |
| 25 | 60,564 " | 60,564 8 " | 55,187 5 " |
| 26 | 60,572 " | 60,572 9 " | 54,732 4 " |
| 27 | 60,581 " | 60,581 2 " | 54,260 6 " |
| 28 | 60,589 " | 60,589 7 " | 53,772 4 " |
| 29 | 60,598 " | 60,598 4 " | 53,267 8 " |
| 30 | 60,607 " | 60,607 4 " | 52,746 9 " |
| 31 | 60,616 " | 60,616 5 " | 52,210 0 " |
| 32 | 60,625 " | 60,625 8 " | 51,657 2 " |
| 33 | 51,695 " | 60,635 2 " | 51,088 6 " |
| 34 | 60,644 " | 60 644 8 " | 50,501 5 " |
| 35 | 60,654 " | 60,654 5 " | 49,904 9 " |
| 36 | 60,664 " | 60,664 4 " | 49,290 2 " |
| 37 | | 60,674 3 " | 48,660 3 " |

The accordance is sufficiently close to leave no doubt that Colonel Lambton's data must have been employed, the longitudinal degrees of the projection are all but identical with Colonel Lambton's and the differences between the radii of projection practically correspond with his meridional degrees in every case, excepting between 33° and 34°, where there is a considerable error, which however, has been allowed for in the practical construction of the projection, and has not very materially influenced the accuracy of this portion of the atlas

With the data in the table of the elements of the projection the rectangular co-ordinates of the points of intersection of the principal meridians with the principal parallels were computed with reference to an adopted central meridian and the points of its intersection by the parallels Putting $\theta$ for the 'angle of projection' for 1° of longitude on any given parallel and $r$ for the corresponding radius of projection then the co ordinates of the extremity of an arc of $n$ degrees on that parallel, as referred to the central meridian and the point at which it is intersected by the parallel, will be

$$r \operatorname{Sin} n\theta \text{ and } r \operatorname{versin} n\theta$$

the former perpendicular and the latter parallel to the given meridian

It is unnecessary to give in this place the values of the co ordinates which were calculated for the projection, they were found on examination to require to be checked by a recomputation which has been commenced but is not yet completed

The meridian which has been adopted as the central meridian or axis of the projection is 76° 30′ east of Greenwich, this is not only stated to be the case in Mr Walker's memorandum book but can be deduced from the calculations of the co ordinates I have not been able to ascertain why a meridian which is so far from being central was selected as the central meridian

What parallel was adopted as the central parallel of the projection is no where stated and the data by which it might be ascertained are incomplete but the value of the radii of projection clearly show that it must lie between 24° and 25°, and most probably is 24° 30′

The sheets of the atlas are rectangular their dimensions as taken between the marginal lines on the copper plates being 38 by 24 4 inches representing a distance of 134 850 fathoms lengthways on the perpendicular to the central meridian, and a distance equivalent to the length of a meridional arc of 1° 28 breadthways

The sheets are situated unsymmetrically with reference to the central meridian, for it passes over the central sheets at a distance corresponding to 37100 fathoms from the west, and 97 750 fathoms from the east margin This is exceedingly inconvenient entailing separate computations for the projection of the sheets east and west of the central meridian which would have been avoided if a symmetrical arrangement had been adopted

The origin of co ordinates is at the intersection of the parallel of 5° with the central meridian, but each of the points at successive intervals of 1° 26′ on the central meridian, from lat 5° upwards may be said to be origins of co ordinates, and employed as such in the calculations for the corresponding belts of sheets, right and left, and this is a very convenient arrangement which lessons the labour of the calculations

The following table gives the distinguishing numbers of the central sheets and the parallels of latitude whose intersections with the central meridian are the points through which the perpendiculars are drawn which are the top and bottom marginal lines of the sheets in each belt

| Sheet | Intersecting Parallels | Sheet | Intersecting Parallels |
|---|---|---|---|
| | ° ′ | | ° ′ |
| | 5 | | 20 46 |
| None | | 54 | |
| | 6 26 | | 22 12 |
| None | | 53 | |
| | 7 52 | | 23 38 |
| 63 | | 52 | |
| | 9 18 | | 25 4 |
| 62 | | 51 | |
| | 10 44 | | 26 30 |
| 61 | | 50 | |
| | 12 10 | | 27 56 |
| 60 | | 49 | |
| | 13 36 | | 29 22 |
| 59 | | 48 | |
| | 15 2 | | 30 48 |
| 58 | | 47 | |
| | 16 28 | | 32 14 |
| 57 | | 46 | |
| | 17 54 | | 33 40 |
| 56 | | 45 | |
| | 19 20 | | 35 6 |
| 55 | | 44 (A) | |
| | 20 46 | | 36 32 |

The dimensions of the sheets from top to bottom have been made to correspond with lengths of 86 716 fathoms to the south of the parallel of 21° and 86 788 fathoms to the north of that parallel, the corresponding values of the meridional degrees are 60,500 fathoms to the south and 60,550 to the north which differ appreciably from those on which the calculations for the projection are founded, though not to any material extent

None of the documents to which I have hitherto had access give any information as to who was the originator of the projection of the Indian Atlas There is a lithographed pamphlet in this office entitled ' Construction of the " graticule for a General Atlas of India' which is believed to have been written by Col Blacker, who was Surveyor General of India, but it does not give either the name of the author or the date at which it was written It proposes a method of projection which in principle is identical with the one actually adopted and is based on the same geodetic elements, but differs in all other details, the central parallel—the adopted value of which influences the whole of the calculations—being lat 20° instead of $24\frac{1}{2}$°, and the central meridian being that of 80° instead of $76\frac{1}{2}$° The size of the sheets was intended to be 38 38 by 27 53 inches, the origin of co ordinates was placed in the centre of the atlas, at the point corresponding to lat 20°, long 80° the intersection of the central parallel with the central meridian

"Tables are added, giving the natural lengths of the co ordinates and their lengths on the scale of the map This scale was in the first instance intended to have been $\frac{1}{0000}$th part of nature, but afterwards was altered to $\frac{1}{253440}$ which is the same as that of 1 inch=4 miles, the tables give the values of the co-ordinates for both scales All the calculations seem to have been carefully made out and verified, and the results are tabulated in a convenient form for use, which is very far from being the case with the calculations for the actual projection

The design of the atlas is believed to have been influenced to some extent by Mr Aaron Arrowsmith's Atlas of Southern India, from Cape Comorin to the river Kistnah which was published in the year 1822, and was evidently designed by its author as the commencement of an Atlas of all India, for it is accompanied by a sketch map showing "how many sheets of this size would " be required for a map of India on a scale of 4 English miles to one inch, " any one of which may be engraved independent of another when materials " offer and may be united to the rest by keeping correctly to the lines as " drawn on this map, the sheets as far as N 16 are already engraved on the " above scale"

But on a close examination it will be found that this atlas has little or nothing in common with the Atlas of all India the publication of which com menced five years afterwards, the lengths of the sheets may have been intended to correspond, and there is an agreement between the limiting meridians of some of the southern sheets which can scarcely have been fortuitous, but there are no other points of similarity Mr Arrowsmith's central meridian appears to have been not $76\frac{1}{2}°$ but $78°$ and the elements of the earth's figure which were adopted for his projection cannot have been those which resulted from Major Lambton's operations and were used as the basis for the calculations of the second atlas for they appertain to a figure of which the polar axis is materially longer than the equatoreal the diminution of the length of the longitudinal degree between lat $8\frac{1}{2}°$ and $14\frac{1}{2}°$ being only 1 07 instead of 1 44 of a mile, a circumstance which may very possibly have caused the subsequent abandonment of this atlas In both atlases the dimen sions of the sheets appear to have been regulated by the size of the double elephant sheet of drawing paper, in the earlier one the details are carried so close up to the edges of the paper as to leave no room for borders with the degrees and minutes of latitude and longitude, which are therefore only given on certain exterior sheets, in the subsequent atlas the extent of the details is less and permits of a border being placed round each sheet

The whole of the sheets of the Atlas of India have been engraved by Mr John Walker, the 24 sheets first issued comprise portions of Northern India and Eastern Bengal as well as a reproduction of Mr Arrowsmith's Southern India, they were published between February 1827 and November 1833, under the name of James Horsburgh Hydrographer to the Honourable East India Company The next sheet was published in September 1836 under the name of John Walker, Geographer to the Honourable East India Company Mr Horsburgh died in that year, and Mr Walker was appointed to succeed him in his duties, retaining the engraving of the atlas

