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GEOLOGICAL SCIENCES IN INDIA IN THE 18TH-19TH CENTURY

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The development of geological sciences in India in the 18th-19th Century can be studied in three stages: 1701-1800, 1801-1851 and 1851-1900. In strict modern sense, geology became important in the third period only. The accounts in the works that appeared between 1700 and 1842 confirm that there was mining of diamonds and coal, and of iron and its smelting in different parts of India.

The East India Company was interested in exploitation of coal in India and got D. H. Williams appointed as Geological Surveyor in 1846. The appointment of Thomas Oldham, after William's death, was a major landmark and his contribution to geological work is beyond comparison. During his tenure, strong foundations were laid for the development of geological sciences in India, on which a large edifice has been built in the present century.

H. B. Medlicott came to India to serve the Thomson College at Roorkee and later joined the GSI. He truly laid the foundations of our knowledge of the Himalayas and coined the word 'Gondwana' for the coal bearing formations of age older than Cretaceous. T. H. Holland was responsible for organising the separate faculty of Geology in the Presidency College, Calcutta where he acted as part-time Professor. P. N. Bose, the first Indian trained in Geology in England, and P. N. Dutta discovered important iron and manganese ore deposits in Bihar and Central Provinces. A separate faculty of Geology came into existence in the Presidency College, Madras in 1910 while in the Bombay University, Geology was offered as one of the optional subjects in B.Sc. since 1879.

Among the Geologists of the GSI, there were Naturalists who made important collections of birds and extinct mammals and wrote books, like Ball's "Jungle Life of India". The Journal of the Asiatic Society of Bengal, the Madras Literary and Science Journal, the Quarterly Journal of Geological Society of London, and Gleanings in Science used to publish most of the geological papers. During Thomas Oldham's time, the publications of the *Memoirs*, *Records* and *Palaeontologica Indica* were started. The first geological map of India was also initiated then.

The earthquake theory, the theory of isostasy, and the discovery of Stone Age implements were great contributions from the geologists of the GSI.

INTRODUCTION

The development of geological sciences in India in the 18th-19th Century can be studied in three stages, viz. 1701-1800, 1801-1851 and 1851-1900. In the first stage the Mughal rule was declining, the English were trying to find a place in India through

their trading company, the East India Company and battles were continuing between the French and the English. There are hardly any references, barring Michael Edward's,[1] to development of sciences in this period. Most of them deal with the social, economic and political aspects of the country. In the second stage, the British found themselves well entrenched in the country. We have, however, accounts of mining, smelting and other operations described in some of the travellers' reports like those of Heyne, James Franklin, Campbell and Buchanan. The third, really marks the beginning of geological education in the country consequent upon the establishment of three Universities at Calcutta, Bombay and Madras, a little before which the Geological Survey of India was founded. In a way, modern geology was put on strong foundations in India during this period which later showed slow and steady development.[2]

1. The First Stage : 1701-1800

Śivatattvaratnākara of Keladi Basavarāja of Keladi, written in 1709 A.D. is an encyclopaedic work. It contains nine chapters called *Kallolas*, each *kallola* being divided into 108 *taraṅgas* or sections. The third chapter has a section that deals with meteorology while another two sections deal with astronomy. Under meteorology, the subjects covered are: formation of clouds, clouds of various colours and their rain-giving capacity, the effects of the various constellations coming on different days of rainfall, the effects of lightning, and winds, their direction and results. Under astronomy, the subjects covered are the solar system, the region of stars, and the nature of eclipses. Chapter IV contains in its first section the geography of India. The seventeenth section deals with precious stones as under:

1. Diamonds, where found, their qualities and defects, classes of diamonds and how to compare their brilliance.
2. Similarly information with regard to pearls, rubies, blue stone, emerald, quartz, topaz, onyx, amethyst and coral.
3. Methods of distinguishing real from false stones.

Two different editions of this work[3,4] have been mentioned recently[5]. It is quite obvious from these that knowledge of minerals, mining and testing them was possessed by specialists in the eighteenth century. Motte[6] undertook a journey on the direction of the late Lord Clive in 1766 to the Diamond mines at Sumbhulpoor. He describes, 'the mountains abound with gold and diamonds but the natives are debarred from working in the mines by their indolence and fear of Maharattas'. He also refers to rocks during the journey from Mirzapur to Nagpur.

Features of geological significance were noticed and reported by others too. Colebrook[7] recorded changes in the course of the Ganges, 'more than once the Ganges is known to have washed the foot of the Rajmahal Hills; in 1779, the rocks at Colgery were surrounded by land; in 1788, they were isolated and the current ran between them with great velocity'. In the essay on the Sacred Isles of the West, Capt. Wilford[8]

discusses that India was once an island separated by sea from the Himalayas. It was about this time that Benjamin Heyne makes a reference to the copper mines in his Tracts on India[9]. In 1801, copper was discovered in the Nellore district. J. B. Travers, District Collector submitted a proposal to the Board on 7.1.1803 for working in the copper ore.

