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PROGRESS OF THE INDIAN SURVEYS, 1875 TO 1890.¹

All who are interested in operations ranging on the scientific side of Indian administration, and the number of such in England and elsewhere must be increasing yearly, will doubtless greatly appreciate another issue of the series of Memoirs begun by Mr. Clements Markham, which enables much information to be obtained from a comprehensive compilation, and saves the need of tedious reference to many volumes of annual reports. Mr. Black also deserves well of the officers engaged on surveys and other kindred operations in India (from which much labour, both mental and physical, is inseparable) for having compiled this convenient record, which ought to do much towards bringing to these undertakings the well-merited recognition of their scientific value. It is to be regretted, however, that the compilation should have been so long deferred as to embrace a period of fifteen years, during which many operations have been initiated and have passed into history. Also, it may be said that a memoir of this kind, which can be made useful in awakening an interest in current undertakings, will fail in this part of its object unless a succeeding volume is presented so as to give early information how these undertakings have prospered. Perhaps, therefore, Mr. Black may find it practicable to repeat the Memoir at a shorter interval, while the recollection of what is found in the present volume remains fresh.

The present volume has a suitable frontispiece in a photo-lithographic reduced copy of Colonel Tanner's beautiful picture of part of the snowy range on the north-west frontier of Kashmir, bringing pleasing recollections to all who were favoured to see the collections of this talented officer's drawings which appeared in the Calcutta Exhibition of 1883, and in the Colonial and Indian Exhibition (in London) of 1886. The copy has been executed by a private firm in London, and is quite to be commended as an artistic picture with fairly good effects obtained from tinted printing; but a more appropriate frontispiece might have been found in a picture executed in the Calcutta Survey Office by the process of photo-etching, which, as is shown at page 227 of the Memoir, has been brought to great perfection by Colonel Waterhouse, and of which some specimens have already appeared in Colonel Thuillier's *Annual Reports of the Survey Department*. Similarly, an example of the cartography, drawing, and printing done in the Calcutta office might have been given in the Map of India, in place of the map printed in England which illustrates the Memoir. A map published in Calcutta, besides serving as a specimen of Indian work, would also have been acceptable as a more reliable record of existing facts, with regard to which the English map, in the one observed particular of the want of colour over Baluchistan to indicate its political position as dependent on the Indian Empire, seems to be faulty.

The contents of the Memoir are ranged in sixteen Chapters, by group-

¹ *A Memoir on the Indian Surveys, 1875-1890.* By Charles E. D. Black. London: Edward Stanford, 1891. Price 7s. 6d.

ing which a better general comprehension may be formed of the several Departments whose operations are treated of, thus :—

Chapters I. and II. The Indian Marine Surveys.

„ III. to XI. The Survey of India, in its various branches and operations, both field and office.

„ XII. The Geological Survey of India.

„ XIII. Indian Meteorology.

„ XIV. Statistical Survey of India.

„ XV. Archæological Surveys.

„ XVI. Geographical Work of the India Office.

From this list the absence of the Revenue Surveys of Madras and Bombay is to be noted, and Mr. Black may find it practicable to add to any future Memoir he may publish a record of what has been done in these undertakings, which, although they have been carried on mainly for the purposes of Revenue assessments and for the demarcation of boundaries, have executed work of a very important character, and have likewise furnished some useful topography. A complete history of these Surveys would be desirable, as it is understood that the operations of both will shortly be brought to a conclusion. There is an absence also of any mention about the Forest Surveys, carried on in connection with the Forest Department, which are known to have furnished maps of general utility and of a high-class character.

The remarks on the subjects of the Memoir will be made as brief as possible, merely indicating some of the prominent features in each of the operations.

The Indian Marine Surveys, since their re-institution in 1875, have been prosecuted at various parts of the coast, where charts are now required in greater detail than was necessary when the coasts of India and Burma were first surveyed. A list is given of the ports and other parts of the coast-line still awaiting revision, and it is shown that the work will occupy the existing establishments for forty years, but it is mentioned that an increase in the establishments is in contemplation, which in the interests of the increasing coast navigation is certainly to be desired.

In the first of the chapters on the Survey of India there is a concise historical account of the Great Trigonometrical Survey from its initiation in 1800, describing its scope and general plan, and showing how the operations have been made not only to serve for the practical purpose of furnishing a skeleton basis on which all the maps of the country are constructed, but also to include the investigations of geodesy, and of the variations of the force of gravity. This is well worthy the attention of all who wish to have a good general idea of this vast undertaking. The design of the Trigonometrical operations for India proper is shown to have been completed, but it has been extended by the annexation of Upper Burma and by the assumption of a British Protectorate over Baluchistan.

