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ECONOMIC COMPULSIONS AND THE GEOLOGICAL SURVEY OF INDIA

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The establishment of British rule in India was attended by many politico-administrative changes. But at the root was economy. The new rulers knew that their empire in India could be sustained only through a systematic exploitation of the land and its people. The vast, virgin lands—rich in mineral resources—promptly attracted their attention. The science of geology which was itself in a nascent stage in Europe at the beginning of the 19th century, was pressed into service without any great loss of time. This brought government, science, and economic exploitation into a close relationship. The economic interest groups desired research to gain immediate and practical ends. Their objectives were primarily practical.

What position the so-called natives came to occupy in its organisation? Who benefitted most from the whole enterprise? These are some of the questions, the proposed paper will seek to answer with the help of some archival documents and contemporary sources.

In a study of any institution, more so in case with a scientific one, it is important to know how and by whom these institutions are supported, the types of activity they carry on, their policies, their internal organisation and interrelations etc.[1] The object of the present paper is to observe how and in what form a particular scientific organisation at a particular historical juncture is related to the then existing politico-economic structure.

By far the best illustration of the use of science for colonial purposes can be found in the workings of the Geological Survey of India (hereafter called the GSI). The economic value of the geological investigations proved of immediate concern to the East India Company with the coalfields of eastern India looming large.[2] In the first quarter of the 19th century noted mineralogists and surveyors like Laidlow, Voysey, Dangerfield, and Herbert were exploring Kumaon, Malwa and the Himalaya regions. But these works were little more than sporadic reconnaissances with natural history. A definite shape however emerges in 1836 when the Company appointed "A Committee for the Investigation of the Coal and Mineral Resources of India", with the Chief object of determining the existence, extent and relative accessibility of the beds of mineral coal in different parts in India and their immediate applicability to the increasing demands of the steam-navigation of the Ganges and its tributaries."[3] This Committee stands as a milestone in the evolution of colonial science in India because here

for the first time various types of coal and minerals were listed alongwith the map illustration of the sites as well. And also for the first time was raised the question of employing trained geologist in India to investigate the coal formations of the country.[4] In October 1843 the Govt. of India urged upon the Court of Directors "the expediency of adopting a system of scientific enquiry both with the view of securing success to such attempts as are made by the Govt. and of promoting confidence among private speculators to embark upon undertakings for obtaining coals."[5]

Not only this, some sort of private pressure was also mobilised to induce the Govt. run fast. For instance, a contemporary observer bemoaned, "the efforts of Govt. have been frequently sadly misdirected in their attempts to introduce and obtain good coal... The Coal Committee recommended that the mines should still be retained in the possession of Govt. This was in 1841, and since that date the Govt. has done nothing to improve the working, or to facilitate the means of access to, or transit from, those mines. It is not the province of Govt. to work coal mines, nor is it ever for its advantage to retain them in its own possession... Instead it should be the object of Govt. to afford every facility for the speculator to invest his capital in working them."[6]

The result was that in 1846 D. H. Williams was appointed as Geological Surveyor to the East India Company. He prepared two reports, one on Damoodar Valley and the other on Ramghur coal-fields. In his second report, William discusses, interestingly enough, the unfortunate results of the permanent settlement on mineral deposits if the Zamindars were to be allowed to assume the mineral rights[7]. His death in November 1848 was followed by a brief interregnum during which McClelland discovered the Giridih coal-field but could not succeed in establishing his credentials as a full fledged in-charge of the survey operations. During this period Dr. Fleming, a Surgeon in Bengal Native Infantry, was conducting a parallel survey work in the Salt Range without any authority from his Bengal counterpart.[8]

Things were thus in a confused state during this preliminary period of geological investigations in India which was finally laid to rest in Nov. 1850 by the appointment of Thomas Oldham who had already distinguished himself as the Director of the Geological Survey of Ireland. His arrival in March 1851 marked the establishment of a 'continuous'[9] Geological Survey of India, which under his superintendence later emerged as a premier scientific institution in India. The Memoirs, Annual Reports, and Records of the organisation bear witness to this.[10]

As expected, coal haunted Oldham right from the beginning. He himself recognised that the original reason for his appointment was the study of the coal resources of India. Consequently, a large proportion of the systematic work done during Oldham's regime of 25 years was directed to the study of coal-fields[11]. No wonder, the very first issue of the now well-known Memoirs[12] which Oldham started in 1856 carried his notice of the coal and iron in Talcheer district[13]. In 1864 he was called upon by the Lieut. Governor of Panjab to examine the Salt Range. The result was his 'memorandum

on the results of a cursory examination of the Salt Range and parts of the districts of Bunno and Kohat, with a special view to the Mineral Resources of those districts.[14]