But before making a detailed reference to Heyne's work, an important contribution by Francis Buchanan must be mentioned here. In his 'Journey from Madras through the countries of Mysore, Canara and Malabar', in three volumes, which was at the behest of Wellesley, Buchanan gives a very detailed description of the rocks, using geological words like granite, granite porphyry, schist, gneiss, quartzite and so on. For instance, while describing the granite used in the construction of a temple dedicated to Hanumanta, near Chinapatam (or China patana), he says that it is a handsome variety, consisting of bright red felspar, a small quantity of glassy quartz, and a minute proportion of black mica and it is a most elegant stone.[10] He described the calcareous nodules as follows[11]: *fracture* splintery and it is *opaque*; the *scratch* is of a colour similar to that of the stone, which is *hardish*; its *lustre* is common. Buchanan describes the occurrence of iron ore at Vencataghery (Venkatagiri)[12], Magadi[13], Ghettipura[14], Madhigiri, Chin-narayan-durga, Hagalawadi and Devaraya durga[15], Chica-Deva-Bella[16], Topum Betta,[17] Colangolu[18], Velater[19] and Pocum hill[20]. A complete account of the manufacture of glass is given: "glassware is one of the manufactures of this place. It is made by two operations. In the first, from the raw material are formed masses of glass; in the second, these masses are wrought up into small bottles, and ornamental rings for the arms of women."

"For making green glass, take the following articles according to apothecary's weight[21]:

	lb.	oz.	dr.	scr.	gr.
Broken glass	14	9	0	0	0
Banajī callu, powdered white quartz	14	9	0	0	0
Lohā (an old button like brass was given to me as a specimen)	0	3	2	1	13
Copper	0	2	9	1	6
Cariculla, iron ore with manganese	0	2	1	2	2
Soulu, or impure soda	29	6	0	0	0
lb	58	11	5	2	11

This is the charge for one crucible." In making red glass, the *lohā* is left out. Forty-four crucibles stand in one furnace. Buchanan also described how rings are made.[22] The occurrence of talc at Gaynangur is mentioned and he says, 'the inhabitants

are wonderfully ignorant of the mineral productions of their country for they did not know the limestone nodules, so common in this place, when shown to them in their own fields. All their lime comes from the city.' About making of steel near Magadi, he says, "good clay is mixed with an equal quantity of charcoal that is made of paddy husks; and having been well moistened with water, is thoroughly mixed, by being trodden under the feet of oxen; it is then picked clean and made into cuppels, which are dried one day in the shade and next day in the sun."

Buchanan also mentions[23] about the collection of gold dust in the river which passes Neelambur in the Mangery taluk of Iruada district.

Next to Heyne's, account this is the most detailed reference to the geological occurrence of minerals, rocks, and smelting of iron. Benjamin Heyne's "Tracts, Historical and Statistical, on India" was published in 1814 and, thus, later to his 'Iron Works at Ramanakkapettah' which was originally sent by him in 1795 to the Governor of Madras, titled as "Doctor Heyne's Report of the Iron Works at Ramanakkapettah". An edited version of this was also published by Dr. Heyne in 1814 as No. 13 in "Tracts, Historical and Statistical, on India". Dharampal includes the version taken from Vol. 1 (No. 613) of the Board's Collections in the India Office (IOR: F/4/1)[24]. Some of the other Tracts relevant here are:

Tract XII, p. 92	Account of the Diamonds in India.
Tract XII, p. 212	Account of the method of smelting iron in the Northern Circars.
Tract XIII, p. 224	Account of the Iron works at Ramanakkapettah.
Tract XV, p. 230	Cursory observations made during a tour from Bezwada to Timmericota.
Tract XVII, p. 247	Observations made on a tour from Samulcotah to Hyderabad.
Tract XVIII, p. 280	A brief account of the Circars on the Coast of Orissa.

Dr. Helenus Scott, in his correspondence to Sir Joseph Banks, President of the Royal Society, London (*circa* 1790-1801),[25] describes how copper plates were joined by the same metal and comments that "at so distant a period of 700 years copper was not a scarce article among the Indians as in this instance, they used it plentifully, and that it was not a new one for it is here a pure metal and worked with skill". This period he mentions must be the 13th century. Interestingly, Marco Polo also describes[26] how diamonds were used to be mined during the reign of Rudramamba (Kakatiya Dynasty) (died in 1296) from Warangal. Scott, in his letter of January 19, 1792, says he would study deeply, the method of using lime in buildings, the methods of making soap, gun powder, indigo, ink, cinnabar, vitriol and iron and copper, alum & c&c. With his letter of January 8, 1794, he enclosed a specimen of a kind of steel, "which is called wootz and is in high esteem among the Indians". His letter of August 15, 1801 reads: "The natives of Malabar have made iron from time immemorial. I send

you in a box about one or two cwt of their iron after one fusion. I also send you a specimen of their ore. I cannot pretend to say to what extent we might procure iron in Malabar for it has hitherto been made there only for their own purposes... I send you a sketch of a Malabar smelting furnace taken on the spot by my friend Major Walker now one of the commissioners for that province, which will give you an idea of their method. It combines together the air and blast furnace and is found to be very sufficient for their purposes....." But he also makes a peculiar statement: 'Copper as far as I know is not manufactured in India...' This obviously cannot be correct. Heyne refers to copper mines, as mentioned earlier, and copper workings in his Tracts.