The Topographical Surveys, which are mainly confined to Native States, and executed on different scales, as may be determined by military requirements, are shown to have been carried on in many internal parts of the country, but they are also being vigorously extended over frontier

territories. The record points to much hard work of a very difficult and harassing character.

The Memoir indicates a great change which has been introduced into the character of the Revenue Surveys done by the Survey of India in the North-West Provinces and in Bengal, where, under the name of "Cadastral Surveys," and on a largely increased scale for the maps, the operations include the mapping of the holdings and the preparation of a record of the occupancy rights of the cultivators. To the Survey establishments has thus been assigned a large part of the duties hitherto performed under Civil Judicial officers, and the change is shown to have resulted in a very considerable reduction in the cost of the combined operations of Survey and Settlement. In Burma the Survey of India also carries on Cadastral Surveys, but the same civil duties have not yet been performed there as in the other provinces, on account of the imperfect acquaintance of the Indian Surveyors with the Burmese language.

The chapter on "Geographical Surveys and Explorations" is full of interesting particulars concerning the enterprise of the Surveyors during the wars in Afghanistan of 1878 and 1880, when under great difficulties a large amount of excellent sketching was executed, resulting, with other materials soon after obtained, in a fairly complete map of the country. In this chapter, also, will be found accounts of the journeys made in frontier territories beyond Kashmir and in Tibet by the now famous trained native explorers, who are sent out in various disguises on routes roughly indicated to them beforehand, and through whose daring and perseverance much geographical information is now possessed of hitherto little-known regions. The chapter likewise shows how a beginning was made of obtaining some topographical knowledge during military expeditions in the outlying tracts of the new territory in Burma when still in an unsettled state, preliminary to the future final survey, which may have to be deferred for years while more pressing surveys are carried on in the central tracts.

The chapter on the "Afghan Boundary Commission," during which the Indian Survey officers had the opportunity of exhibiting more than ordinary enterprise, and when, as Mr. Black remarks, "an enormous addition to our knowledge of Northern and Western Afghanistan was made by the labours and researches of the Boundary Commission which was engaged in conjunction with the Russian Commission in laying down the boundary of the country, in 1884-86," is especially valuable, no complete official account having been written and the compilation being taken by Mr. Black from various published sources. The compilation includes many interesting descriptions of various parts of the country visited by the Surveyors; but, unfortunately, Mr. Black's map of the Indian Empire has not been made sufficiently comprehensive to allow of the country covered by the Commission being fully traced.

The "Tidal and Levelling Observations" described in Chapter VIII. are two distinct operations, executed each for a separate practical purpose, though combined they serve for certain scientific investigations. They have been carried on conjointly by one establishment under one head, and the combination of the separate results shows that the officers of the

Survey of India are on the alert and ready to employ for the advancement of science all suitable facts coming under their knowledge. In the present case, the combination of results has led, among other investigations, to the discussion of the reasons for the difference between the mean level of the sea at Bombay and at Madras as ascertained by the two operations. Tidal gauges have been set up at most of the ports on the Indian Coast, and the tide tables which are published after a complete set of observations has been taken, lasting over five years, are said to have given very general satisfaction. The explanation of the calculations for the prediction of the tides are full of interest; also, the description of a tide-predicting machine—the invention of Mr. Edward Roberts of the Nautical Almanac Office—which is said to execute calculations in about two hours which would by ordinary means occupy from four to five months. In connection with the Levelling operations one line of levels is mentioned, starting from Karachi, running by the Indus Valley, then through the Punjab, North-West Provinces, and Bengal, to False Point on the Bay of Bengal, in length 2300 miles, probably the longest line of levels ever run, which closed with an error under 9 inches per 1000 miles.

Chapter IX., on "Geodetic Observations," minutely describes a purely scientific operation of the Survey of India for the determination of differences of longitude by a combination of astronomical observations with signals through the electric telegraph, to be used mainly for investigations of the figure of the earth. This system is also shown to have been used as the means of determining the true longitude of the Madras Observatory with reference to Greenwich. The Madras Observatory is a highly important point in the mapping of India, and its longitude, hitherto based entirely on astronomical observations, has been found by the recent telegraphic determination to have a probable error of 2 seconds of time, or 30.57 seconds of arc.