*The Scale of the Indian Atlas*

The working scales which have been used by Mr Walker are engraved on a thin brass bar, about 17 inches in length by $1\frac{1}{2}$ in breadth with a scale of fathoms on one edge and a scale of minutes of latitude on the other There can be little doubt—though it is nowhere stated in words on the atlas sheets —that the scale of the atlas must originally have been intended to be that of 1 inch to 4 miles, or the $\frac{1}{253440}$th part of nature for this, the entire length of the fathom scale, from 0 to 60 000 should be 17·045 English inches, but on comparing it with a standard yard by Troughton and Simms, which appertains to the Observatory at the India Store Department, Lambeth, I find that it is only 16·904 inches, the scale of the atlas is therefore the $\frac{1}{255561}$th part of nature or somewhat less than 1 inch to 4 miles as has hitherto been supposed The value of the meridional degree on Mr Walker's scale is taken at 60,500 fathoms, and the actual length of this degree on the scale is equal to 17·055 inches of Troughton and Simms standard yard or very nearly what the length of the fathom scale should have been On the other hand, the fathom scale has been prolonged to a point beyond the 60 000 fathom division, at a distance from the zero of that scale which is almost exactly equal to what the length of the meridional degree should have been Hence it seems probable that the lengths of the scales were laid off with all desirable accuracy in the first instance, but by some mistake the fathom scale length was mistaken for that of the meridional degree and sub divided accordingly, and vice versa

In consequence of this error the dimensions of the copper plates, which should have been 38·31 by 24·65 inches within the border lines, are only 38·00 by 24·45 inches The error necessitates a reduction of scale of all geographical materials which are drawn on the quarter inch scale, before they can be correctly inserted on the copper plates, but otherwise it is of little importance, in the printed sheets of the atlas larger errors arise from the shrinkage of the paper, which, unfortunately, is unequal, being invariably greater lengthways, in the direction passed over by the roller during the process of printing, than breadthways, at right angles to that direction, the dimensions of several sheets which I have measured vary from 37·06 to 37·50 inches in length, and from 24·12 to 24·22 inches in breadth, the greatest contraction having probably occurred when the paper was most moistened before being passed through the press To facilitate accurate measurements from the atlas sheets for certain specific purposes—as for instance, for compiling geographical materials for new maps —it would be a great advantage if a second scale of miles were given in either of the side margins at right angles to the one at present given at the bottom of each sheet

# A LIST OF MEMBERS

OF THE

# MARINE, GREAT TRIGONOMETRICAL, TOPOGRAPHICAL, REVENUE, AND GEOLOGICAL SURVEYS OF INDIA

## MARINE SURVEY DEPARTMENT, 1877

| Names | Substantive Appointment | Date of Appointment | Salary | Remarks |
|---|---|---|---|---|
| SCIENTIFIC OFFICERS | | | Rs | |
| Commander A D Taylor late I N F R G S | Superintendent of Marine Surveys | 27th July 1874 | 1 800 | |
| Staff Commander J H Ellis R N | Deputy Superintendent of Marine Surveys 1st grade | 19th Nov 1874 | 950 | Exclusive of Indian Navy service |
| Navigating Lieutenant F W Jarrad R N F R G S | 2nd grade | 19th Nov 1874 | 700 | |
| Navigating Lieutenant G C Hammond R N | Assistant Superintendent 1st grade | 19th Nov 1874 | 600 | |
| M Chapman late I N | 2nd grade | 21st Jan 187 | 550 | Exclusive of Indian Navy service |
| Navigating Sub Lieutenant E W Petley R N | | 19th Nov 1874 | 400 | Counts no service at present according to Navy rules |
| Lieutenant W H Coombes R N | | 6th Oct 1876 | 3[illegible]0 | |
| Navigating Lieutenant J C Pascoe R N | | 6th Oct 1876 | 3[illegible]0 | |
| P J Falle | | 1st Nov 1874 | 3[illegible] | |
| CIVIL OFFICERS | | | | |
| F C Carrington F R A S | Superintendent Drawing Branch | 26th Dec 1874 | 750 | |
| Surgeon J Armstrong B A | Medical Officer and Naturalist | 24th Jan 1875 | 400 | |

## The Great Trigonometrical Survey, 1877

| Names | Substantive Appointment | Date of Appointment | Salary | Remarks |
|---|---|---|---|---|
| | | | Rs | |
| Colonel J T Walker C B F R S R E | Superintendent 12th March 1861 | 12th March 1861 | 2 56 | Appointed Surveyor General from 1st January 1878 |
| **Senior Branch** | | | | |
| J B N Hennessey M A F R S | Deputy Superintendent 1st grade | | 1 600 | Joined the Department in 1844 including Computing Office |
| Major H R Thuillier R E | 2nd grade | 1st Oct 1867 | 1 82 | Officiating Deputy Superintendent 1st grade Transferred to Mysore Topographical Survey |
| Lieutenant Colonel C T Haig R E | | | 1 540 | On furlough |
| Major J Herschel R E F R S | | | 1 480 | Computing Office |
| Lieutenant Colonel B R Branfill Bengal Cavalry | | 1st June 1865 | 1 300 | Madras Party |
| Captain T T Carter R E | 3rd grade | 21st April 1864 | 1 140 | Guzerat Party |
| W M Campbell R E | | 1st Feb 1867 | | On furlough |
| Henry Trotter R E | | 26th Jan 1869 | | |
| W J Heaviside R E | | 1st March 1868 | | On furlough |
| Major A Pullan (Staff Corps) | Assistant Superintendent 1st grade | 20th Jan 1864 | 1 000 | Kattywar Survey Officiating Deputy Superintendent 3rd grade |
| Captain M W Rogers R E | | 1 th Dec 1868 | 1 140 | Bombay Party do do |
| J Hill R E | | 18th Dec 1866 | 890 | Eastern Frontier Series |
| W H Cole M A | | 1st Sept 1867 | 7 0 | Computing Office |
| Captain A Baird R E | 2nd grade | 4th Dec 1868 | 8 0 | Tidal and Levelling Operations Officiating Assistant Superintendent 1st grade |
| J R McCullagh R E | | 1 th Feb 1869 | | Transferred to Mysore Topographical Survey do 1st grade |
| T McGill | | 17th Dec 18 1 | 750 | Kattywar Survey do |
| W C Beverley | | 1st July 18 4 | | On furlough |
| Lieutenant H J Harman R E | 3rd grade | | 670 | Assam Survey Officiating Assistant Superintendent 2nd grade |
| T C Ryall | | | 600 | Kumaun and Garhwal Survey 1st grade |
| Lieutenant St G C Gore R E | | | 750 | Transferred to Topographical Branch |
| **Junior Branch** | | | | |
| Harry Duhan | Surveyor 1st grade | 22nd April 1845 | 600 | Correspondence Office Personal Assistant |
| H Beverley | | 1st July 18 4 | 500 | Burma Party |
| J Peyton | | 3rd Feb 1860 | 500 | Kumaun and Garhwal Party |
| A D Souza | | 10th Feb 1856 | 500 | Guzerat Survey |
| C J Neuville | 2nd grade | 1st Dec 185 | 400 | Tidal and Levelling Operations |
| L H Clarke | | 26th Nov 18 5 | 400 | Head Quarters |
| W Todd | | 11th Jan 1856 | 400 | Kumaun and Garhwal Survey |
| J Low | | 1st Oct 1857 | 400 | Burma Party |
| C Wood | 3rd grade | | 350 | Computing Office |
| H L T Keelan | | 17th Aug 18 8 | 350 | Transferred to Mysore Topographical Survey |
| F Bell | | | 350 | Kattywar Party |
| G Atkinson | | 1st April 1859 | 350 | Drawing Office |

The Great Trigonometrical Survey, 1877—*cont*

| Names | Substantive Appointment | Date of Appointment | Salary | Remarks |
|---|---|---|---|---|
| JUNIOR BRANCH—*cont* | | | Rs | |
| H Peychers | Surveyor 4th grade | [illegible]2nd Sept 1862 | 300 | Computing Office |
| G Belcham | | 1st Nov 1862 | 300 | Madras Party |
| J W Mitchell | | 1st Sept 1861 | 300 | Eastern Frontier Series |
| L J Pocock | | 10th July 1863 | 300 | Mysore Topographical Survey |
| A Christie | | 7th Au[illegible] 1863 | 300 | Guzerat Survey |
| W O Sullivan | | 1st Oct 1863 | 300 | Assam Survey |
| N C Gwynne | | 19th Oct 1863 | 300 | Kattywar Survey |
| W C Price | | 1st Nov 1863 | [illegible]00 | Eastern Frontier Series |
| C H McA Fee | | 6th Nov 1864 | 300 | Guzerat Survey |
| T H Rendell | Assistant Surveyor 1st grade | 11th Oct 1864 | 250 | Tidal and Levelling Operations |
| Hugh Todd | | 15th July 1865 | 250 | Transferred to Mysore Survey |
| E J Connor | | 1st March 186[illegible] | 250 | Tidal and Levelling Operations |
| J Bond | | 18th Oct 1866 | 250 | Guzerat Party |
| C D Potter | | 29th Oct 1866 | 250 | Madras Party |
| T Kinney | | 17th June 1868 | 250 | Head Quarters |
| J Hickie | 2nd grade | 29th April 1868 | 200 | Guzerat Survey |
| W Fielding | | 3rd May 1868 | 200 | Kattywar Survey |
| G D Cusson | | 8th May 1868 | 200 | Guzerat Survey |
| C P Torrens | 3rd grade | | 160 | Jodhpore Series |
| A Bryson | | 20th Sept 1869 | 160 | Madras Party |
| W Oldham | | | 160 | Transferred to Mysore Party |
| J C Clancey | | | 160 | Eastern Frontier Series |
| J O Hughes | | | 160 | Burma Party |
| I Pocock | | | 160 | Kumaun and Garhwal Survey |
| G T Hall | | | 160 | Kattywar Survey |
| J F McCarthy | 4th grade | | 1[illegible]0 | Assam Party |
| D J Collins | | | 1[illegible]0 | Eastern Frontier Series |
| H Corkery | | | 120 | Kattywar Survey |
| P F Trinity | | | 120 | Bombay Party |
| J Keating | | | 120 | Kattywar Party |
| S T Norman | | | 120 | Guzerat Survey |
| C Norman | | | 120 | |
| R F Warwick | | | 1[illegible]0 | Kumaun and Garhwal Survey |
| J M Kennedy | | | 120 | Transferred to Mysore Topographical Survey |