By 1867 as many as 27 coal-fields had been explored. They were Rajmahal Hills, Raniganj, Kurhurbali, Jheria, Bokar, Ramgurh, Karunpoora, Ectcoora, Palamow, Sirgoojah, Upper Sone, Koorba or Belaspore, Talcheer, Nerbudda and Pench rivers, Chanda, Kota, Cutch, Sind Salt Range, Muree, Darjeeling, Assam, Khasia hills, Garrow hills and Cachar, Chebuda, Burma, and lastly, Tenasserim provinces[15]. In 1859 the amount of coal raised in Bengal was 99,61,928 maunds which moved up to 1,08,34,551 maunds in 1866[15a]. This rise may be explained by the expansion of railways whose consumption of coal rose from 9,91,275 maunds in 1861 to 50,79,612 maunds in 1866[16]. Apart from railways, the discovery of rich deposits of iron and manganese ore raised high hopes about the manufacture of steel in India, and for this also more and more coal had to be dug out.[17]

But upto this time the mining methods were most unsatisfactory. There were open workings or quarries in which the coal had been worked like any ordinary stone[18]. There was no improvement upon what Capt. Hurbert had noticed in 1829; "The whole system is extremely rude and inefficient. Worse methods, I do not think, could well be devised"[19]. In 1869 a report on coal mining was submitted by GSI with suggestions for improvement.[20]

The geologists paid due attention to both the quantity and quality of coal. Quantitywise Oldham did not consider India as "either largely or widely supplied with this essential source of motive power"[21]. And to determine the quality he sent a few specimens of principal coal beds to the International Exhibition in London in 1862 where it was found that the Indian coal contained 52.5% carbon, 31.9% volatile matter, and 15.5% ash, while English coal had 68.10% carbon, 29.20% volatile matter, and only 2.70% ash[22]. Because of its large ash content, the Indian coal proved inferior to the english ones. And thus were dashed, as Oldham himself put it, "the hopes which have been expressed, that the coal-field of India, Borneo, Australia and New Zealand will not alone yield ample supplies, but will also serve to coal the ocean steamers trading and likely to trade between Europe and those far distant regions."[23]

Next to coal and iron, the other minerals to attract notice were laterite, manganese and gold. Laterite was first noticed by Buchanan[24]. Newbold did further work on it in conjunction with the manganese ore of Bidar region[25]. Capt. Jenkins[26] and Dr. Voysey[27] were the first to take note of occurence of manganese in India. Later on V. Ball summarised all that had been written till 1880 on this mineral[28]. With the advent of the nineties, the period of mere prospecting of the Indian manganese ore deposits ended, and the manganese industry proper, in which mining was combined with further prospecting, commenced[29]. Gold was of course the charmed article. In 1822 a surveyor reported how gold was worked at Colar in Mysore.[30] In 1867 Capt. Mantogomerie of the Great Trigonometrical Survey reported large and extensive gold field

at Thok-Jhalung in Tibet but added that due to the Tibetan xenophobia, the surveyors could not make much headway[31]. However, it was not until the close of the century that an exhaustive report on gold-mining was submitted to the Govt. by the GSI.[32]

The geologists had been constantly hindered in their work by the want of maps[33]. Their progress was dependent upon the maps published by the trigonometrical surveyors[34]. They had to often grope in dark and feel harrassed as many times zealous civil or military officers stationed at far off places would raise a false alarm of a big discovery at the slightest notice of some black or grey stone. In Feb. 1864, Oldham had to rush to the Salt Range on such an alarm, and therefore in his report he noted that maps and records prepared in advance would at least have the "quasi-negative value of preventing useless expenditure in misguided directions."[35]

Of the earlier maps contained in the Indian Atlas, a contemporary observer called them "the very perfection of confusion, confusion worse confouned", with numerous defects and unartistic drawings which could not be shown to a foreigner "without a blush"[36]. The first geological map was compiled by G. B. Greenough in 1853[37] and was received well by the reviewers[38]. But he had prepared the map without visiting the country even once. Naturally, in 1856 a Committee of the Asiatic Society of Bengal found Greenough guilty of using outdated topography and offered 53 corrections to it[39]. In 1858, the geological maps of Saugor, Dumoh, Jubbulpore, Bancoorah, Midnapore, Cuttack and Poorie, embracing an area of more than 26,000 sq. miles was submitted to the government.[40] But the preparations of an extensive and authoritative geological map of India took almost 20 years and could be first published in 1877, a year after Oldham's retirement[41]. Earlier, the government had already agreed in 1871 to patronise the publication of geological maps[42] and later on the Surveyor General was asked to supply, on demand, even the most confidential maps to the Director of the GSI.[43]

