PREFACE.

THE Annual Abstract of the Surveys and of other geographical operations in India during the year 1872–73 is arranged on the plan of the "Memoir on the Indian Surveys," and of the Abstracts for 1869–70, 1870–71, and 1871–72, which give a history of these operations up to March 1872. The intention of these Annual Abstracts is to indicate the more important and interesting operations of the year, previous to an examination of the detailed reports, with their valuable appendices. They are also designed to be useful for future reference. It is hoped that the abstracts attain these objects.

Foot notes are given, referring the reader to passages in the Memoir, or in the Abstracts for 1869–70, 1870–71, and 1871–72, in which the previous history of each operation is described, and the previous services of officers that are mentioned is given.

The Memoir appeared in 1870, and Annual Abstracts have been published in the four succeeding years. In 1875, the fifth year, a second edition of the Memoir will be published, embodying all the contents of the four Abstracts and the work of 1874 under the respective heads, and containing many corrections and additions. In the new edition the Memoir will be differently arranged, and pains will be taken to eliminate all the errors of the first edition and to make up for all former omissions and shortcomings. With this end, communications and suggestions will be gratefully received from anyone who may kindly transmit them.

CLEMENTS R. MARKHAM

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ABSTRACT.

I.

Indian Marine Surveys, 1873.

The increasing necessity for making due provision for the surveys of the Indian coasts and harbours, and for the supply of accurate charts, has been fully recognised during the past year, when the enclosures to the Secretary of State's despatch, dated March 30th, (No. 7) 1871,[1] received careful consideration. In a reply, dated June 30th, (No. 26) 1873, the Government of India requested that Captain A. D. Taylor of the Indian Navy, might be deputed to Calcutta, to assist them in devising suitable means for restoring to efficiency the Marine Surveying Department, which had ceased to exist in any form since 1861. Captain Taylor arrived in Calcutta on the 22d of December 1873, and has since prepared, under instructions from the Government, a review of all existing charts and material for charts of the coasts and islands of British India; and a scheme to supplement and perfect existing charts both by working up materials not yet utilised, and by fresh surveys, fully detailing for each project the agency by which he would propose to carry it out, the time it would probably occupy, and its probable cost.

Captain Taylor's exhaustive report reviews each chart and plan, pointing out their deficiencies and estimating their intrinsic and relative value; so that a most complete knowledge is thus obtained of existing requirements.

Commencing at Chittagong the old plan of Captain Lloyd is found to be very incomplete. Next comes the chart from Chittagong, across the sea face of the Sunderbuns, to Cuttack (*Bay of Bengal, Sheet* 5).[2] It is a most useful chart for navigation, but the increase of the banks and the alterations of the channels at the Megna mouths of the Ganges, during 40 years, call for a revised survey of the approaches. Then follows a complete blank in the

[1] See Abstract for 1869–70, p. 11.

[2] See Memoir, p. 25.

series of charts embracing the Bay of Bengal. From False Point in Cuttack to the Santapilly rocks, a distance of 250 miles, the coast of India is unsurveyed. Here the mouths of the Mahanadi are continually changing, and the wreck charts exhibit many casualties. The four-sheet chart of the Coromandel Coast, by Fell and Sweny, is good ;[1] but it requires more deep-sea soundings, especially off Cocanada ; and the bay there, a most important port, ought to be re-surveyed, owing to the great changes wrought by the river Godavari. The surveys of Palk Strait and the Gulf of Manaar were never completed, and the central parts of the channels have not been sounded. As these are the approaches to the Paumben channel, and to deeper cuttings that hereafter may be undertaken, this work is very urgent.

The west coast of India was surveyed by officers of the Indian Navy, a large section by Captain Taylor himself,[2] and the charts are published in three sheets, about 5 inches to a degree, a very good scale for navigation ; and also on the large scale of half an inch to a mile, in 13 sheets, together with several plans of ports on larger scales. But gaps occur at the junctions of five of the surveys along this coast, a fact which shows that a Survey Department without efficient supervision necessarily leads to mistakes entailing future disaster and loss. The first gap is off Calicut and Beypur, another off Boria Pagoda, and others at the mouth of the gulf of Kach, and off Aripo in the gulf of Manaar. But the most dangerous blank is off Danu in the north Konkan, where reefs extend five miles off shore. Here the steamer "Feroze" struck heavily during the last S.W. monsoon. The plans of Cochin and Alepi need correction, as both the Cochin bar and the Alepi mud bank have changed ; and more accurate soundings are needed off Calicut and Beypur. Colachull, the coffee port of Travancor, has never been surveyed at all, and Narakal is in the same position, while Enciam Islet and the deep water between it and the main and Mangalore require examination. The plans of the ports of Ratnagiri, Rajapur bay, Viziadrug, and Deogurh, are all incomplete and require re-examination. The gulf of Kambay now requires re-sounding, as the banks have materially changed in the 37 years since the last survey of Lieut. Ethersey.[3] Constable's survey of the Kattiwar coast on a scale of an inch to a mile, and Selby's

[1] See Memoir, pp. 26 and 27. [2] See Memoir, p. 31. [3] See Memoir, p. 18.

large survey of Mandavi roads are both lying useless and unpublished at the Admiralty. These are the most important out of the long list of desiderata, as regards the Indian coast; but the surrounding islands also require attention. The southern half of the Laccadives, including Minicoy, need survey and to have their geographical positions tested by astronomical observations with good chronometers. The Andamans also require more thorough examination and careful survey, and the channel between them and the Nicobars needs to be better known.

The scope of the annual surveying operations will be limited by financial considerations, and by the number of surveyors that are available. At Calcutta there are only three or four, and at Bombay none. A surveying vessel, when on her ground, would usually be anchored as a mark, whilst her boats and tenders were away sounding, and each of these should have a good surveyor with the boat's crew. Captain Taylor in his report, proposes that there should be a Superintendent of Marine Surveys with a clerk and two draftsmen, and a staff of a dozen qualified surveyors; and it is also of great importance that each vessel should have a medical officer of scientific attainments, who would have peculiar advantages in making collections and pursuing investigations in natural history. As for vessels, wooden pilot brigs and schooners are recommended, each with a steam pinnace; and a steam tender. The work to be done is thus calculated. Three seasons of seven months each will suffice to render the existing charts of the Burmese coast sufficient for present requirements. The coast of Chittagong and its river mouths, and the Megna mouths of the Ganges would occupy one brig with a tender, and two steam pinnaces, one whole season; whilst the survey of the sea face of the Sunderbuns would be postponed until the land surveys in that direction are complete. One brig would be employed, for a season, on deep-sea soundings in the Bay of Bengal; and another in surveying the several ports along the Madras coast. The coast from Point Palmyras to the south-west for 270 miles, demands immediate attention; and there is the advantage, to the surveyors, of being able to connect their work with several stations of the coast series of the Great Trigonometrical series. Two vessels, with steam pinnaces, might complete this work in nine months. A brig and her tender might complete the examination of the unsurveyed straits leading to the Paumben channel in four or five months But the Madras Presidency urgently needs a special small survey

party of her own, with a steamer, to survey the port of Colachull, Enciam Islet, and the deep water between it and the main, to get more soundings between Beypur and Calicut, and to make periodical examinations of Cocanada, Alepi, Cochin, Narakal, and Mangalore. On the Bombay coast the shifting mouth of the Kauli-nadi (Karwar river) requires periodical examination, and large scale surveys are needed of the ports of Honore, Vingorla, Ratnagiri, Viziadrug, Jaighur, Chaul, Hubshi-Jinjerah, and others. Lieut. Palmer, R.N., the commander of the iron-clad Mágdala, is to make an elaborate survey of the bottom, throughout certain portions of Bombay harbour, with reference to a system of defence by torpedoes. North of Bombay the coast was never minutely examined; and certain portions were absolutely neglected. The foul ground off Danu requires immediate attention, and this dangerous projecting part of the coast should have a light. Damaon and Bulsar have never been fully surveyed, and the entrances to the Surat, Broach, and Tankria rivers are known only to native local pilots. The whole gulf of Cambay very urgently calls for thorough re-examination; and fortunately most accurate delineations of the shore lines can be obtained from the recent work of the Great Trigonometrical Survey in Kattiwar and Gujarat.

Captain Taylor recommends that the first survey should be from Point Palmyras to the south-west, and the second of the Great Megna flats, or shoal water off the mouths of the Ganges and Brahmaputra. He would then take up, in succession, the Andaman and Nicobar Isles, the Sittang river, the gulf of Cambay, and the Chittagong coast. Changes may be expected at the mouths of all large Indian rivers, the Indus, Narbada, Tapti, Krishna, Mahanadi, Ganges and Brahmaputra, Irawadi, and Salwin; and also at the bars of minor rivers, especially at Mangalore, Cochin, Negapatam, Chittagong, Bassein, and Rangoon. These, and periodical changes in the form of banks, will demand the continuous services of three or four vessels. The first year's expenses are estimated at 2,800*l.* for the superintendent and his establishment, 1,362*l.* for outfit and repairs, 7,050*l.* for the survey from Point Palmyras and Bimlipatam, and 8,787*l.* for the survey of the Megna mouths of the Ganges, making a total cost of 20,000*l.*

The whole subject of this report was very fully considered by the Government of India, and they accept the responsibility of completing and maintaining the coast of the Indian coast line

from the Pakchan Estuary, at the southern extremity of Tenasserim, to Sunmiyani Bay, on the western limit of Sind; but beyond these limits all surveys must be undertaken by vessels and surveyors of Her Majesty's navy, at the expense of the Imperial Government. They propose, in order to undertake accurate surveys of localities not yet surveyed, and to maintain the accuracy of the charts, to organise a small survey flotilla. It is to consist of one steam tender, three brigs, two schooners, and five steam pinnaces, with competent surveyors and efficiently manned. The following vessels have been selected for this service:—The gunboat "Clyde," a steamer belonging to the Bombay Government, of 300 tons and 60 h.-p. (nominal), two old teak-built pilot brigs of 300 tons, the "Guide" and the "Megna," the "Marie," a teak-built schooner, on board of which Captain Constable did his surveys in Persian Gulf from 1858 to 1860, and a very small schooner called the "Augusta." Two of the steam pinnaces will be built at Calcutta for 300*l.* each. They will be 28 feet long by 7 feet, with engines of 3 h.-p., and will hoist inboard. Two others are to be built in this country. The whole annual cost, including a superintendent of marine surveys, is not to exceed 20,000*l.* The vessels will be provided in India; and it is hoped to commence the first year's surveys, namely the coast between Point Palmyras and Bimlipatam, and the mouths of the Ganges, in the end of 1874. Captain Taylor, than whom no man living has a more thorough knowledge of the subject, both from long experience and natural love of the work, is to be the first Superintendent.

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 is to be 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 great object.

Lieut. Stiffe (late I.N.), formerly employed for nine years on the surveying service of the Indian navy, has compiled a new chart of the Makrán coast, which has lately acquired some importance owing to the establishment of telegraphs along it since 1862. As this

officer had served for many years on this coast, the Admiralty suggested his employment to construct a new chart based on his own observations, and embodying all the information that he or other officers had collected.

It is now being engraved. It is a revise of that made by Brucks and Haines in 1829, and a few particulars of the old survey will explain the value of the present work.[1]

The former survey was commenced at Jáshak by Brucks on the 22nd January 1829, and had progressed as far as Chahbár by the 8th February, on which date the surveyors sailed for Maskat, where Brucks was invalided, and left for Bombay. Haines, who now took command and continued the work, returned to Chahbár by the 20th February, and finished the survey to Karáchi by the 10th April. He thence returned to Gwádar to correct the chronometric measurements between that place and Karáchi, and left the coast for Bombay on the 26th April.

Considering that the time occupied, after deducting twelve days for the trip to Maskat, was only 67 days for the survey of 540 miles of coast (without including the windings of the coast-line), it can only have been by unremitting hard work that any chart could have been produced, with the resources of one small and dull-sailing vessel, E.I.C.S. "Benares." The general correctness of the chart reflects the highest credit on the authors, indeed, according to the standard of hydrography of fifty years since, it was a high class work.

They had but four chronometers, all of which did not go well, and as they carried on the survey by a series of chronometric measurements, made at each day's position, the only part triangulated being the great bays, extreme accuracy could not be expected, especially on that part west of Gwádar, which was not checked by a return measurement. It does not appear that Brucks, on leaving, made over any note books to his successor; and Lieutenant Stiffe has been unable to trace any memoir of his on the part of the coast he surveyed. The information in "Horsburgh," is from the original explorers in 1774. Haines' memoir, which refers to the coast between Chahbár and Karáchi, appears never to have been published until the present time. [Taylor's Sailing Directory, 1874.]

The latitudes of the old chart are fairly correct, the errors not exceeding 1 to 1½ miles.

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[1] See Memoir, p. 10.

In general, the part by Haines is obviously done in more detail than that by Brucks.

The new chart has been based upon a table of positions, the authority for each of which is given. A correction in the Persian gulf longitude of Maskat and the Arabian coast of $-30''$, and in that of Jáshak of $-43''$, has been adopted, in consequence of additional measurements.

For Sunmiyáni, and places to the eastward, the triangulation of the Great Trigonometrical Survey of India has been made use of. The original observation book of Haines has been discussed, and the trigonometrical data contained in it replotted. The longitudes of the charts are referred to Madras instead of Bombay, as Karáchi, the starting point, has been connected by the G. T. S. with Madras more recently, and is probably more correctly determined than Bombay: thus,

	°	′	″
Longitude of Madras, according to results of Taylor's observations - - - -	80	14	19
Diff. Manora lighthouse and Madras by triangulation of G. T. S. - - - - -	13	16	4
Longitude, Manora lighthouse -	66	58	15

The scale of the new chart is the same as the published Persian Gulf chart.