LIST of OFFICERS of the TOPOGRAPHICAL and REVENUE SURVEY DEPARTMENTS, 1877

| Names | Substantive Appointment | Date of Appointment | Salary | Remarks |
|---|---|---|---|---|
| ADMINISTRATIVE STAFF | | | Rs | |
| Major General H L Thuillier C S I F R S | Surveyor General of India and Superintendent of Topographical Surveys | 12th March 1861 | 3 000 | Joined the Department 1836 |
| Major General D C Vanrenen R A I H | Deputy Surveyor General and Superintendent of Revenue Surveys | 3rd Oct 184[illegible] | 2 [illegible] | |
| Captain R V Riddell R E | Assistant Surveyor General | 1st Oct 1867 | 1 300 | 200 each local allowance |
| J O N James | | 29th July 1845 | 1 000 | |
| Captain J Waterhouse S C | | 23rd July 1866 | 750 | |

List of Officers of the Topographical and Revenue Survey Departments, 1877—*cont*

| Names | Substantive Appointment | Date of Appointment | Salary | Remarks |
|---|---|---|---|---|
| TOPOGRAPHICAL SURVEY DEPARTMENT | | | | |
| SENIOR BRANCH | | | Rs | |
| Lieut Colonel G C Depree S C I H | Deputy Superintendent 1st grade | 20th Oct 1851 | 1 600 | No 7 Rajputana Survey |
| Captain George Strahan R E I H | 2nd grade | 2nd July 186 | 1 383 | On furlough private affairs for two years from 1st May 1877 |
| Captain Charles Strahan R E | 3rd grade | 6th Sept 1863 | 1 140 | No 1 or Gwalior and C I Survey |
| REVENUE SURVEY DEPARTMENT | | | | |
| SENIOR BRANCH | | | | |
| Colonel H C Johnstone C B S C P H | Deputy Superintendent 1st grade | 27th May 185 | 1 627 | 1st or Dera Ismail Khan District Survey Punjab Rs 27 14 as personal allowance |
| Lieutenant Colonel F C Anderson S C I H | | 10th Sept 1852 | 1 6 7 | 5th or Banda District Survey N W P Rs 27 14 as personal allowance |
| Lieutenant Colonel J Macdonald S C I H | 2nd grade | 10th Sept 18 | 1 627 | On furlough private affairs for two years from 6th May 1877 |
| R B Smart | | 21st Sept 1846 | 1 00 | 7th or Khurda District Survey Orissa |
| Major J Sconce S C I H | | 21st Oct 1859 | 1 300 | 8th or Western Soane Irrigation Survey District Sahabad Behar |
| Major Donald Macdonald S C I H | 3rd grade | 19th Dec 1860 | 1 166 | 10th or 1st Deccan Topographical Survey Bombay Officiating in the 2nd grade |
| Major T Coddington S C I H | | 17th Jan 186 | 1 000 | On duty at Head Quarters Calcutta |
| Captain W Barron S C I H | | 7th June 186 | 1 000 | 4th or Moradabad and Budaun Districts Survey N W P |
| Major H C B Tanner Bombay S C I H | | 10th Oct 186 | 1 000 | 11th or 2nd Deccan Topographical Survey Bombay |
| F T S Johnson Esq | | 13th Oct 1847 | 1 000 | 6th or Eastern Soane Irrigation Survey District Gya Behar |
| TOPOGRAPHICAL AND REVENUE SURVEY DEPARTMENTS | | | | |
| SENIOR BRANCH | | | | |
| Captain D C Andrew S C I H | Assistant Superintendent 1st grade | 30th Dec 1862 | 1 000 | Cadastral Revision Survey Officiating Deputy Superintendent 3rd grade |
| Captain W H Wilkins S C I H | | 27th April 1863 | 750 | 12th or Midnapur District Survey Bengal |
| J Campbell | | 8th Oct 1844 | 750 | On furlough private affairs for eight months from 8th May 1877 |
| Captain E W Samuels S C P H | | 17th Dec 1863 | 750 | |
| Major W T Badgley S C I H | | 3rd May 1865 | 1 000 | No 6 or Khasi and Garo Hills Survey Officiating 3rd grade Deputy Superintendent |

List of Officers of the Topographical and Revenue Survey Departments, 1877—*cont*

| Names | Substantive Appointment | Date of Appointment | Salary | Remarks |
|---|---|---|---|---|
| TOPOGRAPHICAL AND REVENUE SURVEY DEPARTMENTS | | | | |
| SENIOR BRANCH—*cont* | | | Rs | |
| Captain J E Sandeman S C P H | Assistant Superintendent 1st grade | 6th Oct 1864 | 750 | On special duty Chota Nagpore Estate Survey |
| Captain T H Holdich R E L S | | 23rd July 1866 | 1 065 | On furlough private affairs for two years from 14th May 1877 |
| H Horst | 2nd grade | 1st Sept 1854 | 750 | In charge No 2 or Khandeish and Bombay Native States Survey Officiating in the 1st grade |
| Captain H L Smith S C P H | | 26th March 1866 | 750 | On furlough private affairs two years 24th April 1876 |
| H B Talbot I S | | 1st Dec 1848 | 750 | 6th or Eastern Soan Irrigation Survey Districts Gya Behar |
| Captain J R Wilmer S C H S | | 24th Aug 1869 | 749 | In charge No 5 Topographical Party Bhopal and Malwa Survey |
| Captain H S Cowan S C P H | | 19th Jan 1867 | 749 | 8th Western Soan Irrigation Survey Shahabad District Behar |
| Captain H S Hutchinson S C P H | | 13th Aug 1867 | 749 | 11th or 2nd Deccan Topographical Survey Bombay |
| E C Barrett H S | | 18th Nov 186? | 600 | 7th or Khurda Estate Survey Orissa |
| L J Jackson L S | | 26th Sept 1864 | 600 | 5th or Muttra and Banda Districts Survey N W P |
| Captain E H Steel S C H S | | 26th Jan 1869 | 624 | 2nd or Rohtak and Sirsa Districts Punjab Survey N W I |
| R Beavan S C P H | | 17th July 1868 | 624 | 1st or Dera Ismail Khan District Survey Punjab |
| Lieutenant R G Woodthorpe R E L S | | 14th July 1871 | 670 | No 6 or Khasi and Garo Hills |
| Lieutenant E P Leach R E L S | | 6th Oct 1871 | 670 | On furlough private affairs for one year and six months from 26th Nov 1877 |
| H E Gastrell L S | | 26th April 1869 | 600 | On sick leave for one year from 5th Jan 1877 |
| G H Cooke I S | | 6th Dec 1866 | 600 | 10th or 1st Deccan Topographical Survey Bombay Presidency |
| Lieutenant G W Martin S C H S | 3rd grade | 24th March 1871 | | On furlough private affairs two years 1?th Nov 1875 |
| Lieutenant A J C Scott S C H S | | 17th Jan 1872 | 500 | 4th or Moradabad and Budaun District Survey N W P |
| Lieutenant J R Hobday S C H S | | 7th July 1873 | 500 | No 1 or Gwalior and Central India Topographical Survey |
| TOPOGRAPHICAL SURVEY DEPARTMENT | | | | |
| JUNIOR BRANCH | | | | |
| N A Belletty L S | Surveyor 1st grade | 16th July 1847 | 500 | On duty at Head Quarters |
| J P Baness | | 5th Sept 1856 | 600 | Chief Draftsman Head Quarters Office supernumerary |
| A Chamarett | | 2nd June 1852 | 500 | On duty at Head Quarters Office |
| H J Bolst | | 26th July 1852 | 500 | No 1 or Gwalior & C I Survey |
| G A McGill L S | 2nd grade | 8th April 18?5 | 400 | No 7 or Rajputana and Simla Survey |