Chapter X. furnishes particulars regarding the "Supply of Scientific Instruments" from the India Store Department in London, where the instruments, on being received from the manufacturers, are tested and examined, prior to despatch to a dépôt in Calcutta kept up in connection with the Survey of India, whence they are distributed to many Government departments.

Chapter XI., with the title "Headquarters of the Survey Department," gives much interesting information about the drawing of maps and concerning their publication by the several processes of copper-plate engraving, heliogravure, photo-etching, photo-zincography, and lithography—all practised in the Survey of India Offices in Calcutta, as found to be most suitable to the subjects or requirements in the prints. This is a most instructive chapter, showing the great variety and extent of map-printing which is done in Calcutta. In this chapter, also, space is found to describe the work at the branch office at Dehra Dun, where the final mathematical computations of the Great Trigonometrical Survey are completed, as well as some map-drawing and map-printing, and where there is a small observatory for solar photography.

Much may be learnt of the geology of India and of many of the mineral deposits of the country from Chapter XII. of the Memoir, which

treats in considerable detail of the large amount of work done during the period under review by the Geological Survey of India, both of final systematic examination and geological mapping and of specially called-for reporting in mineral fields. Rapid inspections in the newly-acquired territories of Burma and Baluchistan, and in Afghanistan, during the temporary occupation of that country, are also shown to have been carried on and much useful information obtained. The final examination of the country is proceeding systematically, and about half of India proper is estimated to be finished; but Baluchistan is almost untouched; also, there remain certain parts of the Himalayas east of Garhwal, and of Burma, including enormous tracts of wild country forming the outer eastern borders of the Province and those lying between it, Assam, and Bengal. A manual of geology for India is mentioned as having been published in 1878, supplying the much-felt want of a general view of the accumulated knowledge which, till then, could only be found in detached papers and reports.

The very great progress which has been made in India since 1875 in the science of meteorology is well exhibited in Chapter XIII., which treats of Indian meteorology, and which gives ample proof of the high talents of the officers of the Meteorological Department and of the liberal encouragement the Department receives from the Government. The descriptions of the continuous improvements which have been introduced in the systematic recording of meteorological facts at stations selected by experience, and of the manner in which the facts are now rapidly investigated at central offices, so as to give immediate intimation of impending and alarming changes in the weather, fully indicate the present high efficiency of the Department, and how it labours to meet the requirements of the public. Of its publications, which have been received with much favour, may be mentioned the daily weather reports and charts for the Bay of Bengal issued at Calcutta, similar reports and charts for the Arabian Sea issued at Bombay, and others for India generally issued at Simla. The Memoir also shows that many of the officers have written papers of high scientific value.

The "Statistical Survey of India," forming the subject of Chapter XIV., has embodied inquiries into the topographical, ethical, agricultural, industrial, administrative, and medical aspects of each unit of Indian administration—the district—of which there are 240 throughout the country. Local officers furnished to provincial editors the required statistics, which, in the first instance, were published in bulky volumes by provinces, and then afterwards were reduced under the Director-General of Statistics to a practicable size for general reference, and finally published as the "Imperial Gazetteer," in nine volumes. There is a short discussion on the transliteration of Indian names into the English character, for which a uniform system was introduced, to be used in the published volumes of this survey and to be adopted for all maps and other publications of the Government.

During the period embraced by the Memoir, much activity has been displayed in archæological research throughout India, and Chapter XV., on "Indian Archæological Surveys," furnishes very comprehensive details