The coast-line in the neighbourhood of the above astronomical positions has been re-surveyed as far as time would admit. Jáshak bay, with the coast-line between Ras-al-Kúh and Rás-Jagín, is altogether new work, as also is Gwádar bay. Many landmarks and hills have been fixed, and their heights measured by theodolite. These heights, with the results of careful observations for variation, and some information as to the tides, are given in the table of positions. Many additional soundings have been taken, chiefly during cable operations. The style of delineation of the coast-line has been much modified in accordance with the received hydrographical symbols of the present day.

The names of places and their orthography have been the subject of much study, and the system is in conformity with the rules of the Indian Government. With the sailing directions, now about to be undertaken, will be forwarded for record a book showing the authority for each name, and reason for its adoption. Should it be

considered desirable at any future time to revise the names, this book would be of some service to the person undertaking it.

The rest of the chart has been completed from the following sources :—

Coast of Arabia below Maskat, carefully reduced from the original large scale M.S. of Grieve, and from Capt. Dayman's soundings.

Coast of 'Omán, west of Maskat, and coast west of Jáshak, from the Persian Gulf chart.

From Jáshak to Chahbár from Brucks' survey.

From Chahbár to Sunmiyáni from Haines' survey.

From Sunmiyáni to Karáchi from Carless' survey.

The deep soundings from Jáshak to long. 66′ from Chitty's soundings, and from long. 66° to 67° from the chart of the coast of Sind by Grieve.

The details inland are taken from the routes of Government political and telegraph officers.

The sketches of the land are original (three by Captain Constable).

The correction of the longitude of Maskat of —30″, above referred to, will involve the alteration of all the Persian gulf longitudes by the same amount. It is founded on the new measurements made by Lieutenant Stiffe to Karáchi, Mr. Girdlestone to Bombay, and also on telegraphic determinations of Búshehr by Major St. John, R.E. As it is possible that eventually a further correction of 15″—20″ may be found necessary, it may not be worth while for the present to alter the existing Persian gulf chart so small an amount.

Thus, the chart hitherto used, which was made in 1829, and is no longer adequate to the hydrographical requirements of the present day, will be superseded by Lieutenant Stiffe's new chart of the Makrán coast, containing much additional matter. The additions consist of positions and heights of hills and soundings, while the chart comprehends a more extensive area, including part of the opposite coast of Arabia, which will be a convenience to the navigator. Since the completion of the chart, Mr. Stiffe has been engaged in the preparation of detailed sailing directions for the coast, those in existence being very insufficient.

A wreck chart from Karáchi to Singapur, showing the positions of wrecks during the year 1873, has been published, from which it appears that the number of wrecks for that year was 20, besides the same number of casualties of other kinds. The Deputy Master Attendant, in his review of the wrecks, calls attention to the great increase of trade on the Coromandel coast, and the opening of

several new ports by the visits of the British India Steam Navigation Company's vessels. He urges the necessity for a survey from Point Palmyras to Bimlipatam, and for large scale charts of all the harbours, roadsteads, and rivers on the Coromandel coast. He also represents the importance of a re-survey of the sea face of the Sunderbunds, where the sands have extended, and there are several rivers with good entrances requiring examination.

Captain Taylor, before he left England for Calcutta in the autumn of 1873, 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 sufficiently 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.

II.

Great Trigonometrical Survey of India, 1872-73.

During the year 1872–73, the work consisted of 92 triangles, covering an area of 11,058 square miles, with the great theodolites; and of 3,224 square miles closely covered with points for the topographical surveys, with smaller theodolites, while in an area of 7,290 square miles of a portion of the Himalayas, inhabited by independent tribes, several points have been fixed which will be valuable for preliminary geographical requirements. An area of 2,734 square miles has been topographically surveyed in the Himalayas on a scale of one inch to the mile, and an area of 3,878 square miles on the 2-inch scale, in the Bombay presidency, in the course of which 2,734 linear miles of boundary and check lines have been traversed.

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[1] See Memoir, p. 279.

The southern section of the Bilásprúr series,[1] being a longitudinal chain of triangles extending from Bombay to Vizagapatam, was completed during the year 1871-72. The party, commanded by Mr. W. C. 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 longitudinal series by Mr. Keelan. The country was very hilly and without roads, but in three months Mr. Rossenrode carried the operations northward a distance of 94 miles, where they formed a junction with those of Mr. Keelan. The country in which Mr. Rossenrode and his three assistants were labouring, 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,[2] and it was here that in 1870 Mr. George Shelverton lost his life.[3] Mr. Rossenrode and his whole party suffered more or less from fever. Their way led them past Jaipur, the capital of a wild hill chiefship, and the hill of Sihoa, which is considered to be one source of the Mahanadi river.

Meanwhile Mr. Keelan worked southwards on the same meridian for a distance of 55 miles, and thus the series was completed.[4] Mr. Keelan describes the country as the wildest tract it has ever been his lot to work in, covered with forest, and presenting no well defined points to fix.

The importance of the operations in the Assam valley lies in the necessity for connecting the surveys of the Sibsagar and Lakhimpur districts, which were commenced several years ago, with the general topographical survey. Progress has been 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 has to be cleared. A single line occupied a party of 25 cutters 36 days to clear. The country is very thinly inhabited, so that supplies of labourers have to be brought from a distance, while the most healthy time of the year

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[1] See Memoir, p. 115 : Abstract for 1869-70, p. 11 ; for 1870-71, p. 18, and for 1871-72, p. 11.

[2] See Memoir, p. 55.

[3] See Abstract for 1869-70, p. 12.

[4] See Abstracts for 1869-70, p. 12; for 1870-71, p. 18; and for 1871-72, p. 11. See Abstracts for 1870-71, p. 17, and for 1871-72, p. 12.

for field work is the least favourable for observations of distant points. The atmosphere is clearest just after the termination of the rainy season when jungle fever is rife and the country is very deadly. In the dry season the jungle fires give rise to a canopy of smoke which shuts out distant objects from view. The Assam series was commenced in 1867 by Lieutenant Larmirie, near Gowhatty. In 1870–71, the triangulation was advanced 86 miles by Mr. W. C. Rossenrode, and in the following year Mr. W. G. Beverley carried it 40 miles further. During the season of 1872–73 Mr. Beverley did not advance the principal train of triangles quite 20 miles, though several points were fixed on the hill ranges to the north of the valley. The series is now approaching the town of Sibsagar, while the secondary triangulation has defined the Duffla hills to the north, and will be useful in the operations for fixing the British frontier.

The Jodhpur series is one of the two internal chains of triangles which remain to complete the great north-west quadrilateral, the exterior chains of which connect the base line of Karachi, Sironj, Dehra Dun, and Chach, near Attock. The Jodhpur meridional series will be carried northwards, so as to close on the Sutlej series. Lieutenant Rogers, who is in charge, fixed 12 new stations during the season, extending over a direct distance of 95 miles, preliminary operations being advanced 52 miles further. The country is very favourable, being sandy with isolated hills, the chief difficulty being the scanty supply of water. On the other hand the Jodhpur Durbar rendered most cordial and effective assistance.

The Mangalore meridian series was carried southward from the Bombay longitudinal by Captain Haig and Lieutenant Trotter between 1865 and 1867.[1] Operations were then suspended, and resumed by Major Branfill in 1872–73, and continued south until it joined the longitudinal series which connects Mangalore with Madras. It was thus completed. The series passes for above a hundred miles along the crest of the Western Ghauts, a tract of hills and forests, clouds and mists, rivers and torrents, and one of great beauty. It is the Maisúr district of Naggar, and that portion of it known as the Malnad or "rain district." The valleys are 2,000 to 3,000 feet above the sea, with the rivers Bhadra, Tunga, Choradi, Warda—all flowing to the north. But one of them, the Sheravati, draining the Bednore (Bidarur) or Naggar

[1] See Memoir, p. 112. Abstracts for 1869–70, p. 12, and for 1871–72, p. 12.

basins, flows north-west for 40 miles, and then by a single drop of 800 feet, precipitates itself into the Garsappa ravine. This was ground gone over in the early days of the survey by Colonel Lambton, and several of his station marks were found.

During the previous seasons, from 1870 to 1872, the work of the Brahmaputra series,[1] on the meridian of 90°, had been restricted to preliminary operations. Last season Captain Carter took the field early and made satisfactory progress. Much hindrance was caused by the mists in the mornings, and the smoke of the village fires towards evening. The series was extended for a direct distance of 56 miles, and will probably be completed during the ensuing season. A series of secondary triangles was carried eastwards from the principal series, to fix the town of Mymensingh.

A great deal of work was completed during 1872–73 on the Kattiwar topographical survey, 2,642 square miles having been surveyed, and an area of 2,680 square miles triangulated in advance for the work of next year. The operations lay chiefly in the northern portions of Jhalawar, in a bare and sterile county which is bordered on the north by the Rann of Kách. The topography of the eastern half of the province is now nearly completed, and a survey of the town of Rajkote, the chief place in the province, will be made on a scale of 12 inches to a mile. When the operations of the survey reach the shores of the gulf of Kách, every effort will be made to connect them with the survey of that gulf by Captain Taylor, I.N. The original maps of the survey were lost, but Captain Taylor had fortunately retained copies for his own use, which were lithographed through the Geographical Department of the India Office, and copies have been sent out to India. Captain Trotter had charge of the Kattiwar survey until nearly the end of the season, when he joined Mr. Forsyth's embassy to Yarkand, and was succeeded by Captain Pullen. A peculiar feature of the part of Kattiwar that was surveyed in 1872–73 is the number of large "baolis" or wells, built some hundreds of years ago near what were then large and populous towns. Some of them are very roomy and beautiful, the covering and the ornamentation of the approaches being elaborate and elegant. A broad flight of stairs, richly ornamented at the sides, generally leads down to the water. There is nothing above

[1] See Memoir, p. 114. Abstracts for 1869–70, p. 11; for 1870–71, p. 17; for 1871–72, p. 11.

ground to lead to the supposition that there is anything unusual underneath, a low stone wall being all that is visible to the eye. Captain Trotter also gives an interesting description of the Rann of Kách, and of the new and extensive government salt works at Patri.[1]

The Gujrat survey,[2] under Major Haig, was employed during 1872–73 upon the topography of some portions of the Kaira collectorate, the whole of the Pitlad Mahal in the territory of the Gaikawar of Baroda, and nearly the whole of the territory of Kambay. The area completed was 1,175 square miles. The first attempts to incorporate the Bombay Revenue Survey details with the scientific Topographical Survey failed. It appears that while in Bengal the periphery of a village is first measured, and all interior details are then referred to it; in Bombay so called "base lines" are first measured in the interior of the village lands, and all subsequent measures are referred to these lines by offsets. The Bombay method, therefore, gives the greatest accuracy in the central portions and least on the boundaries, while the converse is the case with the Bengal system. This is the reason why the revenue operations in Bengal are so valuable for topographical purposes, while in Bombay every attempt to construct general maps from the revenue materials has hitherto failed.[3] The marks selected were almost invariably on the exterior boundaries where the work is most inaccurate; whereas, for the above reason, the interior marks would have been best adapted for the purpose. When Colonel Walker returned to India he determined to make another more carefully devised attempt to utilise the Bombay revenue details. He arranged that Major Haig should be supplied with all the data of the revenue survey measurements, as given in the original field books, in addition to the lithographed village maps, which had hitherto been the only materials available for the purpose, and that he should have the assistance of some of the revenue surveyors, especially as all the field books are written in Gujrati. Major Haig was not joined by this revenue party under Mr. Dalzell until February 1873; so that it is premature to draw any positive conclusions as to the results of the experiment.

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[1] See Memoir, p. 118, and Abstracts for 1869–70, p. 13; for 1870–71, p. 19, and for 1871–72, p. 12.

[2] See Abstract for 1869–70, p. 13; for 1870–71, p. 18, and for 1871–72, p. 12.

[3] See Abstract for 1870–71, p. 34.

But Major Haig is already satisfied that great use may be made of the revenue survey materials in improving the accuracy of the topographical maps, as soon as a more extensive and systematic connexion is made between the fixed points of the two surveys than has yet been attempted. "The combination," he thinks, "will "permit of the construction of topographical maps of all the British "portions of Gujrat on a scale of four inches to a mile, with an "amount of additional detail and accuracy, for which improve- "ment the public will be indebted to the Gujrat Revenue Survey."[1]

The survey of Kamaun and Gurhwal has, for two years, been under Lieut. J. Hill, R.E. In 1872-73 topographical operations were carried on in the Mána valley, in the lake country to the east of Naini Tál, in the country round Lohur Ghat, in the portions of the Gori and Ramganga valleys near Arkot, and in the Bhabar parganahs, sub-Himalayan tracts between Haldwári and the Sardah river. The region under survey has a range of over 25,000 feet in altitude, so that it presents every variety of climate. During the year, 2,734 miles were surveyed on a scale of one inch to the mile, and 353 were triangulated in advance for future operations. Much of this area was between 10,000 and 25,000 feet above the sea.

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 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

[1] See page 23.

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 Mangalore, passing through Bangalore 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 Mangalore 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 $\frac{1}{300\cdot80}$). 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 $\frac{1}{294\cdot98}$. Using Captain Clarke's elements, instead of Colonel Everest's, the trigonometrical determination of the difference of longitude between Madras and Bangalore would be diminished by 3·5″, and thus be brought into better accordance with the telegraphic difference, which is still 10·5s. 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 Mangalore 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 were held in abeyance during 1872–73, as Captains Herschel and Campbell, by whom they are carried on, were both employed on the longitude observations.

The pendulum experiments[1] which have been carried on in India since 1865 have lately been brought to a conclusion by a series of observations made at the Kew Observatory by Captain W. J. Heaviside, R.E.

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.

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 Dhun 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 Minicoy, 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

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[1] See Memoir, p. 120.