Capt. C. Mackenzie[27] made a visit to the Pagodas of Parawuttum (Sreesailam) in 1794 and spoke of iron and diamonds as being found in the same mountain range.

The first attempts to exploit the mineral resources of India, commercially on modern lines, was made by two civil servants of the East India Company. They were John Sumner and Suetonius Heatly[28]. On 11.8.1774, they sent an application with 'proposals for working coal mines and selling coal in Bengal' to the Council of Revenue at Calcutta. They claimed to have discovered six coal mines in Panchet and Birbhum. This was approved. Jones[29] in his "Description of the North-west Coal District stretching along the River Damodar, from the neighbourhood of Jeria or Juriagarh, to below Sanampur, in the Pergunnah of Shergarh, forming a line of about sixty-five miles" says about the coal mines and availability of iron ores in the Damodar Valley. On 1st December 1815, he sank the first shaft for coal in this area up to a depth of nine feet. Jone's venture proved a failure, M/s. Alexander & Co., as guarantor of the money (loan of Rs. 40,000 from Government) stepped in to work his lease. By 1835, they also failed and passed the leases to M/s. Carr, Tagore & Co.; the principal partner of which was Prince Dwarakanath Tagore.

2. The Second Stage: 1801-1850

Thus there appears to have been continuous activity in geological field in India at the end of the eighteenth century. After Heyne's publication, the next one that deserves to be mentioned is the paper of Copeland[30] on the cornelian mines in the neighbourhood of Broach which was published in the Transactions of the Literary Society of Bombay. Babington[31] gives the hypothesis of submergence of the plains of Carnatic.

Before D. H. Williams, who was appointed the Geological Surveyor in the Service of the East India Company and joined in 1846, there were many enthusiastic workers who devoted their leisure time to research in the geological field in India. Some of them were by profession not geologists. Of those who were officially employed on geological work, four did really pioneering work: Laidlaw, Dr. H. W. Voysey, Capt. F. Dangerfield and Capt. J. D. Herbert. Laidlaw was attached to the

Surveyor-General's Department, and Voysey to the Great Trigonometrical Survey while Dangerfield and Herbert reported direct to the Government of India. It would be interesting to note that Voysey was a suregeon in the employ of the East India Company, whilst Dangerfield and Herbert were officers respectively of the Bombay Native Infantry and the Surveyor-General's staff. Their official titles were (while on geological or mineralogical work): 'Mineralogist to the Survey of Kemaon' (Laidlaw), surgeon and Mineralogist (or Geologist) to the Superintendent, Great Trigonometrical Survey (Voysey), 'Geological Surveyor to the Himalaya Mountains' (Dangerfield), and 'Geological Surveyor to the Himalaya Mountains' (Herbert)[32]. There was also Dr. A. Fleming, another surgeon, who was 'in charge of the Geological Survey of the Salt Range in the Punjab' from 1850-1852. Adam Hotchkis, an Assistant Surgeon on the Bengal Establishment was also appointed, in 1779, Mineralogical Surveyor under the Government of Bengal and, thus, must have been the first official geologist under the Government in the eighteenth century ! In passing it may be mentioned that there were a few drawn from the Army who were non-official geologists. Among them, Capt. T. J. Newbold of the Madras Army, who was an Assistant Commissioner in Kurnool, and later Assistant Resident at the Nizam's Court, Hyderabad, worked on the geology of the Peninsula. His paper on 'A glance at the Banagapilly Jaghire, written while passing through that territory in March 1836', was published in the Madras Journal of Literature & Science[33]. Dr. Alexander Turbill Christie, Dr. Malcolmson, General Cullen, Dr. Carter, Philip W. Wall and so on were the non-professional geologists whose contribution was quite significant.

Dr. Henry Wesley Voysey was also known as the Father of Indian Geology who was appointed surgeon to the Great Trigonometrical Survey, under the Superintendence of Lieut. Col. Lambton; during a very short period of 5 years he made the first contributions to an understanding of the Geology of India that could justify the title of Father of Indian Geology. The seven papers he contributed, appeared in *Asiatick Researches* and the successor thereto, the Journal of the Asiatick Society of Bengal, between the years 1824 and 1844, all posthumous because he died of fever on the 19th April 1824 whilst on his way from Nagpur to Calcutta. He arrived at Howrah dead in his Palki. Among his most notable works are: tracing the Gondwana sandstone from the Pranhita-Godavari valley into the Ellore country, description of the garnet mines in the neighbourhood of Garibpet and the association of kyanite with these garnets, and the occurrence of clay slate between Paluncha and Baiaram. He also gives a short description of two springs near Bhadrachalam and Dummagudem. These places were later visited by Blanford. On his last journey from Nagpur to Calcutta in 1824, he visited the diamond workings of Sambalpur[34] and also wrote a paper on the Diamond Mines of South India[35]. The final entry, before his death, refers to the Geology of Manthur. The last words of the Journal are: "Rocks of Coliapal (Kuliapal), the same mica schists with quartz veins ore specimen of quartz reminded me of axinite". After writing this he caught fever to which he succumbed[36]. One of the passages of his letter to Lambton has a modern sound[37]:

"In addition to the great advantage to Science and to the Arts from a knowledge of the Geological structure of the country obtained from Section maps and collections of Specimens, I conceive that a very important object of a Geological enquiry lies in determining the cause of these anomalies which sometimes occur in Trigonometrical operations and which can only be explained by supposing them to arise from concealing disturbing forces owing to difference in the specific gravity of the upper, lower or contiguous strata." A clear pointer to isostasy, which was later forming the basis of Pratt's hypothesis[38]. In 1865, Basevi and others undertook an extensive Pendulum operations to determine the figure of the earth, which led to the discovery of gravity anomalies.[39] The second passage is as follows: "The conclusion that the basis of the peninsula of India from Cape Comorin to the parallel of Nagpur is of granite, the constituent parts of which are nearly similar, and that the superincumbent rock where any exists rarely exceeds 1,000 or 1,500 feet in height". Voysey travelled over a very wide stretch of the country and arrived at this conclusion.

Capt. Dangerfield of the Bombay Native Infantry would be remembered as the earliest observer of the Western part of the Nerbudda valley and he prepared the first geological map of a part of India and published it, though Voysey's map of a part of Hyderabad and adjoining country was prepared one year earlier.

Capt. J. D. Herbert, also of the same Infantry, succeeded Capt. Dangerfield in 1825 as 'Geological Surveyor of the Himalaya Mountain', but he was already working on the Gurhwall Survey. He wrote several papers on his geological survey of the Himalayas that appeared between 1825 and 1835 in Asiatick Researches and Gleanings in Science. The Mineralogical Survey of the Himalaya Mountains lying between the rivers Sutlej and Kalee, illustrated by a Geological Map, was undertaken by him by order of the Governor-General, Lord Hastings. Though the work was over in 1825, it was published posthumously in 1842, nine years after his death. His report is considered to be of permanent interest for students of geology in India, as the best local illustration of the state of geology at that time.[40] It was the first attempt of the geological work in India officially.

Originally titled as, 'Observations on Several Iron Mines, in the Central Part of India, with an account of the Indian Mode of Manufacturing Iron and Plans of the Machinery and Implements', Major James Franklin's (of the Bengal Army) report[41], submitted (1829) to the Court of Directors of the East India Company, deals with iron mines situated in the districts of Jabalpur, Baragaon, Panna, Katola, and Sagur, the mode of occurrence of the iron ore in these areas, and the methods of smelting the ore and the furnaces used for the purpose. He says of the Panna district, 'the district of Panna produces diamonds, and the tract in which they are found, borders on the iron mines of Katola; the Ken river being the boundary between them; and though this circumstance is foreign to my present object, it is at least curious, as it may perhaps serve to show, the connection, between the gem and ferruginous matter'. It would be interesting to compare his description of these procedures

with those described by Francis Buchanan and Benjamin Heyne. Similarly, Captain J. Campbell, Assistant Surveyor-General, Madras Establishment, in his paper written around 1842, compares the various modes of manufacturing iron (bar) in various countries like France, Sweden, Germany and England, with those of India and at one point says, 'from what I have seen of Indian iron, I consider the worst I have ever seen to be as good as the best English iron, and that its supposed defects arise from its almost always containing a considerable portion of steel'.[42]

Thus from 1817 onwards more particularly, and even before that in 1807 when Buchanan was given an errand by Wellesley, several appointments were made in India for geological and mineralogical investigations; several civil, medical and military officers in the East India Company's employ were engaged in similar work in their spare time, sometimes for the purpose of promoting the economic development of the tracts for which they were responsible, but at other times apparently from the pure love of research[43]. When so much was being done without any cost to the East India Company, it still made a special appointment of Geological Surveyor, an appointment that led ultimately to the formation of the Geological Survey of India. Before going into these developments, it must be mentioned that some brilliant discoveries were made: Dr. Lush discovered the ossiferous beds of Perim island in the Gulf of Cambay; Dr. Falconer read a paper before the British Association on some of these fossils collected by Lt. Full James; H. Falconer and P. T. Cautley discovered and conducted researches on Siwalik fossils and fauna for which they were jointly awarded in 1837 the Wollaston Medal by the Geological Society of London[44]. The Rev. S. Hislop conducted the first definitely geological and palaeontological work of real value in the field and got a collection of fish and reptilian mammals from the neighbourhood of Maleri in the Jangaon-Sironcha part of the field (1856)[45].

The study of India's coal supplies for steamers for inland navigation received consideration in 1835 and a Committee that went into this question presented a report or a set of reports enumerating 'all the sites of coal at present known to exist on the continent of India'. The list includes not only the Bengal fields—Raniganj (Damooda), Rajmahal and Palamow—but also those of the Nerbudda valley, Chanda and Wardha, the Mahanadi valley, Assam, Sylhet and Burma.[46] McClelland, one of the Coal Committee members corresponded with Lyell and Murchison on the question of employing trained geologists in India to investigate the coal formations of the country.[47] This led to the appointment of D. H. Williams as Geological Surveyor and his service dated from the 5th February 1846. He surveyed the Raniganj field, later the Kymore range of hills to the west of the Son river and lastly the Karanpura coal field. He was attacked by jungle fever and died on 15th November 1848.[48] McClelland continued William's work and discovered the Giridih (Karahbari) coal field, which contains the best coal in India. All geological work was put into cold storage after his term expired and until Thomas Oldham arrived.