List of Officers of the Topographical and Revenue Survey Departments, 1877—*cont*

| Names | Substantive Appointment | Date of Appointment | Salary | Remarks |
|---|---|---|---|---|
| TOPOGRAPHICAL SURVEY DEPARTMENT | | | | |
| JUNIOR BRANCH—*cont* | | | Rs | |
| D Atkinson | Surveyor 2nd grade | 4th Aug 18 6 | 100 | No 5 or Bhopal and Malwa Survey |
| J A Vanderputt | | 1st Sept 18 6 | 400 | No 1 or Gwalior and C I Survey |
| R W Chew | | 1.th Sept 18 6 | 400 | No 8 or Nundydroog Division Mysore Survey |
| A J Wilson L S | 3rd grade | 1st Oct 1860 | 3 0 | No 2 Topographical Party Khandesh and Bombay Native States Survey |
| J A May | | 1st Oct 1860 | 3 0 | On duty at Head Quarters |
| T Adams | | 1st Oct 1860 | 3 0 | |
| R D Farrell | 4th grade | 1st Oct 1860 | 300 | No 8 or Nundydroo Division Mysore Survey |
| L S T Atkinson | | 13th Aug 1861 | 300 | No 7 Rajputana Topographical Survey |
| M J Ogle | | 1st July 1863 | 300 | On furlough for one year from 21st Nov 1877 |
| A G Wyatt | | 1st Nov 1861 | 300 | No 2 or Khandesh and Bombay Native States Survey |
| C I Hamer | Assistant Surveyor 1st grade | 3rd Aug 1863 | 0 | No 5 or Bhopal and Malwa Survey |
| C A R Scanlan | | 9th Sept 1863 | | On duty at Head Quarters |
| R Todd | | 1st Nov 1863 | | No 7 or Rajputana and Simla Survey |
| A Chennell | | 1st May 1864 | | On furlough for one year from 1st Nov 1877 |
| C Papsell | | 2nd Aug 1864 | | No 1 or Gwalior and C I Survey |
| A James | | 15th June 1864 | | No 8 or Nundydroog Division Mysore Survey |
| T L M Claudius | | 10th Aug 1863 | | No 1 or Gwalior and C I Survey |
| T Kitchen | | 4th Oct 1864 | | No 8 or Nundydroog Division Mysore Survey |
| W Stotesbury | | 1st Oct 1864 | | |
| J A Barker | 2nd grade | 18th Sept 186 | 00 | No 8 or Nundydroo Division Mysore Survey |
| L A Wainwright | | 1st May 18 | | No or Bhopal and Malwa Survey |
| W J Cornelius L S | | 1 th Aug 1866 | | No 1 or Gwalior and C I Survey |
| W W McNair | | 1st Sept 1867 | | No 8 or Nundydroog Division Mysore Survey |
| W T Pettigrew | | 12th Sept 1866 | | No or Khandesh and Bombay Native States Survey |
| P J W Doran L S | | 1st Feb 1867 | | No 1 or Gwalior and C I Survey |
| H T Kitchen | | 1st Nov 1867 | | No or Bhopal and Malwa Survey |
| A Cooper | | 1st Dec 1867 | | No 2 or Khandesh and Bombay Native States Survey |
| J H Wilson L S | | 1st April 1868 | | No 7 or Rajputana and Simla Survey |
| W H Lilley | 3rd grade | 1st May 1868 | 160 | No 5 or Bhopal and Malwa Survey |
| W Robert | | 1st Aug 1869 | | No 6 or Khasi and Garo Hills Survey |
| T T Warde | | 1st Sept 1870 | | No 2 or Khandesh and Bombay Native States Survey |

List of Officers of the Topographical and Revenue Survey Departments, 1877—*cont*

| Names | Substantive Appointment | Date of Appointment | Salary | Remarks |
|---|---|---|---|---|
| TOPOGRAPHICAL SURVEY DEPARTMENT | | | | |
| JUNIOR BRANCH—*cont* | | | Rs | |
| C T Templeton | Assistant Surveyor 3rd grade | 1st Sept 1870 | 160 | No 1 or Gwalior and C I Survey |
| J McCay | | 1st Dec 1870 | | No 6 or Khasia and Garo Hills Survey |
| W C G Barckley | | 1st Dec 1871 | | Special sick leave to Europe from 6th April 1876 for eight months granted extension for six months *vide* R A & Co Dept No 7?6 dated 4th September 1876 Extended again for six months further extension for three months Full pay |
| Geo Vander Beek | 4th grade | 1st July 187? | 120 | |
| J Murray | | 10th Oct 1872 | | No 5 or Bhopal and Malwa Survey |
| A Kitchen | | 10th Oct 1872 | | |
| P White | | 10th Oct 187? | | No 8 or Nundydroog Division Mysore Survey |
| E Graham L S | Probationary Assistant Surveyor 4th grade | 11th Aug 1873 | | No 2 or Khandesh and Bombay Native States Survey |
| G L Fleming | | 11th Aug 1873 | | No 8 or Nundydroog Division Mysore Survey |
| G R Copping | | 11th Au 1873 | | No 5 or Bhopal and Malwa Survey |
| G A Knight | | 11th Aug 1873 | | No 8 or Nundydroog Division Mysore Survey |
| Duncan Campbell | | 1st Nov 1874 | | No 6 or Khasia and Garo Hills Survey Joined as Sub Surveyor on 3rd July 1872 |
| REVENUE SURVEY DEPARTMENT | | | | |
| JUNIOR BRANCH | | | | |
| George Housden | Revenue Surveyor 1st grade | 18th Feb 1847 | 00 | 1st or Dera Ismail Khan District Survey Punjab |
| William Henry Peterson L S | | 1st Dec 18 1 | | On deputation to Kamrup Lal Iuraj Holdings Survey Exclusive of Assam and deputation allowance Rs 100 |
| Frederick William Kelly H S | Surveyor nd grade | 17th Aug 18?8 | 450 | Exclusive of personal allowance Rs 100 Supernumerary—Doing duty in Head Quarters Office |
| Charles William Campbell | | 1st Nov 1853 | 400 | ?th or Banda District Survey N W P |
| Edward Loftie | | 1st Jan 1847 | | 2nd or Rohtak and Sirsa Districts Survey Punjab |
| George Henry Blythe | | 1st Dec 1846 | | |
| Frederick Grant | | 11th July 1856 | | 8th or Western Soane Irrigation Survey District Shahabad Behar |
| William Sinclair | 3rd grade | 1st Oct 1855 | 350 | On furlough |
| Constantine Brownfield L S | | 20th Sept 1856 | | Head Quarters |
| Arthur David Smart | | 1st Oct 1870 | | Supernumerary — Doing duty in Head Quarters Office |

List of Officers of the Topographical and Revenue Survey Departments, 1877—*cont*

| Names | Substantive Appointment | Date of Appointment | Salary | Remarks |
|---|---|---|---|---|
| **REVENUE SURVEY DEPARTMENT** | | | | |
| JUNIOR BRANCH—*cont* | | | Rs | |
| James Todd | Surveyor 3rd grade | 27th Dec 1863 | 350 | 12th or Midnapore District Survey Bengal |
| Patrick Augustus George Cowley L S | | 1st Sept 1859 | | 6th or Eastern Soane Irrigation Survey District Gya Behar |
| Charles David | | 1st Sept 1847 | | 12th or Midnapore District Survey Bengal |
| George [illegible] | | 1st Sept 1859 | | 8th or Western Soane Irrigation Survey District Shahabad Behar |
| Samuel Mac? Smythe L S | | 24th July 1860 | | 11th or 2nd Deccan Topographical Survey Bombay |
| Vacant | | | | |
| Jas Stewart Pemberton L S | 4th grade | 6th Oct 1860 | 300 | 2nd or Rohtak and Sirsa Districts Survey Punjab |
| William Robert Lyall | | 13th June 1856 | | Khurda Estate Survey Orissa |
| Henry Ross Littlewood | | 6th Oct 1860 | | 9th or Azamgarh District Survey N W P |
| Wm Alexander Wilson L S | | 1st Jan 1861 | | 14th or Ganges Dearah Survey Bengal |
| William Samuel Buttress | | 1st Sept 1860 | | 1st or Dera Ismail Khan District Survey Punjab |
| Thomas Wilfred Reilly L S | | 18th Oct 18?9 | | 11th or 2nd Deccan Topographical Survey Bombay |
| Alexander Macdonald Lawson L S | | 18th Nov 186? | | 10th or 1st Deccan Topographical Survey Bombay |
| Andrew John Gibson | | 1st May 1861 | | 1st or Dera Ismail Khan District Survey Punjab |
| Henry Bowman | | 16th Oct 186? | | ?th or Khurda Estate Survey |
| Edwin Little | | 1st Jan 1860 | | 5th or Banda Districts Revenue Survey N W P |
| Henry Townsend Hanby L S | | 13th Nov 1862 | | 4th or Moradabad and Budaun Districts Survey N W P |
| George Bailey Scott L S | | 1st May 1863 | | 1st or Dera Ismail Khan District Survey |
| James Hoppner O'Donel | Assistant Surveyor 1st grade | 1st Oct 1863 | 250 | 6th or Eastern Soane Survey |
| Philip Ford L S | | 1?th Dec 1863 | | 2nd or Rohtak and Sirsa Districts Survey Punjab |
| Daniel Arthur King | | 12th April 1864 | | Chota Nagpore Estates Survey |
| Robert Boddington Smart L S | | 1st Jan 1864 | | 5th or Banda District Revenue Survey N W P |
| James Connor | | 15th Feb 1865 | 50 | Supernumerary—Doing duty in Head Quarters Office |
| Thomas Henry Dunne L S | | 15th Feb 1865 | | Supernumerary—Doing duty in Head Quarters Office |
| William James Lane | | 1st March 1865 | | 9th or Azamgarh District Survey N W P |
| John Thomas Umacke Coxen | 2nd grade | 16th May 1863 | 200 | 11th or 2nd Deccan Topographical Survey Bombay |
| John Newland L S | | 22nd Oct 1863 | | 10th or 1st Deccan Topographical Survey Bombay |
| Richard Cunningham Dundee Ewing L S | | 9th June 1866 | | 14th or Ganges Dearah Survey Bengal |
| George William Jarbo L S | | 1st Nov 1866 | | 5th or Banda District Survey N W P |
| James Reid Scott L S | | 19th Jan 1867 | | On duty at Head Quarters Office |
| John McHatton L S | | 1st July 1867 | | On duty at Head Quarters Office |