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 Meer, and passing through Leh, crossed the Takatung pass 18,060 feet in height, into the desolate region of Ruskshu. 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 Mussooric 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 has swung the invariable pendulums, to determine whether they had undergone any alteration since 1865, and he has 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 is being made with the convertible pendulum employed in 1818 by Captain Kater. The bar of this pendulum, owing to some unknown cause, had become bent. The bar has been re-straightened and the knife edges re-ground and rebedded. In its thus altered condition this pendulum has been swung at the Kew

Observatory by Captain Heaviside. Lieut.-Colonel A. R. Clarke, R.E., has undertaken 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 will be made. Captain Heaviside will shortly return to India, when the final results of the whole series of experiments from 1865 will be computed out and arranged for publication.

The operations of the computing office have consisted of a re-adjustment of the secondary triangulation based on the several principal series of the North-West Quadrilateral, and of passing through the press the observations, reductions, and final results of the principal triangulation of the North-West Quadrilateral, which is now completed, and will form volumes III. and IV. of the "*Account of the Operations of the Great Trigonometrical Survey.*" As the whole contents of these volumes will not be needed by geographers, an abstract or synopsis is being prepared, which will give the descriptions and co-ordinates of the stations, and the sides and angles of the triangles. This information will be published in a separate volume for each of the principal series. The first of these synopses is now nearly ready. It is devoted to the work of the great Indus series, and contains the positions of the whole of the points that have been fixed beyond the British frontier, on the spurs of the Hindu Kúsh range, and on the Sofid Koh and Sulaimani ranges and their spurs. During the year Colonel Walker also brought out the second edition of his map of Turkistan, of which the first was published in 1868 in four sheets. It was accompanied by a memorandum giving an account of the various sources from which it was compiled. Major Montgomerie also prepared a series of "Trans-Frontier Maps," on a scale of 16 miles to the inch, containing all the most recent information of the region beyond the British frontier. They show the positions of towns, villages, rivers, and mountain passes, but omit the hills. Three have now been published, Nos. 4, 7, and 9. No. 4 comprises portions of Afghanistan, Kafiristan, Badakshan, Bokhara, Karategin, Swat, and Chitral. No. 7 includes Chilas, Gilgit, Yassin, Kunjeet, Sirikul, the Pamir, Kashgar, Yarkand, and part of Tibet; and No. 9 comprises Nepal, Sikkim, Bhotan, and Great Tibet. Good progress has been made with the series of level charts on which the results of the series of levelling operations for canals and railways are shown, after having been connected with the main lines of level of the

Great Trigonometrical Survey and reduced to the same datum, namely, the mean sea level at Karáchi. Twenty preliminary charts of the triangulation in all parts of India have also been published.

III.

The Topographical Surveys of India and Work in the Office of the Surveyor General, 1872–73.

Seven parties belonging to the Topographical Survey were in the field during 1872–73, as in the previous year. The total amount of work done was 25,327 square miles of final topography, of which 14,054 were on the scale of one mile to the inch, 670 square miles of the Naga Hills on two miles to the inch, and 10,603 square miles in Chittagong, Tipperah, Lushai, and the Munipur Hills on the scale of four miles to the inch. Of this large area only 6,136 square miles were in British territory, and 19,191 in native states. The tracts thus explored were for the most part wild and unhealthy, and those in Bilaspur, Mandla of the Central Provinces, the Garo, Naga, and northern Chittagong Hills were covered with forest, in parts uninhabited, and never before entered by a European.

No. 1 party, under Lieut. Holdich, was at work in Central India, near the river Chumbul, partly in a wild country belonging to Kota and Gwalior, and partly in the district of Chapra, a portion of the Tonk territory, which is split up into six sections scattered over the dominions of Jeypúr, Bandi, Jhallawar, Kota, and Sindia and Holkar. Chapra is bounded on the east by the river Parbati, and has an area of 320 square miles. It is well drained and watered, having hills 1,300 to 1,500 feet above the sea, whence flow streams to an open and well-cultivated tract in the west and north. Mr. Scanlan furnishes an interesting historical and statistical account of the district of Chapra.

The party No. 2, under Mr. Girdlestone, was at work in the Narbada valley, in the territories of Holkar, Sindia, Dhar, and the British district of Nemar. An area of 1,872 square miles was topographically illustrated, and 2,013 square miles of triangulation in advance. This is the second season during which Mr. Girdlestone has been at work in this difficult region, and his management has been marked by great energy and success. The block of country surveyed in 1172–73 consisted of a series of un-

dulating plateaux with three distinct falls or ledges, between the Satpuras and the Narbada, which forms the northern boundary of the work.

The survey of the Vizagapatam Agency was continued by Colonel Saxton's party (No. 3), working southward from the parallel of Vizianagram. The total amount of work was 1,636 square miles of final topography, and 1,500 of triangulation in advance. The country was throughout wild and inhospitable, and overrun with jungle, though the soil is in most parts good, and there is no want of water. Colonel Saxton draws attention to a fine tract of country with an area of about eight by two miles, which is in every way suited for a sanatarium, being easily accessible from the plains and only 50 miles W.N.W. of Vizagapatam. The hills are here 5,000 feet above the sea, the scenery beautiful, and water abundant.

Party No. 4, under Major Depree, was at work in some of the worst portions of the country along the south-west side of the Sohagpúr Taluk of the Rewah Native State, and the north-east border of Mandla in the Central Provinces. There were 2,571½ square miles surveyed, including the "Mekal pat," or Amarkantak plateau. Here, within only a few hundred yards of each other, rise the Narbada, the Son, the Johilla, and the Hali, one of the principal feeders of the Mahanadi. All this ground was very carefully mapped. The Narbada and Johilla both cut their way from off the plateau by abrupt gorges and rocky chasms hundreds of feet in perpendicular depth, and the plateau is inhabited only by aboriginal tribes.

The fifth party was at work in the Malwa native states of Bhopal, Narsingarh, Tonk, and Dewas, under Captain Riddell, over an area of 2,215 square miles; and a plan of the city and fort of Bhopal was made on a scale of 12 inches to the mile. The Vindhyan range of mountains crosses the season's work, at a point where it is traversed by the Great Arc Meridional series.

The pressing demands of the Bengal Government for the exploration and completion of the surveys in the Northern Chittagong hill tracts, the Tipperah, Lushai, and Cachar hills, the Garo and Naga hills, and along the northern Munipur frontier necessitated special arrangements. Four several detachments of No. 6 party were obliged to act independently of each other. Major Godwin-Austen took the Naga and Munipur hills. The Tipperah, Lushai, and Cachar hills were assigned to Captain Badgley; Mr. Cook

was in northern and eastern Chittagong; and Lieut. Woodthorpe in the Garo hills. The objects desired by the Bengal Government were 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; the completion of the survey commenced during the Lushai expedition, and a reconnaissance of the unsurveyed portion of the Garo hills. Altogether 11,273 square miles were surveyed by these detachments. Major Godwin-Austen was unable to explore the Patkoi range further east than longitude 94·18′ E., owing to the opposition of the Munipur Raja, which caused a diversion to the south, and led to the survey of a large portion of the Munipur State, between its disputed northern boundary and the capital. Captain Badgley's party were at work in the interior of Hill Tipperah, the north-east corner of Chittagong, and the Lushai country between Hill Tipperah and the finished surveys of the previous season. This region is crossed by parallel ridges running north and south, which increase in height from west to east, gradually narrowing the valleys between them, with the ridges so narrow at top as to be only knife-like rocks. The sides are covered with forests which are often impenetrable in the ravines and valleys. Mr. Cook continued the surveys in the Chittagong hill tracts south of Dewagiri, accompanied by Captain Lewin, the Deputy Commissioner, and a hundred men; while Lieut. Woodthorpe completed the work in the Garo hills. The narratives of these officers throw much light on previously unexplored and unknown regions. They are extremely interesting, and will well repay perusal.

The Rajputana party (No. 7) under Captain Strahan, delineated topographically 2,760 square miles of ground in the States of Meywar, Marwar, Shahpura, and in the southern portion of Mharwara. Some of the ridges of the Aravalli hills, 4,000 feet above the sea, were within the area, and were extremely difficult of delineation. During the recess the party was employed on the survey of Simla, on a scale of 24 inches to the mile. Six large sheets of the Simla survey have already been published.

Great progress was made in the drawing and compiling branch of the head-quarter office, under the energetic superintendence of Mr. J. O. N. James; in reducing, compiling, and incorporating, the latest survey results on the original sheets of the Indian Atlas. Nine new quarter-sheets have been taken up, and considerable ad-

ditions have been made to 11 of the old full-sized sheets. A great number of other maps have also been completed, or are in progress. The new standard map of India on a scale of 32 miles to an inch, and the reduction on 64 miles to an inch have been advanced. The great obstacle to progress with these maps are the doubts and uncertainty which still exist, owing to the perpetual changes in the boundaries of districts and sub-divisions, more especially in Bengal, and to the various systems of spelling names. The standard map of Bengal, Bahar, Orissa, and Assam, on a scale of 16 miles to an inch will be published as soon as the boundaries of internal jurisdiction are settled. Maps of Oudh and Sind, for the local gazetteers are completed; and a new district map of Darjiling on a scale of four miles to an inch has been compiled.

Excellent progress has been made in the engraving branch, but the small European staff has been very unfortunately reduced, and it is extremely difficult to supply the places of the men who have retired. In the copper-plate printing branch 9,508 impressions have been taken of Indian Atlas sheets and other maps. The staff of native engravers and apprentices continues to make very good progress, and two give hopes of turning out fair hill etchers. Mr. Coard continues to superintend this branch with skill and energy, and is training a large number of native youths.

Captain Waterhouse continues the charge of the photographic branch. During the year 1872–73 the number of maps that passed through his office was 1,611, of which 105,753 copies were printed from zinc, besides 2,010 silver prints, and about 3,000 photo-collotypes. The process of steel facing the engraved copper plates under the superintendence of Captain Waterhouse has been worked with fair success, but the steel surfaces have shown signs of incipient rust in spite of every precaution, and impressions are now taken from the stone. A method of correcting copper plates for erasures or additions with the aid of the galvanic battery has been successfully carried out by Captain Waterhouse. It is a similar process to the one employed in engraving department of the Depôt de la Guerre at Paris, and the Military Geographical Institute at Vienna; and by it the old process of "knocking up" the copper is entirely obviated. In the lithographic branch 481 new maps and plans were produced, and 159,652 copies were taken. Thus no less than 271,528 copies of maps have been struck off during the year, besides a vast amount of colouring and mounting. As many as 5,090 maps were forwarded to the Geographical Department of the

India Office, 25,817 were issued to Government officials in India, and to local agents 5,384.

The total area produced by the Topographical and Revenue Surveys in progress was 41,839 square miles, at a cost of 144,878*l.*, at an average rate per square mile of 2*l.* 14*s.*, being 1*l.* 14*s.* for the Topographical, and 4*l.* 8*s.* for the revenue work. The aggregate result of Topographical and Revenue Surveys from 1847 to 1873 is 743,802 square miles at a cost of 2,002,833*l.*

IV.

Revenue Surveys.

The Revenue Surveys under the Government of India are divided into the upper and lower circles. Of the former there were eight at work during 1872–73 in Muradabad, Muttra, Agra, Humirpur, Delhi, and Hissar, the North-west Frontier, and two in Bhawulpur. In the latter there were seven parties, in Luchmipur, Midnapur, Baitul, Bilaspur, and the Nasik and Ahmadnagar Collectorates in Bombay.

There are now four cadastral surveys at work in the North-West Provinces, in Muradabad, Muttra, Agra, and Humirpur. 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 the year. Colonel Gastrell has introduced several processes by which the labour of mapping will be 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 11 pies. Another season's experience will place the working of the cadastral system on a thoroughly durable and satisfactory basis. But 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 Muradabad and Muttra have 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 Muradabad under Major Vanrenen was commenced in November 1872, and continued until May 1873, the area comprising 731 villages, 376,191 acres, and 348,523 fields. It will be continued in 1873–74, and the amount of work done is very satisfactory. The field survey of every village was carefully checked by lines run across each, and a certain per-centage of villages was further tested by the Deputy Superintendent himself. The work is connected with the stations of the Great Trigonometrical Survey. The Muttra Cadastral Survey is under Colonel Anderson, whose party measured 621,367 fields, the average size of which was 0·6 of an acre. The work in the Agra district consisted of 167,115 fields, covering an area of 307 square miles; and in Humirpur it was commenced in January 1873. The number of fields measured during the season was 132,877. All triple junction stations are to be permanently marked.

The Delhi and Hissar revenue survey party, after completing the Kurnal district, commenced work upon that of Delhi, which contains 821 villages in three Tahsils. This survey is on the old plan, and is not being conducted as the previous four cadastral surveys. About half the Delhi district was completed in the year. The Derajat survey under Colonel Johnstone, was extended from Dera Ghazi Khan into Dera Ismail Khan, including the Indus on the eastern borders. The city of Dera Ghazi Khan has been surveyed on a scale of 12 inches to the mile. The two parties in Bhawalpur completed areas of 1,759 and 3,915 square miles respectively, and the boundary along Bikanir has been marked throughout by masonry pillars. All these operations have been connected with points of the Great Trigonometrical Survey.

In the Lower Circle the work of the revenue surveys amounted to 2,875 square miles. There were two parties at work in Assam, in the districts of Durrung and Lackimpur. In Durrung the area was surveyed on a scale of 4 inches to a mile, except the *lakhiraj* or rent-free tenures, which are done on the 8 inch scale. About 48 square miles of hill sketching were brought in, of which 40 were in Bhutan. The Lackimpur party had to enter on the topographical survey of the vast tract stretching between the cultivated or revenue-paying area already done, and the watershed or natural boundary north and east covering some thousands of square miles. Only 384 square miles were completed, owing to the difficulty in obtaining carriages.

During the working season of 1872–73 a party was employed in surveying 908 square miles in the districts of Hugli and Midnapur, and another in the Bilaspur district.