of what has been effected under the fostering care of the Government, besides giving many interesting particulars of historical retrospect of what had previously been done to a large extent through the personal efforts of distinguished Indian archæologists. The vastness of the field in India for archæological research is amply testified by the present volume, and although many of the better-known antiquarian objects have been examined and described on previous occasions, most of them have been again visited during the period under review, and new facts ascertained regarding them. Many other objects are now described for the first time—some have only recently been discovered—and in the Memoir, or in the larger illustrated publications to which reference is made, much will be found to attract to the study of India of ancient times—by no means the least of the many attractions of our great dependency. The rock-cut temples are of world-wide fame, and singly they have long been the subjects of description and popular illustration. Now they have been included in a special series of artistically-illustrated reports, in which the caves, singly or in groups, have been assigned to their respective constructors, whether Buddhists, Brahmans, or Jains, and the complete list shows that there are over a thousand examples of these caves throughout all India, though most of them are in Western India. Another recent undertaking of the Archæological Survey is the collation of copies of all ancient inscriptions, which include those on rocks, on pillars, on walls of temples or plates of copper, and which may either be regal edicts or title-deeds of grants made by kings and chiefs to temples or religious communities. The copies (with translations) form a series of special reports issued by the Survey. Lastly, in Burma a systematic search is being made for ancient manuscripts, which already has been so far successful as to have led to a collection in the Free Library at Rangoon of a large number of splendid manuscripts in various characters peculiar to the Province or to the countries on its borders. Along with the collection of manuscripts, archæological research has been carried on, and some reports have been issued with lists of antiquarian objects in Lower Burma; but much yet remains to be done in this Province. Besides the examination of the antiquarian remains of India, the important step has lately been taken of adopting systematic measures for their preservation, to which the Secretary of State was urged in a memorial signed by many of the most eminent statesmen and men of letters of the day, and in connection with which lists drawn up for each district have been obtained, specifying (1) those monuments which, from their present condition, ought to be maintained in permanent good repair; (2) those which it is now only possible to preserve from further decay; and (3) those which, from their advanced stage of decay, it is impossible to preserve. Much good work has been done on a moderate expenditure, and due provision has been made for keeping up the monuments of classes (1) and (2).

Chapter XVI., on "Geographical Work at the India Office," explains how the geographical records are cared for in London, and mentions the good work done by able officers who successively have had charge of them. Notably, the services of Mr. Clements Markham are spoken of, to

whom is due the inception of the first of the series of Memoirs of which the present issue has well sustained the high character of its predecessors, and with regard to which a hope may be again expressed that Mr. Black will renew the issue after a shorter period than fifteen years.

JAMES SCONCE, *Colonel*.

GEOGRAPHICAL NOTES.

By W. A. TAYLOR, M.A.,

Assistant Librarian, R.S.G.S.

EUROPE.

Meteorology of Scotland for 1890.—The tables for the year 1890 are published in the *Journal of the Scottish Meteor. Soc.*, Third Series, No. viii. The mean pressure of the air was only '17 inches higher than the average of the preceding thirty-four years, while the mean shade temperature was 46°, or '4 above the average. The rainfall alone showed a marked deviation, being 3'4 inches in excess, but, as the returns from the eight chief towns still show a slight falling off, this excess is probably due to the establishment of wet country stations.

Observations of Dust-particles at Ben Nevis Observatory.—In February 1890 a grant was made by the Royal Society for the purpose of supplying the Ben Nevis Observatory with apparatus for counting the number of dust-particles in the air. Two instruments, one portable and another of larger dimensions, were made after designs by Mr. Aitken. With the latter observations may be made at any time, except when the wind, blowing from the south-west, pollutes the air above the inlet pipes with smoke from the observatory and hotel. Since February 1891 observations have been made every third hour. Some of the results are given, and their bearing discussed, by Mr. Angus Rankin in the *Journal of the Scottish Meteor. Soc.*, Third Series, No. viii. It may be stated that a number of particles under 100 in a cubic centimetre of air is phenomenally small, and a number over 4000 phenomenally large. The highest number was 14,400, which was counted in April 1891. The particles are most numerous during March, April, and May, when easterly and south-easterly winds are prevalent both at sea-level and on the summit of the mountain. On the other hand, when the winds on Ben Nevis blow from the north-west, north, or east, their directions diverge most from those of sea-level winds, and then the dust-particles are most scarce. Hourly observations were made only on four days, but the three-hourly means show the general trend of the daily curve. The means for the three months, March to May, show a minimum, 526, at 4 hours, and a maximum, 1438, at 16 hours, the absolute mean for the three months being 854. The variations seem to be due to the movements of the first or lowest, cloud stratum. In the morning this stratum lies below the summit of Ben Nevis, but towards noon rises and envelopes the top, hovers above it in the afternoon, and sinks to its original position about midnight. Several points remain to be cleared up. Apparently only the free dust-particles are counted, and few, if any, of those on which moisture has condensed to form visible fog: all the lowest values have been recorded when a thin mist enveloped the top. These observations will be of great service in the study of clouds—their forms, heights, and motions. The bearing of dust on the humidity of the air is also an important point; at present the humidity of the Ben Nevis atmosphere is very little understood.