List of Officers of the Topographical and Revenue Survey Departments, 1877—*cont*

| Names | Substantive Appointment | Date of Appointment | Salary | Remarks |
|---|---|---|---|---|
| REVENUE SURVEY DEPARTMENT | | | | |
| JUNIOR BRANCH—*cont* | | | Rs | |
| William James Smith | Assistant Surveyor 2nd grade | 1st Sept 1866 | 200 | On sick leave for one year from 17th July 1877 |
| Septimus Oswald Madras | | 6th July 1868 | | 4th or Moradabad and Budaun Districts Survey N W P |
| Thomas Frederick Freeman L S | | 9th Sept 1868 | | 5th or Banda District Survey N W P |
| George Carleton Swiney | | 17th Sept 1868 | | 10th or Deccan Topographical Survey Bombay |
| Charles Waller Wilson L S | 3rd grade | 21st June 1867 | 160 | 11th or Ganges Dearah Survey Bengal |
| Charles Walter Franklin Seyers | | 1st Dec 1864 | | |
| Alfred Collimore Wilson Lemarchand L S | | 2nd Nov 1868 | | 6th or Eastern Soane Irrigation Survey District Gya Behar |
| John Sidney Swiney | | 5th Jan 1869 | | 6th or Eastern Soane Irrigation Survey Gya Behar |
| George Latter Rodway Scott L S | | 1st March 1869 | | 6th or Banda District Survey N W P |
| James O Toole | | 10th Sept 1868 | | On sick leave for 9 months from 7th May 1876 |
| William Joseph Lincoln L S | | 1st April 1869 | 160 | 4th or Moradabad and Budaun Districts Survey N W P |
| Benjamin Anderson L S | | 20th April 1869 | | 2nd or Rohtak and Sirsa Districts Survey Punjab |
| Thomas Shaw L S | | 1st April 1869 | | 8th or Western Soane Irrigation Survey District Shahabad Behar |
| William Henry Penrose L S | | 11th Aug 1869 | | 11th or 2nd Deccan Topographical Survey Bombay |
| Edmund James Martin | | 16th Sept 1867 | | 6th or Eastern Soane Irrigation Survey District Gya Behar |
| William Dease Corbett | | 1st Dec 1868 | | On special duty Chota Nagpore Estates Survey Bengal |
| George Edwin Parker | | 18th Nov 1870 | | 12th or Midnapore District Survey Bengal |
| George Campbell | | 1st Jan 1871 | | 7th or Khurda Estate Survey Orissa |
| John Murphy | Probationary Assistant Surveyor 4th grade | 2nd Nov 1868 | 120 | th or Banda District Survey N W P |
| Charles Wyatt Joseph Lord L S | | 1st Nov 1871 | | 4th or Moradabad and Budaun Districts Survey N W P |
| Arthur William Smart | | 1st Jan 187 | | 6th or Eastern Soane Irrigation Survey District Gya Behar |
| George Hugh O Donel | | 23rd July 1872 | | 8th or Western Soane Irrigation Survey District Shahabad Behar |
| Henry George Young H S | | 1st Sept 187 | | th or Banda District Survey N W P |
| Percival Edwin Hebbert | | 9th Aug 1871 | | Khoordah Estate Survey Orissa |
| Bruce Macdonald Wilson | | 15th Nov 1872 | | 12th or Midnapore District Survey Bengal |
| Elliot Playfair Smyth Hill | | 16th Nov 187 | | 4th or Moradabad and Budaun Districts Survey N W P |
| Edmund Hume Stephen Gaspar | | 16th Nov 1872 | | 12th or Midnapore District Survey Bengal |

List of Officers of the Topographical and Revenue Survey Departments, 1877—*cont*

| Names | Substantive Appointment | Date of Appointment | Salary | Remarks |
|---|---|---|---|---|
| REVENUE SURVEY DEPARTMENT | | | | |
| JUNIOR BRANCH—*cont* | | | Rs | |
| Richard Randall Dickinson L S | Probationary Assistant Surveyor 4th grade | 16th April 1873 | 120 | 10th or 1st Deccan Topographical Survey Bombay |
| Edward Bolderodi Montbello Drew | | 5th May 1873 | | th or Banda District Survey N W P |
| Paul Agabeg Peters L S | | 1st Nov 1873 | | 1st or Dera Ismail Khan District Survey Punjab |
| Henry Reed Adels | | 19th Feb 1874 | | 11th or Ganges Delta Survey Bengal |
| Charles Samuel Kiaal | | 24th July 1874 | | nd or Rohtak and Sirsa Districts Survey Punjab |
| Conly Thomas James Dease | | 1st Dec 1873 | | 11th and 2nd Deccan Topographical Surveys |
| Thos Campbell | | 1st May 1875 | | 6th or Eastern Sone Irrigation Survey District Gya Behar |
| Lionel Fitzhardinge Berkeley | | 16th Aug 1875 | | 4th or Moradabad and Budaun Districts Survey N W P |

## MADRAS REVENUE SURVEY

| Names | Substantive Appointment | Date of Appointment | Salary | Remarks |
|---|---|---|---|---|
| | | | Rs | |
| Lieutenant Colonel A De Courcy Scott R E | Superintendent | 8th Feb 1877 | 1 800 | |
| I C Tuckle M A | Deputy Supt 1st class | 19th Mar 1858 | 1 100 | Cuddapah (No 3 Party) On furlough |
| W Beaumont | | 21st May 1858 | 1 100 | N & S Arcot (No 5 Party) |
| H O C Cardozo | 2nd class | 5th Feb 1859 | 983 | Bellary and Cuddapah (No Party) Ag Dep Supt 1st class |
| Lieutenant Colonel J G Cloete | | 2nd June 1863 | 1 00 | Coimbatore and Salem (No 1 Party) |
| H Gompertz | | 23rd Mar 1860 | 770 | Madura (No 4 Party) |
| J H Wright | 1st Assistant Superintendent | 21st May 1858 | 550 | Bellary and Cuddapah (No 2 Party) |
| Major C D Baynes | | 18th June 1861 | 1 066 | No 5 Party detached on famine duty |
| A O H Clay | | 1st Nov 1861 | 1 200 | North Arcot (No 3 Party) |
| Captain W Treeth | | 1st Oct 1864 | 900 | Coimbatore and Salem (No 1 Party) |
| J J Tomlinson | | 3rd May 1865 | 550 | Cuddapah (No 3 Party) |
| F A Tomlinson | 2nd Assistant Superintendent | 17th Aug 1859 | 550 | Madura (No 4 Party) Ag 1st Assist Supt |
| Captain R M Clerk | | 17th May 1866 | 730 | Coorg A 1st Asst Supt |
| Major C C Sargeaunt | | 20th Feb 1867 | 966 | Central Office |
| J H Cook | | 21st Jan 1868 | 42 | No 1 Party detached on famine duty |
| E M Barber | | | 4 5 | No 4 Party detached on famine duty |
| Major C A Lardet | 3rd Assistant Superintendent | 6th Oct 1868 | 1 016 | No 5 Party detached on famine duty |
| J H Merriman | | 4th June 1868 | 42 | Ganjam (No Party) |
| A Maltby | | 17th Dec 18 2 | 12 | Bellary and Cuddapah (No Party) |