In the Bombay Presidency two parties have been at work in Nasik and Ahmadnagar. The object of thus detaching two Bengal parties to Bombay was, not that the present Bombay local system should be abandoned, but that, in connexion with it, a plan of operation might be devised, which should secure maps available for geographical and general purposes. The plan, as now adopted, consists of a four-inch scale Mouzahwar survey, and a two-inch topographical survey of the hilly and jungly tracts. The surveyors are to make a complete skeleton survey of the whole of the champaign country, with sufficient closeness to admit of the incorporation of every village boundary from the Bombay revenue survey plans, the triple boundary points of the villages being laid down as a basis for connexion by the Bombay revenue survey authorities. The internal drainage and topography are to be surveyed thoroughly by the Bengal parties, the village boundaries being taken from the settlement maps. By these arrangements all the Bombay districts will be laid down on one uniform scale, while the revenue survey "fields" will proceed intact, and be free from all clashing. It is believed that the Bombay field survey might lay down all details in the champaign country fit for incorporation on the general maps. Hereafter, when the Bombay survey maps are more advanced, and the topography is laid down on a better system than at present, it is hoped that congregated sheet village maps may be made on the four-inch scale, according to the Bengal practice, instead of on the two-inch scale, and that the Bombay revenue survey materials may be then utilised for the purpose. These are the views and recommendations of the conference held at Calcutta on February 24th, 1873, consisting of Colonel Thuillier the Surveyor-General, Colonel Vanrenen, Deputy-Superintendent of Bengal revenue surveys, Colonel Francis, the Bombay survey and settlement commissioner, and Captains Coddington and Tanner, who have charge of the Nasik and Ahmadnagar surveys respectively.[1]

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

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[1] See page 13.

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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 Captains Tate and Dickinson. 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 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 accurately 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 $6\frac{1}{2}$ 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.

The Survey Department in the Madras Presidency was organised in 1858, but 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.).

It is under the direction of a military officer of the rank of colonel, and combines the operations of a revenue or cadastral survey, with those of a perfect topographical survey on a trigonometrical basis. The former, with few exceptions, is confined to land paying land tax to Government on the ryotwari system, and is plotted in village maps on the scale of 5 chains = 1 inch, exhibiting all topographical details and the limits of every field not smaller than two acres, recording its content both by survey and by the old native accounts, nature of tenure and cultivation, source of irrigation, if watered, present assessment, and name of ryot or tenant. Lands held on tenure other than ryotwari, such as zemindari, shrotriem, or inam, ranges of hills and tracts of waste land or forest of inferior value, are excluded from the minute detailed field survey. They are, however, topographically surveyed on a scale of 4 inches = 1 mile (unless of a rugged and unhealthy nature when a reduced scale is adopted) and from these topographical, revenue and purely topographical surveys combined, Talook maps are constructed on the scale of 1 inch = 1 mile. These are again reduced one half to form district maps.

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 amounts 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 is square miles 8,818. There are also square miles 4,296 of partly completed work in these eight districts. The extent of country topographically surveyed and mapped reaches square miles 51,996.

* Tinnevelli.	Nellor.
Trichinapalli.	Kurnul.
Salem.	Kistna.
Chingalpat.	Godavari.
† Madura.	North Arcot.
Coimbator.	Cuddapah.
Nilgiris.	Bellari.
Malabar.	Ganjam.

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, is 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 comes to Rs. 6,486,120 (648,612*l.*), or $4\frac{3}{4}d.$ per acre.

Nilgiri Hills.
Sherveroy do.
Wynaad.
Teak plantation in the Nellambar 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.

17,941 manuscript village and estate maps have been drawn; of these 15,607 have been reproduced by lithography. The topographical maps of 79 talooks have been completed, representing 44,166 square miles, 55 having been lithographed. As yet only two district maps have been compiled, two are under compilation, and materials for two more are being prepared.

Since the commencement of operations the Madras survey has been 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, and during the last year the manipulation has been much improved.

After trying several methods of reducing maps, the following mechanical system of reduction is now employed, and is thought to be the best suited to the Madras survey. Lithographed impressions in blue of the village maps on the scale of 16 inches to the mile (the largest scale in general use) are combined in squares of a convenient size (40,000 feet), and the details required for the Taluq map on the 1 inch scale are slightly exaggerated on them in black ink. Each square is photographed separately, and the reduction from the scale of 1 inch = 1 mile 16 inches = 1 mile to that is obtained by one negative. The carbon prints (transfers) of each square are pieced together carefully on a sheet of paper, on which the same squares have been mathematically projected on the smaller scale. The whole is then transferred to stone. The district maps are compiled in the same manner, with the additional accurate check of having the G. T. stations with lines of latitude and longitude projected on the sheet of paper on which the transfers are pieced together. An adjustment of the squares is also made by which the

convergency of the meridians is provided for, and by these means correct geographical position is given to the district maps.

Photo-zincography has not been fairly started yet on account of there being a large stock of lithographic stones on hand, a large number of which must be first used, and also because the few zinc plates in this office are not of a very good kind. A new supply of zinc plates is expected from England, and in the course of a few months photo-zincography will gradually begin to replace photo-lithography.

Engraving on copper has also been started in the Central Survey Office. A map of the city and suburbs of Madras has been engraved, and it is proposed to issue engraved maps of other important towns and cantonments; arrangements are being perfected for the reproduction by electrotypy of the engraved plates, which will permit of the original being kept in store and revised when necessary.

V.

The Geological Survey of India, 1873.

Dr. Oldham, who may be said to have founded the Geological Survey, took sick leave for Europe early in April 1873, for the first time during twenty-two years; and this is the first annual report that has not been drawn up by him. It was written by his accomplished colleague Mr. H. B. Medlicott. For the last half of the year, six out of the small staff of geologists, were absent from India. Mr. Blanford has been busily engaged in England, working out the zoological collections he brought home from Persia; Dr. Stoliczka accompanied the embassy of Mr. Forsyth to Kashgar;[1] Mr. Fedden and Dr. Waagen have been obliged to leave India on sick leave; and Mr. Willson has left the Geological Survey for an appointment in the Educational Department. His is a permanent loss; for the Government has decided that the pay of his appointment shall be devoted to the experimental training of native apprentices.

Commencing with the formations to which the Indian coal measures belong, Mr. King accomplished a very satisfactory season in the region of the lower Godavari. He revisited the Singareni coal field, which he had discovered and described in the preceding

[1] The news of the melancholy death of Dr. Stoliczka on his way back from Kashgar, has lately been received.

season. Numerous trial borings had meanwhile been put down by the Nizam's officers, and a considerable amount of coal proved, although the seam was not found to be continuous throughout. The Beddadanole coal field was also examined, and the Madras Government has given orders for prosecuting the search there, by borings. In this region only three members of the great rock series had hitherto been discriminated, namely, the Talchirs, the Barakars, and the Kamthi sandstones, which Mr. Blanford had followed down the Godavari from Chanda, where he had, from the evidence of the fossil plants, ranked them with the Damuda horizon. But, from fossils found in the upper sandstone series of the Godavari basin, it is considered that, in part at least, it represents formations younger than the reputed age of the Damudas. The obscurity regarding the correlation of this whole series of rocks with established formations has been owing to the failure hitherto to link any important portion of it with beds containing a distinctive marine fauna. Such a connexion was made with the Rajmahal group, through the Kach deposits, but the connexion of the Rajmahal group itself with the main rock series is very uncertain. Mr. King has at last hit upon what may yield a clue to the puzzle, namely, a fossiliferous zone of marine beds at Ragavapuram, 30 miles due west of Rajamandri, well intercalated with the upper sandstones continuous with those overlying the Beddadanole coal measures. He has also found fossils in the same region, 30 miles N.N.E. of Cocanada, in some detached sandstone beds along the northern margin of the Godavari delta. Dr. Stoliczka has recognised them as on the horizon of the uppermost Jurassic zone, in the Kach series, which had long been assimilated to the Rajmahal group. Above these rocks, and underlying the trap, Mr. King discriminates a belt of sands with a thin limestone, which he conjectures to be cretaceous. The working out of all these suggestive discoveries is of the greatest importance to the geological history of India.

The Warda coal fields, in the northern part of the Godavari basin, engaged the attention of Mr. Hughes during the whole season. Two pits have been sunk to the coal, one at Warora and one at Pisgaon. Mr. Medlicott took up work in Satpura, with the intention of carrying out the examination of formations closely connected with the coal measures there, and by which they were concealed; and at the same time he was to afford geological guidance for the borings he had recommended in the Narbada valley. These trials were undertaken upon the probability that the

Satpura coal measures might here extend from the Sitarva field, beneath the alluvial plain. No depth could be assigned for the covering deposits, but from 200 to 500 feet was given as the probable range. Borings are in progress, but the upper deposits have proved to be of great thickness. In the Damuda basins Mr. Willson spent the season in retracing the lines of the Karapuna coal fields on the newly issued maps of the Hazaribagh district. Mr. Hacket traced the boundaries of the Vindhyan and older rocks on the new maps, along the northern side of the Narbada valley, filling in a large area. Mr. Mallet took up an important section of the crystalline and metamorphic rocks in South Bahar, with the advantage of the new large scale maps of Hazaribagh. Far to the south-west Mr. Foote was at work in the southern Mahratta country. So much of the gross area was gone over as was necessary to close in the north-east quarter of Atlas Sheet 41, and work was carried on in the quartzite area around Toragul and Ramdrug.

In the extreme north-west Mr. Wynne was engaged in working out the ground to the north of the salt range, where the tertiary series occupies a large area and forms the outer ridges of the mountain region. The top and bottom horizons are identifiable with the Sivalik and Subathu groups of the sections far to the east, but the same marked divisions of the series are not expressed in the west. A long stretch of intervening mountains between the Jhilum and Ravi remain to be examined.

The survey of Pegu was completed by Mr. Theobald in 1872–73. This work was commenced in the end of 1861 by Mr. Blanford, assisted by Mr. Fedden, and Mr. Theobald took Mr. Blanford's place in 1864. All the formations have a north and south strike, and are thus absolutely cut off along the frontier, but on the east the boundary is very regular and natural. The difficulty of observing rocks in a wild tropical region like that of Pegu is, however, very formidable. Rank vegetation produces deep soil; and it may be days before, in marching through a hill country, the geologist gets a fair section of rock in place. Fossils, too, are very scarce in Pegu. Enough only have been discovered to establish the existence of triassic, cretaceous, and nummulitic strata, forming the Arakan Yomah, beneath the general mass of younger tertiary deposits on the east, forming the Pegu Yomah. The south-eastern districts of the province form a distinct geological field from that now completed by Mr. Theobald. They are entirely formed of crystalline and sub-metamorphic rocks, in

which there is much promise of metalliferous deposits. On this account Mr. Fryar, the mining geologist, has been deputed to examine them.

Mr. Bauerman, a metallurgist, was employed during 1872–73, to examine and report upon the iron ores of India, with a view to the promotion of iron manufacture. His conclusion is the same as that which has long been expressed by the Geological Survey, namely, that under existing circumstances the Raniganj coal field is the most promising place for a trial, the principal defect there being the flux, and further search has been diligently made by Mr. Hughes, of the Geological Survey, for means of surmounting the known deficiencies. As regards the requisites for iron manufacture at Raniganj, there is, in the first place, an enormous amount of coal. Mr. Hughes says that there is perhaps no area of similar size in the whole world which can compare with the Raniganj field for actual thickness of the seams. The weak point of Indian coal is the amount of ash, but better may be discovered as the field becomes progressively developed. The average per-centage of ash is 15, but quite lately specimens have been found with only 8·9 and 8·7 per cent. of ash respectively. The deposits of Raniganj iron ore are of two distinct geological ages, the older associated with the coal measures, while the more recent are connected with the rock known as laterite. Laterite as a rule is not rich in iron, but the ironstones of the coal measures, which are valuable ores, occur over an area of several square miles in thin beds, varying in thickness from two to eight inches, about 6,400,000 tons per square mile. The main dependence of any iron works must, therefore, be upon the iron ores of the coal measures. As regards a flux, there is an unlimited supply of *kunkur*, containing 70 per cent. of carbonate of lime.

The Government have determined to make an attempt to train native geologists. Unfortunately, the expense of this experiment is to be met by curtailing the effective staff of the Survey, while the native students will be a direct incumbrance. There are to be four native apprentices. One joined in March 1873. The rest will follow. They are all from the Lahore College, and their qualifications consist of a moderate knowledge of English and of elementary mathematics. They are first to attend courses of physical science lectures at the Presidency College, and they may hereafter be utilised as fossil collectors.

The Records have been published regularly every quarter, and

contain numerous interesting papers. Among these are a sketch of the geology of the North-West Provinces; a map and description of the Bisrampur coal field; notes on the crystalline rocks of south Mirzapur by Mr. Mallet; a discussion on the geological age of old river valley deposits, in which (in the Narbada valley) Mr. Hacket had found a most symmetrically formed stone implement; a notice of the Beddanadole coal field by Mr. King; a sketch of the geology of the Rawal Pindi region by Mr. King, and a description of the brine springs in Pegu by Mr. Theobald. Of the MEMOIRS the first part of volume X. was issued. Mr. Bruce Foote describes a large tract of country close to Madras, comprised in Atlas Sheet No. 78, which is geologically coloured. Part II. of volume X. contains Mr. Theobald's description of the geology of Pegu. The issue of the PALÆONTOLOGIA INDICA contains the final illustrations of the cretaceous fauna of southern India, by Dr. Stoliczka.

The first of the systematic publication of the geological maps on the scale of one inch to the mile was made in 1873, by the issue of the twelve sheets of the district of Dumoh. The rest will, as a rule, be issued on a smaller scale. Of the Indian Atlas Sheets, the quarter sheet 78 W. was published during the year, and several of the adjoining sheets are ready for the engraver.

VI.

THE ARCHÆOLOGICAL SURVEY OF INDIA, 1873.