In the meanwhile, a rival Geological Survey was at work in the Punjab. Dr. A.

Fleming, Assistant Surgeon, Bengal Native Infantry, was in charge and worked on the Salt Range and on its coal and other minerals. His work was recognised as good as that of Williams and McClelland.

3. The Third Stage: 1851-1900

Thomas Oldham, before he was appointed as Geological Surveyor to the East India Company, was local Director of the Geological Survey for Ireland in 1846, was also occupying the Chair of Geology in Dublin in 1845, and was President of the Geological Society, Dublin in 1848 when he was also elected a Fellow of the Royal Society of London. His appointment, made in November 1850, was for five years and was renewed periodically until he retired in 1876. He used to describe himself as Superintendent of Geological Survey of India[49]. During his long service of 25 years, the Geological Survey of India grew in every respect; the permanent headquarters was established in Calcutta with its Office, Museum and Library. J. G. Medlicott joined him in 1851 but left in 1862 to become Inspector of Schools in the Education Department of Bengal. R.I. St. George was transferred after a year's service to the East Indian Railways as an engineer. W. Theobald earlier worked with McClelland since 1849, but joined Oldham in 1853. John S. Kennedy worked with the Medlicott brothers in the Nerbudda district, but died after one field season. H. B. Medlicott was lent to the Thomson College of Civil Engineering, Roorkee in 1854, thus probably was the first teacher of Geology, and he rejoined the GSI in 1862. He succeeded Oldham as the Superintendent. W. T. Blanford retired in 1882 and his younger brother H. F. Blanford left the Department in 1861 to become Professor of Physics at the Presidency College, Calcutta. He was the first official Meteorological Reporter in India. Thus Oldham had a very strong team to start with.[50] During the period 1851-1856, this small band had recognised and named the principal divisions of the Vindhyan system, and of the coal-bearing series, and had also clearly separated the two systems one from the other, thus dispersing the clouds of confusion that had so perplexed the earlier geologists, due to the existence of sandstones and shales in both systems. The origin of the Talchirs as due to ice action had been recognised, one of the factors to lead later to the conception of Gondwana land. Oldham himself showed the connection between oil accumulation and anticlinal structure, in Burma in 1855.[51] Foundation was laid for the classification and nomenclature of the Vindhyan and the coal-bearing Gondwana systems.

The second five-year period service of Oldham began, coinciding with the taking over of the office of Governor-General of India by Lord Canning who took, 'really enlightened interest in Geology'[52] and gave orders that the work was to be conducted in the manner that Oldham advocated. Thus, the latter was able to initiate publication of 'Annual Report of the Geological Survey of India, and of the Museum of Geology' in 1858-59. The publication of Memoirs of the Geological Survey of India was also started in the same year. Their earlier papers were published in the Journal of the Asiatic Society of Bengal, Madras Journal of Literature and Science, Quarterly

Journal of the Geological Society of London and Gleanings in Science. Still earlier, papers used to be published in the Transactions of the Bombay Literary Society and Asiatic Researches. The first geological map on the scale of 1 inch to a mile was published in 1863 along with the Memoir (Vol. III, pt. 1) on the Raniganj Coalfield. The first mineral statistical return was published in 1869, which was entirely related to the Raniganj Coalfield. The definite assignment of what we now know as the Lower Gondwanas to the Trias, Permiam and Upper Carboniferous was done at this time taking into consideration the vertebrate remains and the Glossopteris and other plant fossils. Work was carried on in Bengal and Central India by Blanford and J. G. Medlicott, while H. B. Medlicott surveyed a large tract in the lower and outer ranges of the Himalaya, and the Siwalik Hills, between the Ganges and the Ravi rivers. Firm nomenclature was proposed for the various divisions. Down South, Blanford (H. F.), C. A. Oldham, William King and H. Geoghagan were working on the Nilgiri Hills, after completion of which the party bestowed its attention on the marine cretaceous rocks of Trichinopoly. Robert Bruce Foote joined them in 1858.

The Museum of Economic Geology was started in 1840 and the collections were housed with the Asiatic Society. This becames the Museum of Geology in 1857, with H. F. Blanford as its first Curator.

Dr. Ferdinand Stoliczka and Valentine Ball joined the GSI in 1862 and 1864 respectively. During Oldham's third assignment beginning in 1861, the publications of the *Records of the Geological Survey of India* and *Palaeontologia Indica* were initiated in 1868, the Annual Report now becoming part of it. Routine and detailed investigations were carried out in Bengal and Bihar, with particular attention to the coalfields of the Damodar valley—Bokaro and Ramgarh. The Vindhyans, Chota Nagpur. Assam coal, The North-west Himalaya, Western India including Konkan received detailed attention. In the Madras Party, R. B. Foote discovered on 30th May 1863 for the first time in India an implement of the Early Stone Age at Pallavaram. Later a large assembly of implements was discovered by King and Foote in the north-west of Madras. 'Thus was introduced to Europe the Stone Age Archaeology of India'.[53] Foote was the pioneer in the discovery of the Stone Age in India. Wynne, Ball, Blanford and others later discovered such implements elsewhere also. Foote also gave lectures on geology at the College of Civil Engineering, Madras (1861-63) and C. Oldham followed him (1866-67). In 1863-64, a small series of fossils and minerals were placed at the disposal of the Presidency College, Calcutta, to illustrate lectures on Geology and Mineralogy.