## Bombay Revenue Survey

| Names | Substantive Appointment | Date of Appointment | Salary | Remarks |
|---|---|---|---|---|
| **Southern Maratha Country** | | | Rs | |
| Lieutenant Colonel W C Anderson | Survey and Settlement Commissioner | 2nd March 184 | 2 494 | |
| R E H Light | Assistant Superintendent | 21st March 18[illegible]1 | 1 000 | |
| W S Price | | 2nd July 1856 | 79 | |
| F C Beynon | | 16th Oct 1857 | 995 | |
| Captain G Coussmaker | | 10th June 1862 | 800 | |
| F T Willaume | | 31st Oct 1863 | 795 | |
| Captain C W Godfrey | | 0th Aug 1864 | 995 | On furlough |
| A P Young | | 6th May 1867 | 695 | |
| W Turnbull | | 14th Aug 186 | | |
| R T Wingate | | th Jan 1868 | | |
| Lieutenant T C Symonds | | 1st March 1871 | | |
| A P W Mark | | 17th Oct 1871 | 560 | On furlough |
| J H C Dunsterville | | th Jan 1869 | | |
| Captain T M Ward | Acting Assistant Superintendent | 9th Nov 1864 | 7[illegible]5 | |
| Lieutenant L L Fenton | | 7th Nov 1873 | 560 | |
| W F Marriott | | 7th May 187[illegible] | 460 | |
| J L Lushington | | [illegible]7th July 1874 | | |
| F B Young | | 24th Aug 187 | | |
| Walter S Owen | Probationary Assistant Superintendent | [illegible]9th March 1875 | 17 | |
| **Guzerat** | | | | |
| N B Beyts | Superintendent and Assistant Collector and Magistrate | 14th Oct 1854 | 1 17 | |
| Rao Bahadoor Shumbooprasad Luxmilal | Assistant Settlement Officer and Deputy Collector | | 72 | On special duty in the Political Department in the Morvi State in Kattywar |
| A S Bulkley | Assistant Superintendent | [illegible] Nov 18 | 795 | On sick leave to Europe |
| H H Summers | | 27th Sept 1854 | 695 | |
| T R Fernandez | | 26th July 1861 | | Superintendent of Bhownuggur Survey |
| F De Souza | | [illegible]th Dec 185 | | |
| W E Waite | | 18th Oct 1866 | | In charge of City Survey and Enquiry Office Ahmedabad |
| H D E Forbes | | 4th Oct 1871 | 560 | |
| A Dalzell | | [illegible]rd Aug 1871 | | |
| F Le Mesurier | | | | |
| **Poona and Nassick** | | | | |
| Colonel J T Francis | Survey and Settlement Commissioner | 8th Dec 184[illegible] | 2 494 | On furlough |
| Lieutenant Colonel E L Taverner | Superintendent Poona Sholapur and Nassick Survey | 30th Oct 1853 | 1 752 | On furlough |
| J W Scott | Assistant Superintendent | 2[illegible]th June 1856 | 795 | |
| H K Disney | | 27th March 1860 | | |
| H M Grant | | | 695 | Dead on 2nd Aug 1877 |
| R B Pitt | | 12th Oct 185[illegible] | 795 | On furlough |
| W M Fletcher | | 23rd Jan 1866 | 695 | Transferred to the S M L Survey |
| Lieutenant W C Black | | 17th Nov 1869 | | |
| A B Fforde | | 24th June 1868 | | |
| J C Whitcombe | | 8th April 18[illegible]7 | | |

## Bombay Revenue Survey—*cont*

| Names | Substantive Appointment | Date of Appointment | Salary | Remarks |
|---|---|---|---|---|
| POONA AND NASSICK—*cont* | | | Rs | |
| P S Fitzgerald | Assistant Superintendent | 17th June 1871 | 4[illegible]0 | Acting Assistant Political Agent Mabeekanta |
| I W L Moriant | | 13th Nov 1868 | 69 | |
| H I Holland | | 11th May 187[illegible] | 160 | On furlough |
| I W Fraser | | 1[illegible]th Sept 1873 | | Temporarily transferred to S M I Survey |
| RUTNAGIRI | | | | |
| J P Gibson | Deputy Superintendent | [illegible]nd Feb 18[illegible] | 99[illegible] | |
| C Hexton | Assistant Superintendent | | | Pensioned |
| W G Harrison | | [illegible]th June 18[illegible] | [illegible]9 | |
| J W Young | | [illegible]th May 18[illegible] | | |
| I Hearn | | [illegible]th Sept 18[illegible] | [illegible] | On furlough |
| J Adams | | 3rd Feb 18[illegible]1 | [illegible]0 | |
| Captain F B Stace | | 27th Jan 1871 | [illegible]0 | Acting Fourth Assistant Political Agent in Kattywar |
| C H Davidson | | [illegible]3rd Feb 187[illegible] | | |
| H F Hatch | | 1st Dec 1873 | | |
| SIND SETTLEMENT SURVEY | | | | |
| Lieutenant Colonel M R Haig | Settlement Officer | [illegible]nd Nov 18[illegible] | 1[illegible]7[illegible]7 | |
| Major C I Fisher | Deputy Settlement Officer | 1[illegible]th Nov 18[illegible] | 700 | |
| W Wilkins | First Class Assistant Settlement Officer | 1[illegible]th Feb 1877 | 500 | |
| G Barrie | First Class Assistant | 27th Oct 18[illegible] | | |
| J I Nash | | 12th Aug 18[illegible] | | On furlough |
| C I Matheson | | 9th Jan 18[illegible]7 | | |
| W A Boulton | Second Class Assistant | 6th Dec 18[illegible]9 | 400 | |
| Meeah Mahomed | Sub Assistant | 1st Jan 18[illegible] | [illegible]00 | |
| Lieutenant Colonel C A Laughton | Acting Superintendent Poona and Nasik Survey | 19st Dec 1851 | 110[illegible] 1[illegible] 0 | Sind City Surveys being completed transferred to act as Superintendent Revenue Survey Poona and Nasik |

## LIST of OFFICERS of the MYSORE REVENUE SURVEY

| Names | Substantive Appointment | Date of Appointment | Salary | Remarks |
|---|---|---|---|---|
| | | | Rs | |
| The Honourable Colonel W C Anderson | Survey and Settlement Commissioner | [illegible]8th Sept 1863 | 1 100 | |
| Major J P Grant | Superintendent | 1st Nov 1863 | 1 310 | On furlough to Europe for [illegible]0 months |
| J W M Anderson | Deputy Superintendent | 7th Nov 1863 | 1 0 0 | Officiating Superintendent from 13th July 1877 |
| 1ST GRADE | | | | |
| Captain J Rutherford | Assistant Superintendent 1st grade | 1st Feb 1865 | 860 | |
| G Mackenzie | | 31st Oct 18[illegible]3 | [illegible]0 | |
| I W Major | | [illegible]3rd April 18[illegible] | [illegible]0 | |
| J B Lawrence | | 1[illegible]th Jan 18[illegible]9 | 6[illegible]0 | |
| F H Butcher | | 2nd Oct 18[illegible] | [illegible]0 | |

List of Officers of the Mysore Revenue Survey—*cont*

| Names | Substantive Appointment | Date of Appointment | Salary | Remarks |
|---|---|---|---|---|
| 2ND GRADE | | | Rs | |
| Captain M F Coussmaker | Assistant Superintendent 2nd grade | 24th Dec 1865 | 560 | On leave on Medical certificate to Europe for two years from 2nd July 18[illegible] |
| R L Price | | 1st Nov 1872 | 560 | |
| J P Barker | | 22nd Dec 1866 | 560 | |
| Lieutenant A H Macintire | | 6th Dec 1869 | 560 | |
| G F Meiklejohn | | 30th Nov 1867 | 60 | |
| Captain D Cowie | | 3rd Dec 1870 | 560 | |
| W E A James | | 1st Dec 1867 | 60 | |
| F B Clerk | | 16th Jan 1868 | 560 | On special duty connected with famine relief |
| 3RD GRADE | | | | |
| Captain A McCally | Assistant Superintendent 3rd grade | 18th Jan 187[illegible] | 4 | |
| G K Betham | | 1st Nov 1873 | 4 | |
| A G Hudson | Probationary Assistant Superintendent | 23rd Nov 1876 | 180 | |
| E W Laseran | | 22nd March 1877 | 180 | |

LIST of OFFICERS of the BERAR REVENUE SURVEY

| Names | Substantive Appointment | Date of Appointment | Salary | Remarks |
|---|---|---|---|---|
| 3RD GRADE | | | Rs | |
| R R Beynon | Superintendent | 30th Oct 1859 | 1 400 | |
| 1ST GRADE | | | | |
| Captain C C Pemberton | Assistant Superintendent | 14th Sept 1864 | 79 | On furlough to Europe for two years from the 14th Feb 1877 |

LIST of OFFICERS attached to the ADMINISTRATIVE and DRAWING BRANCHES of the SURVEYOR GENERAL'S OFFICE, on the 1st April 1877

| Names | Substantive Appointment | Salary | Date of Appointment | Remarks |
|---|---|---|---|---|
| | | Rs | | |
| A E Byrn | Registrar and Accountant | 400 | 13th April 1865 | Previous service in other Government offices from 9th October 1864 to 12th April 1865 |
| M Francis | Head Clerk | 230 | | |
| I A D Rozario | 2nd Clerk | 150 | 17th April 1876 | Previous service as Clerk in British Burma Secretariat from 14th October 1874 to 16th April 1876 |
| D Byrns | 3rd Clerk | 100 | 24th April 1876 | Previous service as an Accountant in the Northern Bengal State Railway from 1st March 1874 to 23rd April 1876 |
| H R Vallis | 6th Clerk | 60 | 6th March 1869 | |
| Eight native clerks on salaries ranging from Rs 20 to Rs 100 | | | | |
| J F Baness | Surveyor and Chief Draftsman | 600 | 5th Sept 1856 | |
| T W Babonau | 1st Draftsman | 300 | 9th Aug 1861 | |
| J R Adels | 2nd Draftsman | 230 | 23rd March 1866 | |