The third and fourth volumes of the Archæological Survey of India,[1] containing the reports for the year 1871–72, were published at Calcutta in 1873 and 1874. The introduction to the third volume contains a detailed account of General Cunningham's plan for carrying out the survey, with the memorandum of instructions to his assistants. The body of the work includes a report of researches at various places in the Gangetic valley, from Mathura to Lakhisarai, by Major-General Cunningham in 1871–72, illustrated by 47 plates. The fourth volume contains the reports on Delhi by Mr. Beglar, and on Agra by Mr. Carlleyle. The illustrations consist of inscriptions, copies of sculptures and other architectural details, and maps.

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[1] Archæological Survey of India. Report for the year 1871–72, by Alexander Cunningham, C.S.I., Major-General (Royal Engineers), Director-General of the Archæological Survey of India, Volume III. (Calcutta, 1873); Volume IV. (Calcutta, 1874).

General Cunningham, and his Assistant Mr. Beglar, explored the greater part of the Central Provinces during the year under review;[1] the General taking the western, and Mr. Beglar the eastern half. At Jabalpur they examined together the old temple at Bhera Ghat, overhanging the marble rocks. General Cunningham says that the circular colonnade which surrounds the temple, with its long line of female statues, all of life size, is one of the most curious and perfect specimens of Hindu architecture he has yet met with. The temple is dedicated to Siva, but the discovery of a small statue, with the Buddhist creed inscribed on the pedestal, leads to the conclusion that this circular colonnade once enclosed a Buddhist *stupa*. General Cunningham assigns the establishment of the Siva temple, on the ruins of Buddhism, to the 9th or 10th century.

To the north of Jabalpur several temples were explored, and good copies were obtained of the Asoka inscription on the rock at Rupnath. To the west of Jabalpur the decayed city of Burhanpur was examined, and plans made of the Jami and Bibi Masjids, the former being one of the finest Muhammadan buildings in India. It contains a record of Akbar, mentioning his conquest of Khandes and the Dakhin (Deccan). From Asighar a second similar record of Akbar was obtained, with an inscription of his son Dâniyâl, and others of Shah Jahan and Aurangzib. To the south the Buddhist caves and Brahmanical temples at Bhandak were explored, and the colossal sculptures at Lâlpet, outside the walls of Chanda were visited. Thence General Cunningham proceeded to the famous group of temples at Markanda, on the Wen-gangâ river. On the northern frontier of the Central Provinces he visited an old temple dedicated to Saraswati, in the small state of Myhere. It is on the top of a lofty conical hill.

But the most interesting remains are at Bharahut, six miles to the north-east of Uchahara, nine miles to the south-east of the Sutna railway station, and 120 miles to the south-west of Allahabad. In our maps the place is called *Bharaod*, and General Cunningham believes that it may be identified with the *Bardaotis* of Ptolemy. It is the site of an old city, which only 60 years ago was covered with a dense jungle. In the midst of this jungle stood a large brick stupa, 68 feet in diameter, surrounded by a stone railing, 88 feet in diameter and 9 feet in height. The whole of the stupa has been carried away to build the houses of the present village; but

[1] See Abstract for 1871–72, p. 29.

rather more than half of the stone railing still remains, although it has been prostrated by the weight of the rubbish thrown against it when the stupa was excavated. When General Cunningham first saw the place only three of the railing pillars near the eastern gate were visible above the ground, but a shallow excavation soon brought to light some pillars of the south gate, from which he obtained the measurement of one quadrant of the circle. He was thus able to determine the diameter of the enclosure, the whole of which was afterwards excavated partly by himself and partly by his assistant, Mr. Beglar. In many places the accumulation of rubbish rose to 8 feet in height, and as the stone pillars were lying flat underneath this heap, the amount of excavation was necessarily rather great; but the whole work did not occupy more than six weeks, and all that now exists of this fine railing is now exposed to view.

This colonnade of the Bharahut stupa is of the same age and style as that of the great Sânchi stupa near Bhilsa. But the Sânchi railing is quite plain, while the Bharahut railing is profusely sculptured—every pillar and every rail as well as the whole coping being sculptured on both faces, with an inscription on nearly every stone. From the characters of these inscriptions, as in the similar case of the Sânchi stupa, the erection of the railing must be assigned to the age of Asoka, or about B.C. 250.

The inscriptions are mostly records of the gifts of pillars and rails like those of the Sânchi and other stupas. But there is also a considerable number of descriptive records or placards, placed either above or below many of the sculptures. These last are extremely valuable, as they will enable archæologists to identify nearly all the principal figures and scenes that are represented in these ancient bas-reliefs.

Amongst the numerous sculptures at Bharahut there are no naked figures as at Sânchi and at Mathura, but are all well clad, and especially the women, whose heads are generally covered with richly figured cloths, which may be either muslins, or perhaps brocades or shawls. Most of the figures, both male and female, are also profusely adorned with gold and jewelled ornaments, in many of which one of the most significant Buddhist symbols plays a prominent part. The earrings are mostly of one curious massive pattern, which is common to both men and women. The *ankûs*, or elephant goad, was also a favourite ornament, which is placed at intervals in the long necklaces of ladies.

At each of the four entrances the corner pillars bore statues, each 4½ feet in height of *Yakshas* and *Yakshinis* and of *Nâga Rajas*, to whom the guardianship of the gates was entrusted. Thus at the northern gate there are two male figures and one female, which are respectively labelled *Ajakâlaka Yakho*, *Kupiro Yakho*, and *Chadâ Yakhi*, that is, the Yakshas named *Ajakâlaka* and *Kupira*, and the Yakshini *Chandâ*. Other Yakshas are named *Suviloma*, *Virudaka*, and *Gangito*, and a second Yakshini is labelled *Yakhini Sudasana*. On two other pillars there are male figures, each with a hood canopy of five snakes' head, and each labelled *Nâga Raja*. These have their arms crossed upon their breasts in an attitude of devotion appropriate to their appearance on a Buddhist building. On two middle pillars there are two female statues, respectively labelled *Chukaloka Devatâ* and *Sairimâ Devatâ*, whom General Cunningham takes to be goddesses.

Amongst the scenes represented there are upwards of a dozen of the Buddhist legends called *Jâtakas*, all of which relate to the former births of Buddha. Luckily these also have their appropriate inscriptions, or descriptive labels, without which their identification would hardly have been possible. Amongst these *Jâtakas* are the following :—

(1.) *Hansa Jâtaka*, or "Goose-birth," of which the only portion now remaining below the inscription is the expanded tail of a peacock, which must therefore have played some part in the story.

(2.) *Kinara Jâtaka*.—The Kinaras were a kind of demi-gods. Here two of them, male and female, are represented, with human heads and clad in leaves, standing before some human personage who is seated. The assignment of horses' heads to the Kinaras must therefore belong to a later date.

(3.) *Miga Jâtaka*, or the well-known legend of the "Deer," in Sanskrit *Mriga*. General Cunningham calls it a deer and not an antelope, as is generally understood, because all the animals in this bas-relief are represented with antlers. The King of Kâsi is seen aiming an arrow at the King of the Deer (Buddha).

(4.) *Magha Deviya Jâtakam*, or "Magha Devi-birth." General Cunningham knows nothing of this story.

(5.) *Yava Majhakiyam Jâtakam*.—This title means literally the "mean or average amount of food," which was attained by daily increasing the quantity with the waxing moon and decreasing it with the waning moon. The bas-relief shows a king seated with

baskets of grain (?) before him, each bearing a stamp or medallion of a human head. To the left some men are bringing other baskets. Barley (*yava*) would appear to have been the principal food in those days.

(6.) *Bhisaharaniya Jâtaka.*—A *rishi* (or sage) is seated in front of his hut, with a man and woman standing before him, and a monkey seated on the ground, who is energetically addressing the sage.

(7.) *Latuwa-Jâtakam.*—The "Latwa-bird-birth."—This legend apparently refers to some story of a bird and an elephant, of which General Cunningham heard a curious version in Kashmir in 1839. In the bas-relief there is a bee stinging the eye, and a bird pecking the head of an elephant, with a frog croaking close by, while the elephant is treading on a nest of young birds. To the right the same (or a similar) bird is sitting on the branch of a tree over an elephant who is running away with his tail between his legs. Near the top the hind half of an elephant is seen rushing down some rocks. In the Kashmiri version an elephant while feeding throws down a nest of young birds into a stream, where they are all drowned. The parent bird seeks the aid of the bees and mosquitoes, who attack the elephant with their stings, and having half blinded him he rushes off towards the stream, and plunging headlong down the rocks is drowned. The fable seems intended to show the power of combination. There can be no doubt that the two legends are substantially the same: and it seems probable that other Buddhist *Jâtakas*, still preserved in modern legends after the lapse of more than 2000 years may be found. Perhaps this particular legend may be found in the *Pancha Tantra*.

(8.) *Vitura punakaya Jâtakam. Vitura* may perhaps be a mistake for *Vithura*, "a thief."

Of illustrations of the life of Buddha during his last appearance there are some good examples. The earliest of these is a medallion containing Mâyâ's dream of the white elephant, which is superscribed *Bhagavato Ukdanti*. A second scene belongs to the reign of *Ajâta Satru*, King of Magadha, in the eighth year of whose reign Buddha attained *Nirvâna*. This is labelled.

Ajâtasata Bhagavato vandate.—Some of the well-known assemblies of the Buddhists would also appear to be represented, of which one is called the *Jatila Sabha*. A second probably belongs to a later period of Buddhist history, about midway between the death

of Buddha and the reign of Asoka. This sculpture represents a large assembly and is duly labelled.

Sudhamma Reva Sabha Bhagavato Chudâ Mahâ.—The words *Reva Sabha* probably mean the assembly or synod which was presided over by the famous Buddhist priest Revato just 100 years after the death of Buddha, or in B.C. 378.

But the Bharahut sculptures are not confined to the legends and events connected with the career of Buddha, as there is at least one bas-relief which illustrates a famous scene in the life of Râma. In this sculpture there are only three figures, of which one seated to the left is holding out an arrow towards a male and female who stand before him—the latter being behind the other. These figures are labelled respectively *Râma* (the rest lost, but most probably *Chandra*), *Janaka Râja* and *Sitala Devi*. General Cunningham believes that this is by far the earliest notice that we possess of the great solar hero Râma and his wife.

General Cunningham looks upon the discovery of these curious sculptures as one of the most valuable acquisitions that has yet been made to our knowledge of ancient India. From them can be learnt what was the dress of all classes of the people of India during the reign of Asoka, or about three-quarters of a century after the death of Alexander the Great. We can see the Queen of India decked out in all her finery, with a flowered shawl or muslin sheet over her head, with massive earrings and elaborate necklaces, and a petticoat reaching to the midleg, which is secured round the waist by a zone of seven strings, as well as by a broad and highly ornamented belt.

Here we can see the soldier with short curly hair, clad in a long jacket, or tunic, which is tied at the waist, and a dhoti reaching below the knees, with long boots, ornamented with a tassel in front, just like Hessians, and armed with a straight broad sword, of which the scabbard is three inches wide.

Here also we may see the standard-bearer on horseback, with a human-headed bird surmounting the pole. Here, too, we can see the king mounted on an elephant, escorting a casket of relics. The curious horse-trappings and elephant-housings of the time are given with full and elaborate detail.

Everywhere we may see the peculiar Buddhist symbol which crowns the great stupa at Sânchi used as a favourite ornament. It forms the drop of an earring, the clasp of a necklace, the support

of a lamp, the crest of the royal standard, and the decoration of the lady's broad belt and of the soldier's scabbard.

There are also houses of many kinds, and several temples, one of which is labelled *Vijayata pásádè*, or the "Temple of Victory." There are animals of several kinds, as elephants, horses, deer, cows, and monkeys, and a single specimen of a real tapir. There are numerous crocodiles and fishes, and in one sculpture there is a very large fish, which is represented swallowing two boat-loads of men. There is also a great variety of flowers, and several kinds of fruits, amongst which the mangoe is very happily treated.

But perhaps the most curious of the Bharahut sculptures are a few scenes of broad humour, with elephants and monkeys as the only characters. In two of these an elephant has been captured by a band of monkeys, who have fastened a billet of wood along the inside of his trunk so as to prevent him from moving it. Ropes are fastened to his neck and body, the ends of which are pulled by monkeys, who are walking and dancing in triumphal procession to the sound of shells and cymbals played by other monkeys. The spirit of these scenes is very droll. A third scene represents the monkeys holding a giant by the nose with a pair of pincers, to which is fastened a rope dragged by an elephant. The action and attitudes of the monkeys are very good. The intention of all these designs is exceedingly spirited, but the execution is coarse and weak.

In the short inscriptions on the railing of the Bharahut stupa, General Cunningham found the names of the following places:— *Sugana*, or Srughna; *Vedisa*, or Bhilsa; *Páta*[illegible]*la*, or Patna; *Kosámbi*, or Kosam; *Nandinagarika*, or Nandsur; and *Násika*, or Nâsik; besides a number of unknown places. *Kammadan* remains of the *masá* is most probably some town on the river *Tamasa*, ing of the time Tons of our maps.

From these inscriptions also General C Mâlaprabhi has learned the names of several parts of the Buddhist on stone and railings, one of which is a new word, or at least a new [illegible]s to be found in the dictionaries. [illegible]eśvara.

On the top of *LâlPahár*, or the "Red Hill," w[illegible]amen verhangs Bharahut, he obtained a rock inscription of one of the [illegible]t *Kalachuri* Rajas, Nara Sinha Deva, dated in Samvat (Sake) 909. Altogether General Cunningham and Mr. Beglar have collected about 20 inscriptions of the *Kalachuris*, who took the titles of *Chedindra* and *Chedinarendra*, or "Lord of Chedi," and called the era which they used the *Chedi Samvat* and the *Kalachuri Samvat*.