A set back for geological study and a sad period for GSI began with the death of Oldham, C. A. in 1869. Ormsby died in 1870 while the greatest shock was felt in the death of Dr. Ferdinand Stoliczka, the GSI's 'Palaeontological Oracle'.[54]

Thomas Oldham had often lamented the impossibility of recruiting geologists in India owing to the absence of provision for the teaching of this science.[55] He made

attempts to establish Lectures in certain branches of science in connection with the GSI so that some general knowledge of these subjects might be diffused. Then he appointed four Indian apprentices for training in Geology—they were Ram Singh, Kishen Singh and Hira Lall, the fourth not having joined. Arrangements were made for their attendance at the lectures on physical science at the Presidency College, Calcutta. Only the latter two continued in service as Sub-Assistants till retirement.

During this period, the stratigraphical sequence in Tertiary rocks in Assam was determined by Mallet and that provided the basis of all subsequent geological work in the coal and petroleum occurrences of Assam. Mallet visualised the possibility of the existence of Damuda rocks below the Gangetic alluvium between Rajmahal and the foot of the Darjeeling Hills[56]. He also investigated the copper and iron ore deposits of the Darjeeling Himalaya and he found the local inhabitants mining and smelting copper ore. Valentine Ball was making a study of the belt of old workings of copper in Bihar that he traced for 80 miles. The maps he prepared then led to the prospecting of the copper belt in the present century and ultimately to the formation of the Indian Copper Corporation[57]. Work in the Rajmahal Hills by Ball, in Chota Nagpur and the Valley, and by Mallet in South Mirzapur and North Hazaribagh and by Medlicott in the Satpura coal basin had far-reaching results: in that the lower age limit of the Deccan Traps could be fixed, and in the finding of important minerals like corundum near Pipra, mica and fixation of the term Gondwana for the coal-bearing series. Classical Memoirs on the Salt Range (Wynne) the Cuddapah Basin (King and Foote), the Southern Mahratta Country and the Nellore Carnatic were published during this period.

Geologists from India were also deputed for work beyond Indian frontiers, Mallet to Aden, W. T. Blanford in Persia, and Stoliczka to Yarkand.

While the main reason behind the appointment of a Geological Surveyor by the East India Company was to survey the coal resources of the Country, yet Oldham saw to it, in addition, that the economic resources of the tracts surveyed were also investigated. The iron ores, the limestone and building stones, the Salt deposits of the Salt Range, the Petroleum springs of Assam, the Punjab and Burma, and numerous occurrences of a number of minerals came to light in these surveys.

One of the magnificent contributions of Oldham to Geology is his initiation of investigations of earthquakes of India and Burma. He himself wrote a scholarly memoir on the Cachar Earthquake of the 10th January, 1869.[58] It was R. D. Oldham who distinguished the three distinct forms of wave-motion represented in the seismograph records of earthquakes. He was also able to draw conclusions of fundamental importance concerning the constitution of the earth[59] and especially to distinguish between a dense core and a lighter shell, and to determining the approximate diameter of this heavy core (a radius about four-tenths that of the earth).

Thomas Oldham also prepared a list of the thermal springs of India and the revised and edited list by his son, R. D. Oldham enumerated 301 springs.[60] The first official geological map of India was partially compiled during Thomas Oldham's time, though it was issued in 1877. However, even before this, G. B. Greenough presented a large geological map of this country in 1854 at the Liverpool meeting of the British Association. It was felt to be out-of-date and was retained as 'a memorial of our geological knowledge at the time of its publication'.[61] All the subsequent geological maps of India more or less conformed to the first official map.

The establishment of the GSI probably hasteneed introduction of Geology as one of the subjects of instruction in the newly established Universities at Calcutta, Bombay, and Madras. Wood's despatch was a landmark in the history of western education in India. It said, "We must emphatically declare that the education we desire to see extended in India is that which has for its object the diffusion of the arts, science, philosophy and literature of Europe; in short, of European knowledge".[62] Though it was in 1857 that these universities were founded, it was only in 1892 that Geology was organised as a separate faculty at the Presidency College, Calcutta mainly due to the efforts of T. H. Holland who was part-time Professor. Presidency College, Madras had such a separate faculty only in 1910 though it had Geology as an auxiliary subject much earlier. In the Bombay University, Geology was one of the optional subjects for the B. Sc. Degree, instituted in 1879.