## List of Officers attached to the Administrative and Drawing Branches of the Surveyor General's Office on the 1st April 1877—*cont*

| Names | Substantive Appointment | Salary | Date of Appointment | Remarks |
|---|---|---|---|---|
| | | Rs | | |
| G B Korper | 3rd Draftsman | 180 | 17th Feb 1871 | |
| R A Gibson | 5th Draftsman | 130 | 10th Oct 1870 | Previous service as Probationary Assistant Surveyor in the Great Trigonometrical Survey from 1st October 1868 to 30th June 1870 |
| G I Tate | Apprentice Draftsman | 90 | 1st March 1874 | |
| One native Draftsman one Computor fourteen Assistant Draftsman and four Colorists on salaries ranging from Rs 16 to Rs 160 | | | | |
| W Green | Record Keeper | [illegible]0 | 1st Jan 186[illegible] | |
| T I Ware | Storekeeper | 170 | 21st Sept 1871 | |
| One Native Assistant Storekeeper and Despatcher on a salary of Rs [illegible]0 | | | | |

## Engraving Branch, Surveyor General's Office, 1st April 1877

| Names | Substantive Appointment | Salary | Date of Appointment | Remarks |
|---|---|---|---|---|
| | | Rs | | |
| C W Coard | Superintendent of Engravers | 7[illegible]0 | 4th Nov 18[illegible]8 | |
| Presidency House Rent | | 100 | | |
| W Donaldson | Engraver | [illegible]60 | [illegible]th Nov 1868 | |
| J M Dalziel | | | | |
| C C Palmer | | 400 | 5th Sept 187[illegible] | |
| Presidency House Rent | | 50 | | |
| D I Mitchell | | 360 | [illegible]nd Sept 187[illegible] | |
| Presidency House Rent | | [illegible]0 | | |
| J Pulford | | 3[illegible] | 10th Oct 187[illegible] | |
| Presidency House Rent | | [illegible]0 | | |
| O [illegible] | | [illegible]7[illegible] | 5th Sept 187[illegible] | |
| Presidency House Rent | | [illegible]0 | | |
| F B Rodger | | [illegible]00 | [illegible]0th Aug 187[illegible] | |
| Presidency House Rent | | [illegible]0 | | |
| A G Palmer | | 1[illegible]0 | 1st Oct 18[illegible] | Previous service as apprentice Surveyor in drawing branch from 1st April 1871 |
| S M Coard | | 100 | | Previous service as apprentice Surveyor in drawing branch from 1st February 1875 |
| H C Martin | Copper Plate Printer | 275 | 10th Dec 187[illegible] | |
| Presidency House Rent | | [illegible]0 | | |

1 Native writer on Rs [illegible]0
10 Native engravers on salaries ranging from Rs [illegible]0 to Rs 12[illegible]
1[illegible] Native apprentice engravers on salaries ranging from Rs 10 to Rs [illegible]4

## Officers and Native Establishment attached to the Superintendent of Revenue Surveys Office, 1st April 1877

| Names | Substantive Appointment | Salary | Date of Appointment | Remarks |
|---|---|---|---|---|
| Correspondence Department | | Rs | | |
| J I Adels | Head Assistant | [illegible]00 | 1st April [illegible] | |
| A C Cunningham | 1st | 300 | 1st April 18[illegible] | |
| 14 Native Assistants | | From 30 to 17[illegible] | Various | |

Officers and Native Establishment attached to the Superintendent of Revenue Survey's Office, 1st April 1877—*cont*

| Names | Substantive Appointment | Salary | Date of Appointment | Remarks |
|---|---|---|---|---|
| DRAWING DEPARTMENT | | Rs | | |
| F W Kelly | Revenue Surveyor and Head Draftsman | 5 0 | 1st April 1866 | Includes Rs 100 personal allowance |
| J Connor | Assistant Surveyor 1st grade and Draftsman | 3 | 9th May 1870 | |
| J McHatton | Assistant Surveyor nd grade and Draftsman | 25 | 1st Nov 1876 | |
| 21 Native Draftsmen | | From 16 to 1 5 | Various | |
| ADDITIONAL ESTABLISHMENT FOR DRAWING DEPARTMENT | | | | |
| A D Smart | Revenue Surveyor 3rd grade and Draftsman | 100 | 1st July 1871 | |
| T H Dunne | Assistant Revenue Surveyor 1st grade and Draftsman | 00 | 1st May 187 | |
| 5 Native Draftsmen | | From 35 to 0 | Various | |

OFFICERS attached to the MATHEMATICAL INSTRUMENT DEPARTMENT, 1st April 1877

| Names | Substantive Appointment | Salary | Date of Appointment | Remarks |
|---|---|---|---|---|
| | | Rs | | |
| Captain R V Riddell R E | Officiating Superintendent Math Inst Dept | | | |
| R Wehlisch | Mathematical Instrument Maker | 700 | 11th July 1866 | |
| I Bolton | Assistant Mathematical Instrument Maker | 4 0 | 16th Sept 1868 | |
| J V Halden | Storekeeper | 00 | 6th Nov 1866 | |
| M O Brien | Head Clerk | | 22nd Sept 1860 | |
| M J O Brien | Assistant Clerk | 7 | 20th Feb 1877 | On Probation |
| 6 Native | Clerks | 170 | | |
| 158 | Artificers and Assistants | 1 6 0 | | |

OFFICERS attached to the LITHOGRAPHIC BRANCH of the SURVEYOR GENERAL'S OFFICE, 1st April 1877

| Names | Substantive Appointment | Salary | Date of Appointment | Remarks |
|---|---|---|---|---|
| | | Rs | | |
| Captain R V Riddell R E | Assistant Surveyor General in Charge | | | |
| E Jevozy | Head Assistant and Chief Draftsman | 4 0 | 15th June 1870 | |
| H Niven | Head Printer | 300 | 5th Jan 186 | |
| H L Lepage | Head Draftsman | 230 | 15th July 1871 | |
| Native Establishment | 1 Examiner | 1 0 | Various from 18 to the present time | |
| | 25 Draftsmen &c | 848 | | |
| | 3 Writers | 130 | | |
| | 11 Compositors | 1 0 | | |
| | 20 Printers exclusive of Assistants | 210 | | |

OFFICERS and ASSISTANTS attached to the PHOTOGRAPHIC BRANCH of the SURVEYOR GENERAL'S OFFICE, 1st April 1877

| Names | Substantive Appointment | Salary | Date of Appointment | Remarks |
|---|---|---|---|---|
| | | Rs | | |
| Captain J Waterhouse | Assistant Surveyor General in Charge | 550 | 3rd July 1866 | |
| J Mackenzie | Photographer | 330 | 1st June 186 | |
| Sergeant J Harrold | | 0 | 19th March 1873 | |
| L Marshall | | 170 | 0th March 1871 | |
| R George | | 11 | 1st Feb 187 | |
| L I[illegible] | | | | |
| A Feloy | | 100 | 11th Sept 1876 | |
| A A Madge | Assistant Photographer | 0 | 1st Nov 1876 | |
| C DeCruz | | 45 | 1st May 1868 | |
| B Mackenzie | Zincographer | 0 | 4th Nov 1867 | |
| J Watson | | | | |
| I A Feltane | | 100 | 15th Nov 1876 | |
| J A Wallis | Zinc Corrector | 70 | 6th March 1871 | |
| Native Establishment | 1 Storekeeper<br>3 Clerks<br>11 Draftsmen or Zinc Correctors<br>8 Assistant Photographers<br>71 Printers and others | | | |