They have also got an inscription of the great Chalukya Raja Tribhuvana Malla, who began to reign in A.D. 1076, and reigned fifty-one years. The inscription is dated in Sake 1008, or A.D. 1086, and the place of its discovery, Sitabala confirms the account of his having conducted an expedition across the Narbada.

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 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 Belgam, where he began work on 2nd February.

In the Fort at Belgam are three old Jaina temples, built about the year 1200, A.D. One of them has been repaired, and, with additions built around it, is now used as quarters for the families of married soldiers. A portion of a second has been pulled down to make way for a road; and the third is enclosed in the commissariat premises. There must have been other temples also about the place, for many of the stateposts to compounds both inside the fort and outside, are pieces of old temples. Sculptured stones are also occasionally seen, which seem deserving of preservation in a local museum, which should be provided. The district around is sufficiently rich in temples, with lots of sculptures, inscriptions, &c. to stock a small museum in a few years, and arrangements

Plans of the three inclined temples, drawings of columns and details, and photographs of the finely carved bird's-eye views, and photographs of the inner door and of the finely carved porphyry dome of the larger temple were obtained. An inscription, removed from one of these temples many years ago, and now in the Bombay Asiatic Society's Museum, says it was built by Lakshmi-Bhupati, the son of Kârtavîrya, the son of Sena Râja of Venigrama (Belgam), and dedicated to Sântinâth, the 16th Tîrthankara or Jaina pontiff in Saka 1127 (A.D. 1205).

In the fort are several Persian inscriptions, one of them to the north of the main gate is translated:—

"Ya'qub 'Alî Khân, who is a joy to the heart, and by whose "benevolence the world is prosperous, built the wall of the fort "which has a strong foundation, like the wall of Alexander." The date in the chronogram is A.H. 937, or A.D. 1530. Another in the south-east of the fort has been forwarded to Professor Blochmann, of Calcutta, who thus translates it:—

"O Opener! The fort having been destroyed by the rains, it was "again made strong and firm. It was entirely renovated in the "time of 'Abdul Husain, the powerful. A reckoning, according "to the date of the Hijrah, was written down; know it to be the "year 1043 (A.D. 1633-34). Written by 'Abdul 'Azâz."

Copies of other two were also taken, but have not yet been deciphered.

On 7th February the work at Belgam was closed, and on Monday, the 9th, Mr. Burgess visited Ankalgi Monastery, and proceeded thence by Gokak to Konur. Time did not admit of copies being made of the inscriptions there, but a photograph was taken of a fragment of an old temple, and others of the best of the remaining dolmens in the neighbourhood of the village—great numbers of which have been destroyed by "wadâris," or wandering stone-cutters. The fine old temple at the Falls was also surveyed and photographed. In this temple is an inscription in very old characters, but partly illegible; this was also photographed.

Some very old ruins also exist here on the north bank of the Ghâtprabhâ, but they are so overgrown with prickly pear that, to permit a careful examination they would require to be cleared, for which there was no funds at the command of the survey.

Hukeri was next visited, but the Muhammadan remains there seem of such interest as to be deserving of the time necessary to plan and photograph them.

Returning by Belgam, Kâdaroli on the Mâlaprabhâ was next visited, where are two or more inscriptions on stone slabs. The first of these was photographed, and proves to be a grant "of S'ri-Prithvîvallabha Mahârâjâdhirâja-parameśvara-parama-"bhaṭṭâraka-śrîmad *Bhuvanaika Malladeva*, the ornament of the "race of Satyâśraya." "Dated on a full moon day at the summer-"soltice in S'aka 997 (A.D. 1075), the year Râkshasa, on a Sunday "in the month Pushya." The language is Canarese. At this village, in the bed of the river, is a curious group of old shrines, of which a plan and photograph were taken.

On 23rd February a photograph, plan, and rubbing of inscription,

They have also got an inscription of the great Chalukya Raja Tribhuvana Malla, who began to reign in A.D. 1076, and reigned fifty-one years. The inscription is dated in Sake 1008, or A.D. 1086, and the place of its discovery, Sitabala confirms the account of his having conducted an expedition across the Narbada.

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 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 Belgam, where he began work on 2nd February.

In the Fort at Belgam are three old Jaina temples, built about the year 1200, A.D. One of them has been repaired, and, with additions built around it, is now used as quarters for the families of married soldiers. A portion of a second has been pulled down to make way for a road; and the third is enclosed in the commissariat premises. There must have been other temples also about the place, for many of the gateposts to compounds both inside the fort and outside, are pillars from old temples. Sculptured stones are also occasionally turned up which seem deserving of preservation in a local museum could such be provided. The district around is sufficiently rich in old sculptures, inscriptions, &c. to stock a small museum in a short time.

Plans of both the ruined temples, drawings of columns and details, and photographic views, and photographs of the inner door and of the finely carved porphyry dome of the larger temple were obtained. An inscription removed from one of these temples many years ago, and now in the Bombay Asiatic Society's Museum, says it was built by Lakshmi-Bhupati, the son of Kârtavîrya, the son of Sena Râja of Venigrama (Belgam), and dedicated to Sântinâth, the 16th Tîrthankara or Jaina pontiff in Saka 1127 (A.D. 1205).

In the fort are several Persian inscriptions, one of them to the north of the main gate is translated:—

"Ya'qub 'Alî Khân, who is a joy to the heart, and by whose "benevolence the world is prosperous, built the wall of the fort "which has a strong foundation, like the wall of Alexander." The date in the chronogram is A.H. 937, or A.D. 1530. Another in the south-east of the fort has been forwarded to Professor Blochmann, of Calcutta, who thus translates it:—

"O Opener! The fort having been destroyed by the rains, it was "again made strong and firm. It was entirely renovated in the "time of 'Abdul Husain, the powerful. A reckoning, according "to the date of the Hijrah, was written down; know it to be the "year 1043 (A.D. 1633–34). Written by 'Abdul 'Azâz."

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were taken of the pretty mosque at Sampgâm. The inscription, however, proved to be only three verses from the Qoran, viz., sûrah LXI. 13, XII. 64, and VI. 161. Next day the old temple, probably a S'aiva one, at Bail Hangal, was surveyed and photographed, but time did not admit of the two long inscriptions here being copied.

Saundati was next visited, and one of the two inscriptions here was photographed, but has not yet been read. The same evening the party started for Yellamâ, a shrine built in the rocky bed of the Sarasvatî, a small stream flowing eastwards among the hills east of Saundati. The temple has been rebuilt and repaired in recent times, and is one of the most famous places of pilgrimage in the Canarese country.

Another march brought the party to Huli, where are numerous remains of old temples, dating probably from the 10th to the 13th century. There are also several inscriptions, but the expedition had not the time to spare to copy them, and the want of a qualified pandit prevented the possibility of making a selection of the oldest or most interesting. The great temple of Panchalinga now used by the Lingayats was found to have been originally a Jaina Basti,—the Jinas having been hewn off the lintels of all the doors except that to the shrine in the south end of the inner hall. This temple is supposed by Mr. Burgess to date from about the year 1100, A.D. A plan and photographs of it were taken, as also of some others close by. But some expenditure to clear away the prickly pear and make some slight excavations was necessary to make a satisfactory examination of the more promising remains here, and for this there was no provision.

On 2nd March the temples of Panchalinga Deva at Manauli were examined, but the villagers objected to the oldest temple being entered. Three photographs, one of them of an inscription, were taken here.

From Manauli two marches were made to Badâmi in the Kaladgi Zilla. On the south of the town is a rocky hill, facing the fort, which is north of it, and in its north-west face are four caves, three of them Brahmanical and one Jaina. These caves had been often incidentally noticed, and Dr. J. Bird, who had visited them, devoted a section in his *Historical Researches* to their description, and tried to prove that they belonged to the 10th century, A.D., but even from his account it is impossible to make out whether they were S'aiva or Vaishnava,—the Jaina cave seems to have entirely escaped his notice. To examine these caves more thoroughly, and if possible

fix their age, was a principal object of this tour. They stand, as to arrangement of parts, between the Buddhist Vihâras and the later Brahmanical caves at Elorâ, Elephanta, and Jogeśvara in Salsette, and, hence, must be placed before the 8th century. Cave I. contains the linga in the shrine, and in various parts of the cave are figures of S'iva, Ganpati, Kartikeya, Mahisâśuri, Arddhanâri, and Harihara, with S'esha and other figures specially S'aiva; hence it may with safety be relegated to that sect. The style of the cave, too, would indicate that it is probably the oldest here, and may be attributed to the end of the 5th century.

In Cave II., though there is also a cell with the *chavaranga* or altar for the *linga*, the sculptures are so distinctively Vaishnava as to show that it originally belonged to that sect. Though rich in sculpture, much of it well deserving of being moulded, neither of these caves have any inscription. The second is probably the later of the two, but not by more than half a century.

The third cave is by far the largest and finest of the series, and in some respects one of the most interesting Brahmanical remains in India. It measures about 70 feet by 48, and is approached through a large square court in front of it, which is entered by a door on the west side. On the wall to the right of this door is an inscription in characters of about the 6th century, and there are other inscriptions, mostly very short ones, on the rock near the cave. At each end of the front of the cave is a gigantic figure, that on the east Vishnu armed, but at rest, the other the same *deva* in conflict with an enemy. At the ends of the Veranda are gigantic forms, 11 feet high, of Vishnu on Ananta or S'esha and Narisinha, and on the back wall of the verandah are equally large figures of Varâha and Harihara. The roof of the verandah is also elaborately carved, and has all been painted. The six columns of the verandah have each brackets on the sides and inwards to the ceiling, carved with pairs of figures or with a single female and attendant dwarf.

On a pilaster beside the figure of Varâha is an inscription in 24 lines,—letters of it scarcely legible,—which was copied with much difficulty, by means of estampages; and from these Professor Eggeling has been able to read it. It records that S'ri Mangalîśvara,—
" of the Chalkya (for *Chalukya*) race, worshippers of Vishnu, of the
" Mânavyagotra, sons of Hâriti,—in the 12th year of (his ?) reign, in
" the year S'aka 500 (*i.e.* 578 A.D.), built a house of the great Vishnu,
" surpassing all things divine and human, constructed by wonderful
" labour, and beautiful with its enclosing boundaries, and granted the

" revenues of a village for making daily offerings to Nârâyaṇa and " for giving charitable relief to 16 Brahmans and to mendicants." This grant, he adds, " is made to increase the religious merit of my " eldest brother *Kirttivarman*."

This remarkable inscription, besides settling the date of the cave at three and a half centuries older than Dr. Bird would have led us to believe, helps greatly to clear up what had already been inferred from other inscriptions, that Mangalîśa practically ruled the country in the name of his elder brother Kirttivarman. The style of these caves too is so closely connected with that of several old temples at Badâmî and many more at Paṭṭadkal and Aiwalli, that even in the absence of inscriptions we can be at little loss to assign them approximately to the age in which they were built. But inscriptions are always of the highest importance as confirmative or corrective of dates theoretically assigned.

There are inscriptions in a much more modern character on two pillars in the cave, from one of which Dr. Bird read, " *Nâkula hala* " *navakâla mritana ghaya*, 1476,"—(the figures are 1436), which he made out to mean " the new date of Hala Hala or Buddha," and to date from B.C. 543! Good " estampages " of these inscriptions have been brought home. A complete delineation of the Badâmî Caves, with a few casts would form a valuable illustration of Hindu art and Vaishnava mythology, only to be rivalled by what Ajanṭâ affords of Buddhism.

Cave IV. is a Jaina Cave, dedicated to Mahâvîra, and with a large figure of Parśvanâth in the one end of the verandah, and another *jina*, perhaps Mahâvîra, both nude, in the other. Scores of figures of *jinas* are also carved in different parts of the cave. It perhaps belongs to the 7th or 8th century, A.D.

On the north side of the *talao* or lake at Badâmî, and on the fort rock are several old temples, built with very massive square pillars, and belong to about the same age as the caves. There are also others of more modern date.

Bânaśankari and Alaitîrtha were both visited, but there was not time for any very detailed examination, and the season being now well advanced and the heat very intense, the party moved on to Paṭṭadkal on the Mâlaprabhâ. The number of old temples still remaining here, and still more the number that must have been pulled down over an area extending considerably to the north of the village, are evidences that in ancient times Paṭṭadkal must have been a place of no small repute. Only the great temple is now used

for worship, all the others, including the curious old temple of Pâpnâth,—with scenes from the *Râmâyana* on the outsides of its walls, all labelled, like the sculptures on the Bharahut tope,—are occupied by the villagers as sheds for their cattle, to cook in, &c., and some have been used as quarries from which to obtain building materials. Plans and other drawings were made of the more important; several inscriptions were also copied, but have not yet been deciphered. The temples may be approximately ranged from the 5th to the 10th century, those of the northern or Bengal style being the more recent, for it is curious that here, as at Bhavânesvar, the Bengal and Dravidian styles are found side by side.

On 13th April, the examination of the remains at Aiwalli was begun. Here is a Jaina cave, hitherto undescribed, but evidently of the same age as that at Badâmi, and like it of the Digambara, or naked sect, worshippers of Mahâvîra Svâmi. Pârśvanâtha, with the seven-headed snake overshadowing him, figures at one end of the verandah, and Mahâvîra (?) at the other, whilst a chapel has three of its sides filled with figures, of which the last *tîrthankar* is the centre. This is quite a counterpart of a similar chamber in a Brahmanical cave not far from this one,—also hitherto unnoticed—in which S'iva forms the central figure. This second cave at Aiwalli apparently belongs to about the same age as Cave I. at Badâmi; the sculptures are much the same, but the arrangements are very different.

On the hill above the Jaina Cave are numerous dolmens of large size, most of them wanting the stone at the end with a round hole in it, which seems to have served as the entrance.