H. B. Medlicott succeeded Thomas Oldham as Superintendent of the GSI. He suggested the term 'Gondwana' in 1876 for all the coal-bearing rocks except those of the Cretaceous and Nummulitic Ages. On the suggestion of Edward Suess, this term later came to be applied to the southern continent that existed 200 million years ago. Medlicott's tenure also saw the publication of 'The Manual of the Geology of India' in four parts, a great classic and an invaluable tool for undrestanding the Geology of India. Also it was Medlicott who recruited P. N. Bôse, the first Indian trained in England, as an assistant in 1880. During Holland's time, Bose and P. N. Dutta respectively were behind the discoveries of the iron ore deposits in Bihar and manganese ore in Bhandara and in the Chindwara valley. Bose, who became the first Indian Director, published the study of microsections as an aid to the study of rocks. He is said to have inspired J. N. Tata to establish the Iron and Steel Works at Jamshedpur.[63]

Many of the earlier officers of the Survey were not only geologists, they were Naturalists. W. T. Blanford, Stoliczka and W. Theobald were zoologists and made extensive collections of mammals that were extinct and of birds. Valentine Ball was an Ornithologist and an equally great botanist. His book, 'Jungle life of India' bears testimony to this. But of immediate interest is his other book, 'The Diamonds, Coal and Gold of India', published in 1881. It describes the places where diamonds cocur in India. It appears that there were 60,000 persons at work at the diamond mines of Kollur in Krishna district when he visited it. He felt that the Kohinoor and the Great Moghul were the same. An interesting observation he makes is[63]: 'Indeed it is stated

that Hyder and his son Tippoo erected their mints, the ruins of which are to be seen to this day, in the district close to the spot where the Ooregaum company is at present working'.[64]

Of equal interest is another work that appeared in 1874, titled 'Undeveloped Wealth of India and State Reproductive Works', published by Virtue, Spalding & Co, London, in which there are contributions by W. T. Blanford (The Coal Basins of Bengal), Hughes (Extent of Berar and Chanda Coal), and (Extent of Coal in India), Fryer (Note on Chanda Iron Ores), Oldham (Iron Ores and Smelting of Iron in India) and Tyrrell (Picking India's Pocket) and so on. All these and other articles in this book were to point out to the Government that the natural resources in India were not being developed and exploited.[65]

There was thus a crusade for development of geological sciences in India in the second half of the nineteenth century and a strong foundation was laid by the pioneers then and we are now witnessing the fruits of their labour.

REFERENCES

[1] Edward, Michael, *A History of India—From the Earliest Times to the Present Day*, Asia Publishing House, 1961, p. 444.

[2] Sunder Gopal: Social Set up of Science and Technology in Mughal India, *Indian J. 'Hist. Scie.* Vol. 4, Nos. 1 & 2, 52-58, 1969.

[3,4] Keladi Basavaraja: *Śivatattvaratnākara.* Two editions, 1926 & 1964.

[5] Dikshit, G. S. : *The Śivatattvaratnākara* as a source for Sciences in Ancient & Medieval India, *Indian J. Hist. Sci.*, Vol. 4, Nos. 1 & 2, p. 11, 1969.

[6] Motte, T., *Early European Travellers in the Nagpur Territories.* Reprinted from Old Records, Nagpur. Government Press, 1924.

[7] Colebrook, R. H., *Asiatic Researches*, Vol. VII, pt. L. in *Memoirs of the GSI*, Vol. 13, pt. 2 on "Geology of the Rajmahal Hills, V. Ball, 1801.

[8] Wilford, F., *Asiatic Researches*, Vol. VIII. p. 209 in *Mem. GSI*, Vol. 13, pt. 2, 1805.

[9] Heyne, Benjamin. Tracts, Historical and Statistical on India, in *Mem. GSI.* XVI, pt. 2. W. King: The Geneisses and Transition Rocks, and other formations of the Nellore portion of the Carnatic, 1880.

[10] Buchanan, Francis, *Journey from Madras through the Countries of Mysore, Canara and Malabar.* Vol. I, p. 53, 1807.

[11] ———— p. 43.

[12] ———— p. 130.

[13] ———— p. 170.

[14] ———— p. 179.

[15] ———— Vol. II, p. 4.

[16] ———— p. 138.

[17] ———— p. 260.

[18] ———— p. 386.

[19] ———— p. 436.

[20] ———— p. 494.

[21] ———— Vol. I, p. 147.

[22] ———— p. 149.

[23] ———— Vol. II, p. 440.

[24] Heyne, Benjamin, Iron Works at Ramanakkapettah in *Indian Science and Technology in the Eighteenth Century* by Dharampal, 1971, Implex India, Delhi, 215-19.

[25] Scott, Helenus, Aspects of Technology in Western India, *in* Dharampal's book, *op. cit.* p. 264-74, 1790-1801.

[26] Marco Polo, *The Travels of Marco Palo*, Books Inc. New York, pp. 287-89.

[27] Mackenzie, C., *Asiatic Researches*, Vol. V, p. 303, 1794, in *Mem. GSI.* No. VIII, W. King: *Kadapah and Karnul Formations*, pp. 1. 319, 1872.

[28] Heatly, S.G.T. 1842, Contributions towards a History of the Mineral Resources of India, *Jl. Asiatic Soc. Benga.*, Vol. XI, pt. 2, pp. 813-15, 822 in *Bengal: Past & Present*, Vol. LXXXIX, Pt. I, Serial No. 167, January/June 1970, Calcutta Historical Society, Calcutta.