Members of the Geological Survey of India

## Members of the Geological

(Those who have died in the Service are in Small

| Name | Official Position in 1877 | Date of Joining the Survey | Date of Retirement or Death | Periods of Leave in England | Salary 1877 |
|---|---|---|---|---|---|
| | | | | | In Rupees per month |
| A H WILLIAMS | | Feb 1846 | Died 1848 | | |
| R G HADDON | | 1847 | Died 1851 | | |
| —— JONES | | 1847 | Died 18 8 | | |
| *J McClelland* | | 1848 | Left 18 1 | | |
| JOHN JOHNSON | | Dec 1848 | Died 18 0 | | |
| Wm Theobald | Deputy Superintendent Bengal | Nov 1848 | | 2 years and 2 months | 1 100 0 0 |
| *A & B Gomess* | | 1849 | Left 185 | | |
| *Thomas Oldham* | | March 1851 | Retired in Mar 1876 | 1 year and 5 months | |
| *J G Medlicott* | | Dec 1851 | Left in July 186 | None | |
| *R J St George* | | July 1853 | Left in December 1853 | None | |
| H B Medlicott | Superintendent | March 1854 | | 11 months and 19 days | 1 800 0 0 |
| J S KENNEDY | | 18 | Died in February 1856 | None | |
| W T Blanford | Senior Deputy Superintendent | Oct 1855 | | years months & 21 days | 1 400 0 0 |
| *H F Blanford* | | 1855 | Left in December 1861 | None | |
| C Œ OLDHAM | | April 1856 | Died in March 1869 | One year (only lived 6 months out of the 1?) | |
| W K LOFTUS | | Feb 1857 | Died in July 1859 | None | |
| Wm King | Deputy Superintendent Madras | March 18 7 | | 1 year and 3 months | 1 100 0 0 |
| W L Willson | 2nd Class Assistant | 1857 | | 1 year and 3 months | 700 0 0 |
| J GEOGHEGAN | | April 1857 | Died in May 1858 | None | |
| H CHILD | | June 1857 | Died in June 1858 | None | |
| R B Foote | 1st Class Assistant | Sept 1858 | | 1 year 4 months and 25 days | 1 000 0 0 |
| F R Mallet | 2nd Class Assistant | Feb 1859 | | 1 year | 700 0 |
| *A Tween* | | May 18 9 | Retired October 1876 | 6 months private affairs 15 months sick leave with 3 months extension | |
| F Fedden | 3rd Class Assistant | Oct 1860 | | 2 years and 2 months | 500 0 0 |
| R TRENCH | | 1860 | Died in May 1861 | None | |
| C A Hacket | 3rd Class Assistant | Nov 1861 | | 1 year and 3 months | 500 0 0 |
| A B Wynne | 2nd Class Assistant | 186 | | 2 years 7 months and 23 days | 700 0 0 |
| *C Wilkinson* | | 186 | Left in February 1865 | None | |
| T W H Hughes | 2nd Class Assistant | 186 | | 1 year 4 months & 8 days | 700 0 0 |
| *Hugh Kane* | | 1862 | Left in March 1864 | None | |
| F STOLICZKA | | Dec 1862 | Died June 1874 | None | |
| V Ball | 2nd Class Assistant | Oct 1864 | | None | 700 0 0 |
| M H ORMSBY | | March 1866 | Died in June 1870 | Sick leave 18 months | |
| MARK FRYAR | | May 1868 | Died in November 187 | None | |
| T H Turner | Assistant Curator | April 1869 | | None | 300 0 0 |
| J Schaumburg | Artist | April 1869 | | None | 325 0 0 |
| W R Bion | Chief Clerk and Librarian | Dec 1870 | | None | 210 0 0 |
| W Waagen | | Dec 1870 | Retired Aug 1875 | 20 months with 10 months extension | |
| *J Alexander* | | Jan 1871 | Left in August 1871 | | |
| *J Wilson* | | Sept 1871 | Left in March 1873 | 6 months and 1 month extension | |
| R Lydekker | 3rd Class Assistant | Nov 1874 | | None | 150 0 0 |
| O Feistmantel | Palæontologist | March 1875 | | None | 00 0 0 |

## SURVEY of INDIA

(Capitals those retired from the Service in Italics )

| Travelling and Horse Allowances | Districts in which he has served with Dates | Remarks Previous Service &c |
|---|---|---|
| Rupees | | |
| | Raneegunge coal field 1846 47 Pachete 1848 | Previously on Geological Survey of Great Britain Died of jungle fever |
| | Do do do | Died of general debility and liver the result of exposure |
| | Do do do | Died of jungle fever after a few days illness |
| | Kuhurbali and Rajmahal Hills | Of Bengal Medical Service Temporarily in charge of Survey after death of Mr William |
| | | Died of fever |
| 130 0 0 | Ramghur 1848 Rajmahal Hills 1849 0 (Punjab 18 0 ) Rajmahal Hills 18 4 Burma 1854 55 Orissa 185 ( Nerbudda Valley 18 6 7 Kattywar 1857 8 Ganges Valley 1858 60 Pegu and Arracan 1862 70 British Burma 1870 73 Siwalik Hills 1874 75 Sub Himalaya 1876 77 | |
| | Calcutta and Cossyah Hills 18 0 1 | Still alive New Comr of Sunderbunds |
| | India generally and Burmah | LL D F R S F G S Formerly Director Geological Survey of Ireland |
| | Rajmahal Hills 18 1 3 Nerbudda Valley 18 4 Midnapoor 18 7 58 Sonthal perguunahs and Behar 18 8 60 Sone Valley Rewah 1860 62 | B A Joined Educational Department as Inspector of Schools |
| | Rajmahal Hills 18 3 | B A C E Joined East India Railway as Engineer |
| 00 0 0 | Nerbudda Valley 18 4 5 Sub Himalaya 18 56 Bundelkund 18 57 Shut up (Mutiny) 18 7–58 Sub Himalaya 1859 6 Sone Valley 186 63 Behar 1863 64 Assam 1864 6 Rajpootana 186 6 S W Frontier Districts 1866 67 Garrow Hills 1867 68 Sone Valley 1868 69 Pachmari Hills 1869 70 Bundelkund and Satpura 1870 71 Satpura 1871 73 Garo and Rajmahal Hills 1873 74 Satpura and Nepal 1874 75 Jamu 187 76 Satpura 1876 77 | M A F G S C E F R S |
| | Nerbudda Valley | B A Died of fever liver and dysentery |
| 110 0 0 | Orissa 18 58 Rajmahal Hills 18 57 Raneegunge 18 8 60 Pegu and Arracan 1860 62 Bombay Presidency Malwa and Central Provinces 186 70 Abyssinia 1868 69 Nagpur and Godavari Valley 1869 71 Bombay and Persia 187 Leave 1873 74 Simla 187 77 | A R S M F C S F R S |
| | Orissa 185 56 Trichinopoly 18 7 61 | A R S M F C S Now Meteorological Reporter to Government of India |
| | Rajmahal Hills 18 57 Madras Presidency 1857 58 | B A Died of blood poisoning from guinea worm contracted on service |
| | Rajmahal Hills 18 57 | Died of liver abscess |
| 130 0 0 | Madras Presidency 18 7 6 Kadapur 18 0 Godaveri District 1871 77 | B A |
| 130 0 0 | Bengal 1857 6 Central India 1866 70 N W and C Provinces 1870 72 Banda and Rewah 1873 Bundelkund 1874 77 | |
| | Madras Presidency 1857–58 | B A C L Died from sunstroke |
| | Orissa 1857 8 | A R S M Died of cholera |
| 130 0 0 | Madras Presidency 1858–70 Kaladgi and Belgaum 1870 71 Upper Kistna Valley 187 73 South Maratha Country Nellore and Kistna District 1874 75 Nellore 1876 77 | F C S |
| 130 0 0 | Raneegunge 1853 South Mirzapur and Singrowli 1870 Hazaribagh 1873 Sikkim 1874 Assam 187 76 Office 1877 | F G S |
| | Raneegunge 185 60 | A R S M |
| 130 0 0 | Pegu 1860 63 Bengal 186 6 Berar 186 67 Cutch 1867 69 Nagpore and Berar 1869 70 Chanda and Nizam s territories and East Berar 1870 71 Sick leave 187 73 Nizam s territories 1874 Sind 1875 77 | A R S M F C S |
| | Upper Soane Valley 1860 61 | Previously on Geological Survey of Great Britain Died of phthisis aggravated by exposure |
| 130 0 0 | Bengal 186 Gwalior and Rajpootana 1863 68 Jubalpur 1869 70 Jabalpur 1870 South Rewah 1871 Nerbada Valley 1872 73 Rajputana 1874 Furlough 1875 Rajputana 1876 77 | |
| 130 0 0 | Bombay Presidency Malwa and Nerbudda Valley 186 6 Cutch 1867 69 Salt Range Punjab 1869 71 Hazara 187 Punjab and Kohat 1873 Rawal Pindi 1874 Furlough 1875 Upper Punjab 1876 77 | F G S |
| | Bombay Presidency 186 6 | A R S M Health broke down resigned in consequence |
| 130 0 0 | Bengal 186 68 Central Provinces 1869 70 East Berar 1870 71 Leave 1872 Wardha coalfield 187 Nagpur and Nizam s territories 1874 Wardha coalfield 1875 Godaveri and Pranhita valleys 1876 77 | A R S M F G S |
| | Sone Valley 1863 64 | B A M D Health broke down resigned in consequence |
| | Himalaya Bengal | Ph D F C S Previously on Geological Survey of Austria Died of meningitis caused by exposure at high elevations |
| 130 0 0 | Bengal 1864 68 Chota Nagpur 1868 73 Satpura 1874 Sambalpur 1875 Talchir coalfield Bastar and Jaipur 1876 77 | A M F C S |
| | Bengal | LL D C E Died of debility induced by sunstroke and liver |
| | Central Provinces | |
| | Office Calcutta | |
| | Office Calcutta | |
| | Office Calcutta | |
| 130 0 0 | Salt Range 187 73 | Ph D Health broke down resigned in consequence |
| | | Now tutor to the Durbanga Rajah |
| | Bengal 1871 73 | Joined the Educational Department as Professor of Physical Science |
| 130 0 0 | Office 1874 Himalaya 187 77 | A B |
| 130 0 0 | Rajmahal Hills 1875 Kurhurbalee 1876-77 | M D |

# INDEX

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