The temple on the north-east wall of the village, locally known as the Durga, and hitherto described by the few persons who had seen it as a S'aiva temple, was intended to be a subject of special examination. It was supposed to be the locale of an inscription, dated 584 A.D.; and from its terminating in an apse at the back, and its general plan, so far as that could be made out from photographs, it was expected that its interior arrangements would throw so much light on the subject of cave architecture, that few temples in India would more fully repay a careful survey and detailed illustration. Unfortunately the heat was intense at Aiwalli in April, and the frequent heavy thunderstorms that occur at that season in the Canarese districts put a sudden stop to the work. A plan, however, was made of the temple; the inscription of Pulakési II.

(A.D. 584) was not found to belong to it; but another inscription was found beginning, *Svasti, Vikramâditya Satyâs'raya, &c.* Now as Vikramâditya died in A.D. 680, this gives us the date of its construction within a very few years, and confirms the date which theoretical considerations would lead us to attribute it to. The temple, moreover, has not been built for S'aiva worship, but for Vaishnava, to which the early Chalukya princes of the Dekhan were attached, the plan is unique and almost suggests a copy from a Buddhist Chaitya cave. The Marâthas of a century or two ago piled up a ramp of loose stones on the roof and round the spire, and the roof has fallen in filling the interior with débris; if this were cleared out, the temple might be used as a place in which to store inscriptions and sculptures, which are very numerous here.

In the village a considerable number of fine old temples have been appropriated as dwellings, cowsheds, &c., and very many others of great age have been destroyed or ruined for sake of the large stones they yield for building purposes. To the south-west of the village, and at some distance from it, is a large collection of ruined or deserted temples, mostly small, which it would take a volume to illustrate fully. It was impossible, however, to remain longer out, and Mr. Burgess's party left Aiwalli on the 17th April, and reached Bombay on the 27th, bringing 54 photographs, between 25 and 30 inscriptions, about 40 ground plans, sections, drawings of columns, &c., and 40 sketches of sculptures. A portion of these will be prepared for publication and submitted to Government, with a report of the season's operations.

VII.

Meteorological and Tidal Observations in India, 1873.

The question of the organisation of a Meteorological Department in India is still under consideration; the despatch from the Secretary of State on the subject, dated the 18th of May 1871, and enclosing the report of the committee of the Royal Society, not having yet been answered. They have, however, together with some further correspondence, been presented to Parliament on the motion of Mr. Egerton Hubbard.

In Bengal the same system of meteorological registration as has been described in previous abstracts, was carried on during 1873, and Mr. Blanford received the monthly abstracts of results from

the North-West and Central Provinces, but not from other parts of India. Such obstacles to work must always be expected so long as there is an independent system of registration in each province. This absence of central control is noticed and deplored, not only in India and in England, but in other countries; and it has been 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. In Bombay the Kolaba observatory is most efficiently directed with valuable results by Mr. Chambers; and there are four other meteorological stations the observations taken at which are sent to England, where no particular use has hitherto been made of them. The system in the Madras Presidency has been described in a former abstract. It is under Mr. Pogson, the astronomer. There is one excellent private observatory at Vizagaptam in Daba gardens, belonging to Mr. G. V. Juggarow; which is superintended by Mr. A. V. Nursingrow. The monthly results are published annually, and Mr. Blanford speaks highly of them.

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. There is no hope, however, that any advance can be made until a central office has been established to receive, reduce, and draw conclusions from careful observations taken over the whole area of India.

Meanwhile the most valuable meteorological work of the year has been 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 Cuttack 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 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 propulsion 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.

Mr. Blanford's Meteorological Report for the year 1873 is the seventh that has been submitted since the Department was established in 1867. It is the first which has to treat of a year of 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 has already been made is, 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 are untrustworthy and not comparable, and nothing is received from Bombay, Madras, or Burma. It is now possible to frame a conception of the general distribution of pressure and temperature over about half India and its seas. It will not, however, be 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 is brought into one *nexus*, so that the records of all can 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 are 10 second-class stations, and will shortly be 12, including one at Nancowry in the Nicobar Islands, and 145 third-class stations for observing rainfall. There is at length to be a meteorological observatory at Calcutta, Sir George Campbell having secured a suitable piece of ground at Alipore, and provision having been made in the budget for the building and for the self-registering instruments now being constructed in England.[2] Self-registering anemometers, giving a simultaneous record of the direction and velocity of the wind, are 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 is 1,936*l*.

The chief meteorological characteristics of 1873 were excessively high temperature, especially in Oudh and the North-west Province, 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

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[1] See page 38.

[2] Since this was in press the allowance of Rupees 25,000 for the Observatory has been struck out of the Budget for 1874–5.

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.[1] 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.[2] In 1868 there was unduly low pressure at Sagor and False Point, in the north-east corner of the Bay of 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

[1] See Memoir, p. 214.

[2] Journal of the Asiatic Society of Bengal, Volume XXXIX., page 123.

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 Oude 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 lay 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.

Tidal Observations in India.

In the abstract for 1870–71 an account was given of Colonel Walker's measures, while in England, for organising a plan for the investigation of the law of tides of the Indian Ocean, and of Lieutenant Baird's work in drawing up an account of the method of reducing tidal observations by a harmonic analysis, as conducted

by the British Association. The steps were also described, which Colonel Walker took to procure the necessary instruments.[1] Lieutenant Baird made an experimental trial of the performances of the tide gauge at Chatham, the results of which were very satisfactory.

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 Nowanár 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 then proceeded eastwards towards the head of the gulf, and discovered a position near Hanstál 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 will be 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 will be 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 will be attached and carried into deep water. The cylinders will be 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

[1] Abstract for 1870-71, p. 49.

whenever the tide is falling. The flexible piping will terminate 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 will be attached to the iron piping in such a manner as that it may be readily removed and cleared whenever necessary. The interior diameter of the piping will be two inches, which has been 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 will be set up over the cylinders, and their iron bed plates will indicate the places to which the tidal measurements will be referred, and they will be connected by levelling with permanent bench marks fixed in the ground in the vicinity of the stations.

Lieutenant Baird was employed during several months at Bombay in making the requisite arrangements. He then proceeded to construct the stations on the coasts of the Gulf of Kach. Colonel Walker reports that he has worked with great assiduity and skill, and with a hearty interest in the success of these important tidal investigation.

VIII.

The Madras Observatory, 1872–73.

Mr. Pogson, the astronomer in charge of the observatory at Madras, has submitted a report upon the proceedings of that establishment up to the end of 1873. Beyond announcements of discoveries, and the observations necessary to substantiate them, communicated to the Royal Astronomical Society and the Astronomische Nachrichten, nothing has been published during Mr. Pogson's term of office, which commenced in 1860.[1] He undertook to work on a programme of operations which he now considers to have been 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.

[1] See Memoir, p. 241.

As the heaviest work on hand, namely, the catalogue of stars made with the new meridian circle, is now nearly completed, it is considered that, for a time, observations may 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 may be brought out in pretty rapid succession, and all arrears cleared off before any fresh undertaking is 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 has 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 form the arrears, and most of them are reduced and ready for the press. They are well worthy of publication, and prove that the predecessor of Mr. Pogson conscientiously exerted himself for the attainment of such results as were within his very limited instrumental means. The hourly meteorological observations from 1851 to 1860[1] are still unpublished. Those from 1851 to 1855 are printed and nearly ready for issue. Of the hourly magnetic observations, only the results from 1846 to 1850 have yet been published. Those from 1850 to 1855 are printed and will shortly be distributed.

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 have already been made, is to be 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

[1] See Memoir, p. 209.

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, is about two-thirds finished. 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 equatoreal 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 equatoreal. 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 equatoreal. 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 equatoreal 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 equatoreal, 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 of 1866 were the mounting of the new $8\frac{1}{2}$-inch equatoreal, 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 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 equatoreal. In 1870 the firing of the fort gun by an ingenious electrical discharging apparatus was substituted for the dropping of a ball, to give the time. In 1871 a fourth series of observations of Mars was made with the large equatoreal; 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 Coimbatore 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 ordinary telescopic phenomena. The report on this work has not yet been submitted by Mr. Pogson, owing to continued pressure of work. 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. The observations of Biela's comet, which was last seen 18 years ago and had since been given up as lost, were taken under very extraordinary circumstances. But the observations are stil

were discontinued, and the meridian circle was used exclusively for star places to complete the catalogue in hand. A fifth series of Mars observations was taken have April and May, with the large equatoreal.

Mr. Pogson represents that an experienced European assistant had been granted him in 18[illegible] at there would have been no arrears at the present time. 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 equatoreal; but still without all the proper appliances.

Arrangements have been made for the observation of the transit of Venus in India, which have been entrusted to Colonel Tennant. Among the instruments ordered by the Secretary of State, a photo-heliograph was sent out to India in June, and a chronograph and three electric clocks in the middle of July; the remaining appliances, a six-inch equatoreal telescope and a transit instrument, being still in the hands of the manufacturers, Messrs. Cooke and Sons of York.[2]

Meanwhile the Government have sanctioned the funds necessary for building an observatory, and Colonel Tennant is proceeding with the arrangement at Rurki. Colonel Walker has been enabled through changes in his Department to make some intruments available, which will partially fill the place of what were ordered from England, and Colonel Douglas, R.A., has also contributed some timekeepers. Colonel Tennant proposes to observe at Rurki, where he will be assisted by Captain Campbell, R.E., of the G. T. Survey. He has

[1] Monthly Notice, R.A.S., XVII., p. 208–21.

[2] The transit instrument has since been shipped.

unreduced and unpublished In 1873 the observations of the moon been authorised to send an officer (probably Captain Strahan, R.E.) as far up into the Panjáb as possible to get eye observations of the last contact of Venus and the Sun. Observations will be made at Madras by the astronomer, for whose requirements a chronograph has been ordered at Bombay by the Superintendent of the Kolaba Observatory, who, however, has few appliances, and at the head-quarters of the G. T. Survey, Dehra Dún.

IX.

Geographical Exploration, Publications and New Maps.

In 1872, one of Major Montgomerie's Pundits made a journey north-eastwards from Shitgatzé to the great Namchú Lake, and then southwards to Lassa; but the account of it has not yet appeared. In 1873, a Pathan was sent to the region beyond the Hindú Kúsh range, with instructions to penetrate, if possible, into the *terra incognita* of Shighnan, Roshan, Darwaz, and Karatagin, to the north of the river Oxus. One of the Pundits has been sent into the part of Great Tibet beyond the northern watershed of the Brahmaputra river; and four are attached to Mr. Forsyth's embassy to Kashgar, in the expectation that they may be able to make their way back to India by various routes which are closed to Europeans. Intelligence had been received of the murder of the Mirza, whose exploration of the route from Badakshan across the Pamir Steppe to Kashgar was described by Major Montgomerie in the report of the Great Trigonometical Survey for 1869-70.[1] He had been sent on a second expedition, with his son-in-law as an assistant, to travel through Afghanistan. At first his reports were received pretty regularly, but for several months he was not heard of; and it now seems likely that, after traversing the road from Herat to Maimana, he was murdered with his companion during the night while asleep, by the guides they were employing. A servant is said to have escaped, and to have given information which led to the subsequent execution of the murderers by order of the Governor of Maimana. Endeavours are being made to obtain fuller information respecting the fate of this faithful and intelligent emissary, and to get possession of his papers.

Much geographical information is expected from the members of Mr. Forsyth's embassy to Kashgar. Captain Trotter, formerly

[1] See Abstract for 1869-70, p. 26.

in charge of the Kattiwar Survey, passed some time at Colonel Walker's head-quarters, before starting, in practising astronomical observations, and particularly those for the determination of absolute longitudes. Two other officers attached to the mission, Captain Chapman, R.A., and Captain Biddulph, also spent a short time in practising observations and reductions. A Kashmiri surveyor of the Rajputana survey, and four of the Pundits, were sent with Captain Trotter; and Colonel Walker has done all in his power to promote the success of the geographical operations of the mission. From Kashgar three members of the mission made an excursion to the Pamir table land, namely, Colonel Gordon, Captain Trotter, and Dr. Stoliczka, the geologist. The results of their journey may be summed up as follows:—There are two Karakul lakes on the plateau, the drainage from one flowing east, and from the other west. The eastward stream is the Ghiz, which, passing through the Ghiz-Dawan, becomes the Kashgar river. That flowing west joins the stream from the Ghiz lake or Pamir Kul, and forms the Murghab river. It enters Shignan at Bartang, and falls into the Oxus five days journey below Kila Panja, at a place called Vamer. Shignan (Shaghnan) has been ascertained to be perfectly independent, and is ruled over by Yusuf 'Aly Shah, who also owns Roshan and the adjoining Pamir. The territory of Wakhan extends up to the junction of the Aktash stream with the stream flowing from Lake Karakul, and contains the great, little, and Alichur Pamirs. The true water-parting between the east and west is the Kizilyart plain, belonging to the Amîr of Kashgar. The Shignan Pamir and the Kizilyart plain are inhabited by wandering Kirghiz. The other Pamirs have been abandoned of late years. From Tashkurgan to the small Karakul Lake is one day's march, from the small to the great Karakul five days, and from the great Karakul to Ush is six days' march. The Barojit Pass into Chitral is reported to be extremely easy, and open during the whole year, except about six weeks in March and April.

The results of the work done by Sir Frederic Goldsmid, and the officers employed on the Persian Frontier Commission, are about to be published. The narrative of Sir Frederic's earlier travels, with an account of the construction of the telegraph line between India and England, will be found in the handsome work published by Messrs. Macmillan, entitled "Telegraph and Travel." An official work will also be published, comprising an introduction by Sir Frederic Goldsmid, a narrative of the journey from Bandar Abbas,

through Sistan to Mash-had by Major Euan Smith; geographical memoirs and accounts of their independent journies by Major St. John and Major Lovett; and the scientific results of Mr. Blanford's visit to Persia.