[29] Jones, *Asiatic Researches*, Vol. XVIII pt. 1, pp. 163-70, 1829, in *Bengal: Past & Present*, op. cit.

[30] Copeland, J., 1815, Eastern Guzerat, including Rajpeepla, *in Mem. GSI.* Vol. VI, pt. 3, 1869. W.T. Blanford, On the Geology of the Taptee and Nerbudda Valley and some adjoining districts.

[31] Babington, Geological Society of London, Vol. V, p. 329. 1819, in *GSI Mem.* No. X. pt. 1. Geology of parts of Madras & N. Arcot Districts.

[32] Fermor, L. L., *First Twenty-Five Years of the Geological Survey of India*, GSI Misc. Pub. No. 39, p. 5, 1976.

[33] Newbold, A Glance at the Banagapilly Jaghire, taken while passing through that territory in March 1836. Madras. *Jl. Lit. & Sci.* Vol. III, p. 117, 1836, in *GSI Mem.* VIII.

[34] Ball, Valentine, *The Diamonds, Coal and Gold of India: Their Mode of Occurrence and Distribution*, Trubner & Co. London. p. 26, 1881.

[35] Voysey, H. W., The Diamond Mines of South India. in *GSI Mem.* No. VIII, op. cit., 1825.

[36] ————1823, *Jl. of Asiatic Researches*, Vol. XIII, 1844, pt. 862. in *GSI Mem.* XVIII, pt. 2, 1881, Ball, V. Geology of the Districts of Manbhum and Singhbhum.

[37] Fermor, L. L. *op. cit.* p. 17.

[38] Pratt, Archdeacon, A. H., On the Degree of uncertainty which local attraction, if not allowed by Geodesy ... and specialities on the construction of the earth's crust. *Jl. Asi. Soc.*, XXXIV (2), 34-42, 1865, *in* The Character of the Introduction of Western Science in India During the Eighteenth and Nineteenth Centuries, S. N. Sen, Indian *Jl. Hist. Sci.* Vol. 1, No. 2. p. 112-22, 1966.

[39] Basevi, James Palladis, On the Pendulum Operations about to be taken by the Great Trigonometrical Survey of India etc. *Jl. Asi. Soc.*, XXXIV, p. 251-72, 1865, in S. N. Sen, *op. cit.*

[40] Fermor, L. L. *op. cit.* p. 19.

[41] Franklin, Major James, The Mode of Manufacturing Iron in Central India, 1829, *in* Dharampal, *op. cit.* p. 220-48.

[42] Campbell Captain J., Manufacture of Bar Iron in Southern India, 1842, *in* Dharampal *op. cit.* p. 249-63.

[43] Fermor, L. L., *op. cit.* p. 21.

[44] Sen, S.N., The Character of the Introduction of Western Science in India during the Eighteenth and Nineteenth Centuries. *Indian Jl. Hist. Sci.* Vol. 1, No. 2, p. 112-22, 1966.

[45] Hislop, Rev. M. S. On the Geology & Fossils of the neighbourhood of Nagpur, Central India, *Qly. Jl. Geol. Soc. Lond.* Vol. XI, p. 365. 1856, *in GSI Mem.* XVI, pt. 3. Wking.

[46] Fermor, L. L., *op. cit.* p. 22.

[47] ————*op. cit.* p. 24.

[48] ————*op. cit.* p. 26.

[49] ————*op. cit.* p. 38.

[50] ————*op. cit.* p. 42.

[51] ————*op. cit.* p. 43.

[52] *Ancient India*, No. 18 & 19, 1962-63. Arch. Sur. of India.

[53] ————No. 9, 1953.

[54] Medlicott, *Rec. Geol. Surv. Ind.* VII, p. 2.

[55] Fermor, L. L., *op. cit.* p. 89.

[56] ————*op. cit.* p. 94.

[57] ————*op. cit.* p. 96.
[58] ————*op. cit.* p. 121.
[59] ————*op. cit.* p. 123.
[60] ibid.
[61] Fermor, L. L., *op. cit.* p. 125.
[62] Gupta, S. P. 1979, *Modern India and Progress in Science and Technology*, Vikas Pub. House Pvt. Ltd., p. 164.
[63] ibid. p. 41.
[64] Ball, Valentine, op. cit. p. 105.
[65] *Undeveloped Wealth in India and State Reproductive Works*, Virtue, Spalding & Co., London, 1874.

18th century 19th century colonial science India natural history. This is a preview of subscription content, log in to check access. Notes.Â Grout A 1995 Geology and India, 1770â€“1851: A study in the methods and motivations of a colonial science, Ph D thesis, London UniversityGoogle Scholar. Harris FR 1958 Jamsetji Nusserwanji Tata: A chronicle of his life (Bombay: Blackie and Son)Google Scholar. Hawgood BJ 1994 The life and viper of Dr Patrick Russell MD FRS (1727â€“1805): Physician and naturalist. Toxicon 32 1295â€“1304PubMedCrossRefGoogle Scholar. Headrick DR 1981 The tools of empire: Technology and European imperialism in the nineteenth century (Oxford University Press)Google Scholar.