Mr. Blanford's portion of the work will be divided into two parts, zoology and geology. The former, which will be the most voluminous, will treat of the vertebrate fauna, with the exception of the fishes. In the collections obtained by Mr. Blanford himself, supplemented by a very valuable series of skins previously amassed for the Indian Museum by Major St. John, and placed at Mr. Blanford's disposal for examination, there were altogether rather more than 2,000 specimens (dried or preserved in spirit), representing 32 species of mammalia, 248 birds, 62 reptiles, and 5 amphibia; and by collating the data given by S. E. Gmelin, Pallas, Ménétries, Eichwald, and other explorers of the shores of the Caspian, together with those furnished by De Filippi and others from various parts of Persia, Mr. Blanford has ascertained that the known fauna of the country combines 87 species of mammals, 380 of birds, 91 of reptiles, and 9 of amphibians, of each of which notes as to localities, and where practicable, structure and habits, will be added. The novelties described, of several of which brief notices have been given in various scientific publications, amount to 10 mammals, 8 birds, 19 reptiles, and 1 amphibian. All of these will be fully described, and, together with a few rare forms described but not figured by previous observers, illustrated by lithographs, many of them coloured, and woodcuts. The whole account will be preceded by some remarks on the general distribution of the Persian fauna, and its relation to that of adjoining regions.

The geological portion of the work will consist principally of an account of the rocks observed during Mr. Blanford's journey through Persia. A brief sketch will be given of what is known of the general structure of the country from the explorations of Mr. Loftus and others, but it is considered that so large a part of Persia is as yet unknown, that nothing like a complete description of the geology can be written as yet. A geological map will accompany this portion of the work.

During the past year Major St. John has completed a map of Western Bálúchistán on the scale of eight statute miles to the inch. It includes the country between the Mekrán coast and latitude 28° 20″, and the 58th and 64th meridians, thus covering the whole of the territory recently regained by Persia and the frontier district

which owe allegiance to the Khán of Kalát. With the exception of the coast line, and the route of Captain Grant in 1809, all the material used in the compilation of this map is original. The country on both sides of the Kalát frontier, and all north of the 27th parallel except Panjgúr is from Major St. John's own survey in 1872. The country in the vicinity of the roads from Gwádar to Bampúr viâ Kasrkand and Sarbáz; from Gwádar to Bolída, and thence by both routes to Panjgúr is from surveys by Major Lovett, C.S.I., in 1871. The roads through the Pá-godár pass from Bampúr to Sarbáz, and from Kastag to Gwádar, are from surveys made by Lieut-Colonel Ross and Quartermaster-serjeant Bower, R.E., in 1871. Other routes are inserted on the authority of Captain Grant, 1809; Sir F. J. Goldsmid, 1862 and 1866; Lieut.-Col. Ross, 1865; and the same officer and Mr. Sealy, 1867. Appended to the map are sections of the country between the Bampúr and the Kharán deserts, and between each of these deserts and the sea. Valuable as have been the results of the labours of the frontier commissions under Sir F. J. Goldsmid in a geographical point of view, much remains to be done before our knowledge of Bálúchistán can be considered adequate. Besides the many spaces left blank and marked unexplored on Major St. John's map, the geography of that part of the Kalát territory lying between the frontier districts and Colonel Green's surveys, or roughly speaking, between the 64th and 66th meridians, is still unknown, save on the route taken by Lieut.-Col. Ross along the prolongation of the Kej valley in 1865.

The map has been carefully executed in lithography by Mr. Trelawny Saunders. Its large scale, eight miles to the inch, necessitated by the purpose for which it was required, viz., as a basis for the settlement of frontier disputes, seemed to render its publication unadvisable. One hundred copies only have therefore been struck off. All the information contained in it will, however, be available to the public on a smaller scale in Major St. John's general map of Persia.

This work is far advanced towards completion, Messrs. Stanford being already engaged on the reproduction of four of the six sheets.

The map is based in the first instance on the longitudes of Tehrán, Bushire, and the towns between them, fixed by means of the telegraph by Major St. John and Captain Pierson in Persia, with the co-operation of Colonel Walker in London and Lieutenant Stiffe in Karáchi. A parallel base is afforded by the map of the Turco-Persian frontier survey, of which sheets on a reduced scale are in

preparation, at the joint expense of the Foreign and India Offices, in the office of Sir Henry James at Southampton.[1] The observations of Fraser, Lemm, and Khanikoff furnish a series of astronomically fixed points, connecting Tehrán with the Russian frontier on the north-west, and the Caspian ports on the north, and with Mash-had and Herat on the east. M. Khanikoff's work, or rather that of his assistant M. Lenz, gives in addition a chain of points connecting his routes in Khúrasán, Sístán, and Karmán with those of Majors St. John and Lovett from the south. The coast lines of the Persian Gulf and the Caspian are derived from the most recent Russian and English charts. A description of the amount and sources of detail which Major St. John has been able to fit on the skeleton thus provided had better be deferred till the completion of the map. Suffice it to say, that though, with the exception of the Turco-Persian frontier survey, there is little that is new in the two western sheets, the topography of the country embraced by the other four, *i.e.* east of the Bushire-Tehrán road, is mainly compiled from authorities whose work, where not entirely new, has never yet appeared in any general map of Persia. While much has thus been added to the information obtainable from existing maps, much that is erroneous and untrustworthy has also been swept away. A system of trans-literation has been introduced, uniform as far as possible under the circumstances. The various languages in which authorities have recorded their travels, and the impossibility of obtaining the Persian orthography in many cases, render absolute uniformity out of the question. No attempt has been made at conjectural geography, and blanks have been unhesitatingly left in the absence of direct visual evidence. The result is to show that in spite of the immense increase of information recently acquired our knowledge of the topography of Persia is much less in extent and detail than might be supposed from existing maps, German and English. This is especially the case in South Fars and Western Irâk.

The six sheets of the map, which is on the scale of 16 statute miles to the inch, are divided as follows:—The 1st or N.W. sheet comprises Adarbaiján, Ghilán, Kúrdistán, Karmánsháh, Hamadán, and part of Irák. The 2nd or N. sheet contains eastern Irák, western Khúrasán, and Mazandarán, and includes the Great Salt Desert. The 3rd or N.E. sheet has but the eastern half of a single province, Khurasán; and the 4th or S.W. those of Arabistán

[1] The non-completion of this work has delayed Major St. John's map several months.

and Khúzistán. The 5th or S. sheet comprises the great southern provinces of Fars and Karmán, with part of Yazd; and the 6th or S.E., Sístán, Narmashír, and Balúchistán. The outline is being executed by Messrs. Stanford on copper; the hill shading will be given by the peculiar process patented by them. It is hoped that the whole will be published by the end of the year.

The map of western Asia, under construction by Captain Felix Jones, is progressing satisfactorily. It comprises four sheets of double elephant size, that is, 40 by 26 inches each of which three sheets can be made ready for reproduction at a brief notice, and the fourth, or S.W. sheet, will be in hand in a short period. This has been deferred to the last to give place to the results of the Palestine Exploration Surveys, very liberally promised by the Committee of the fund.

Representing, as these sheets will do, all the modern features of the Old World as well as the classical sites of antiquity for which the region between the Mediterranean and the Caspian, the Red Sea and the Persian Gulf, is renowned, the work will prove of public utility and generally instructive in a variety of ways. The more so as in its treatment a new process of cartography has been employed; a process tending to throw the natural features of countries more into relief than map surfaces usually do, and will therefore commend itself. But it here merits notice as important to public works of a geographical character. Those most conversant with the subject discern but little difficulty in the reproduction of maps similarly treated; all that is suggested is, that if reproduction be intended it should not be delayed, for the simple reason that our climate is but a sorry preservative of the original fair aspect of manuscript works of any kind.

The gazetteers of Central Asia, prepared under the superintendence of Colonel McGregor, for political and military reference, are making progress. The first, which appeared in 1872, was "Part I. A "contribution towards the better knowledge of the topography, "ethnology, resources, and history of the Trans-Indus Frontier." It has, however, been recalled for further improvement. Parts II. and IV., on Afghanistan and Persia, were noticed in the last abstract.[1] Part VII. (Section I.) has since been received, which is "A gazet- "teer of Kashmir and the adjacent districts of Kishtwán, Badrawán, "Janú, Naoshra, Punch, and the valley of the Kishen-ganga,"

[1] Abstract for 1871–72, p. 41.

of the revenue surveys, and of al[illegible]ajor Charles Ellison Bates. The Survey. [illegible]tory and review of the physical

The catalogue of general map[illegible]lition of the people, besides tables Indian Atlas, and contains all the

The g[illegible] Captain Lockhart, of Khíva, by Captain Collett, of Bokhara, [illegible]tain Chapman, and of Kokand, by Captain Trotter, have not yet been received in this country.

A gazetteer of the province of Sind, compiled by Mr. A. W. Hughes of the Bombay Uncovenanted Civil Services, has been published in 1874. The introduction contains a comprehensive account of the boundaries and extent of the province, of its physical geography, scenery, soil, and climate, crops and cultivation, irrigation canals, and forests; of its history, and the system of civil administration; of the population, the tribes, and castes, their language, religions, manners and customs, and of recent improvements. The places are then given alphabetically in the body of the work; the accounts of the different districts being classified and arranged in the same way as that of the whole province in the introduction. There are useful statistical tables at the end, and the work is illustrated with maps and photographs. An excellent general index adds to the completeness of this ably compiled and very useful work.

Another gazetteer which has recently appeared is that of the little state of Karauli, the author being Captain P. W. Powlett, settlement officer of Alwar. It opens with a historical sketch of the Jadu Rajputs from the time of Bijai Pal (995 A.D.) down to the present time. Then follows a statistical account of the state (from which we learn that the area, as determined by the operations of the topographical survey, is about 1,260 square miles only, being a third less than hitherto believed), a description of the mines and quarries, forests, wild animals, and jungle products. The population, a detailed account of which is given, is about 140,000. After the nature of tillage, the means of irrigation, and the tenures have been explained, a notice is furnished of labourers and wages, land revenue, measures and weights, manufactures, and miscellaneous matters. Part III. deals with the darbar, aristocracy, and official classes; and Part IV. with the several districts, towns, and villages. In the appendices we find lists of the masonry forts held by the darbar troops, and of the various trees and shrubs peculiar to the country, as well as a sketch of the geology by Mr. C. A. Hacket, of the Geological Survey of India. The work winds up with a copy

neet comprises the great southern of the treaty of alliance and with part of Yazd; and the 6th or between the Rajah of Karauli and alúchistán. The outline is being

The publication of a text book in copper; the hill shading will be the rudiments of physical geogr patented by them. It is hoped that and climate of India, by Mr. y the end of January took place at Calcutta in 1873. Its prepa under cas suggested by the senior Board of Examiners in Arts for the Calcutta University, who felt that elementary text books treating of natural sciences, for use in India, should deal more especially with objects familiar and interesting to the Indian learner. 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 appeared of these interesting subjests. Mr. Blanford, who was formerly on the geological survey, and has been for some years meteorological reporter to the Government of Bengal, is specially qualified to undertake this task, and the results of his labours are so excellent that it is much to be desired that they should be republished in England.

X.

The Geographical Department of the India Office.

The most important work of the Geographical Department, during the year 1873–74, has been the preparation of the general catalogue of manuscript and printed reports, field books, memoirs, maps and charts of the Indian surveys, for the press. This 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. A list of these, with the contents of each volume, commences the catalogue; together with the manuscript angle books. Then follow the printed reports, including Sir George Everest's accounts of the measurement of an arc of the meridian; Sir Andrew Waugh's exhaustive report on the extent and nature of the surveys, prepared for Parliament in 1851; the annual reports; and Colonel Walker's account of the operations of the Great Trigonometrical Survey, vol. I. The list of charts and plans of the triangles of the survey next occupies 27 pages. There is then a list of the printed reports

of the revenue surveys, and of all the publications of the Geological Survey.

The catalogue of general maps of India commences with the Indian Atlas, and contains all the early memoirs and maps of the Madras Military Institute; early general maps of India, or parts of India, by Rennell, A. Arrowsmith, Colonel Hodgson, Monier Williams, Reynolds; and the later maps of Allen, Thuillier, Walker, and Stanford.

The series of old Portuguese plans of Indian towns, and of old Dutch charts and maps of India, which have been added to the collection in the Geographical Department, are specially interesting.

The collection also contains a valuable series of maps of the Ganges and other rivers in India, most of them in manuscript. Tassin's maps of the Ganges Delta appeared at Calcutta in 1835 and 1840. There are 32 manuscript maps of the Ganges, by Colonel Rennell; Colebrooke's manuscript survey; Wood's beautiful manuscript maps of the Ganges, from Hurdwar to Allahabad; Hogdson's Ganges; maps of the Brahmaputr by Bedford and Wilcox; manuscript surveys of the Indus, by nes, Wood, and Grieve; and surveys of the Burmese rivers.

After the catalogue of general maps foll bse of the different divisions of India, commencing with tl engal Presidency. These commence with the Bengal Atlas of Colonel Rennell, and numerous old route maps, memo d field books. There are also six manuscript maps of Bengal d ts by Dr. Buchanan Hamilton. The rest are arranged according to districts; and the list of maps of districts and rivers of Bengal, the North-West Provinces, Oudh, and the Punjab, fills 70 pages. Another 30 pages contain the maps of countries in the Rajputana and Central India Agencies, and of the Nizam's territory. Mysore and Curg are represented by the old maps and memoirs of Colonel Colin Mackenzie, and by the surveys of Connor, as well as by more modern maps. The maps of British Burmah fill seven pages. The earlier maps of the Madras Presidency, and those of Colonel Priestley's survey, including the village maps, occupy 90 pages, and the Bombay list fills 27 pages.

Then follows the list of maps of the Portuguese and French territories in India, of Central Asia, including Turkistan, and of Afghanistan. The latter include the reports and papers of Sir Alexander Burnes' mission, with the manuscri ACE; d sketches by Lieutenant Wood during his expedi NG CROSS; ree of the Oxus; the route surveys of the army CORNHILL; derson and