The geological works of many a explorers would have been lost[44], had someone not thought of preserving the collections, putting them to laboratory tests and making their fruits public through publications. The Asiatic Society of Bengal was the first to expouse the cause of a museum as early as in 1796. In 1814, one Dr. Wallich offered specimens from his own rich collections in order to form the nucleus of a museum. The opening of the Raniganj coal-field and the reports of Dr. Helfer and other scientific officers directed so much attention to the mineral resources that it was resolved to establish a museum of economic Geology[45]. Within two years Dr. Oldham and his men had been able to arrange and name altogether 6,800 specimens of fossils, 1550 of simple minerals, 700 of rocks and 1,500 ore, giving a total about 11,000 specimens.[46]

Closely connected with the works of the Museum was that of the laboratory,— the determination of minerals, rocks and fossils sent by private individual as well as those collected by the GSI staff. A tea-speculator would ask about tea-soils while the P.W.D. about the iron sand stones from Rangoon[47]. Commercial interests thus pro-

vided the motive force. However, under T. H. Holland's curatorship lab work touched real heights; while during 1882-90 the average was about 50 tests a year, it was 790 during 1903-8.[48]

All these explorations and researches could have reached the discerning quarters only through publication. Journals like the Asiatic Researches, Gleanings in Science and the Journal of the Asiatic Society were the great vehicles for the wide dissemination of such knowledge. But the gravest defect of the early writers was that they made a jumble of their informations and did not in their written account distinguish what they had actually seen from what they had heard and guessed at. This was, as a reviewer noted, because of the very constitution of the intellectual milieu which was composed mostly of the public servants, and even those who were alone available for the duties of scientific research, had to work with fettered hands and in a limited sphere.[49]

But when the staff of the GSI was increased in 1856 and its labours systematised, it was ordered that the reports on different districts, examined geologically by its officers, should be published in one continuous and uniform series, not as previously in various journals, and in different forms[50]. The result was the Memoirs of the GSI catering to the need of detailed and comprehensive accounts of specific economic minerals of a region. In 1862 was launched the *Palaeontologia Indica* with the prime objective of publishing the result of palaeontological research carried out by the GSI on fossil collections. The region-wise volumes gave place, in 1899, to the New Series permitting diversity in the region as well as in the subject treated within the same volume. The third important publication was the Records of the GSI, born in 1868 to publish short and brief scientific papers prepared by the officers of the Survey[51]. This annual publication formed usually a 4 part volume, Part 1, being mostly the Annual General Report of the Department, part 2, devoted to mineral production statistics, and part 3 and 4 to scientific papers.[52]

Besides these, there was prepared, with the approval and sanction of the Government of India, a *Mannual of the Geology of India*[53], in two volumes by H. S. Medlicott and W. T. Blanford, published in 1879, to which were subsequently (in 1881) added a volume on the *Economic Geology*[54] by Valentine Ball, and one on the *Mineralogy* by F. R. Mallet. These volumes contained not only much information collected by the Survey, which it had not been possible to publish previously but for the first time, by collecting scattered information into one general review, made the geology of India, generally accessible and intelligible.[55]

Oldham talked of Govt. pressure and the GSI had to contend with what Oldham called "The force of circumstances to take up in detail the examination of special districts[56]. As the GSI was a government organisation, it had to work only along the lines which would bring economic benefits to the Raj. Oldham himself tried to rationalise it, "In a new country, the mineral wealth of which is only now becoming known,

the natural and inevitable tendency of such geological enquiries is more practical and economical than they would be where civilization had longer held her ways and where the energies and skill of many, interested in such pursuits, had been for generations brought to bear upon them."[57]

The only idea the Government then had of the duties of a geological surveyor was that he should go about from place to place, and report upon real or fancied discoveries of minerals[58]. The government would always keep on goading the various organisations to work along only economically beneficial lines. T. Oldham once almost regretfully recorded, "the pressing demand for a knowledge of the true state of the coal-fields of the Damoodah and Adji, led to the diversion, under the special sanction of the government of India, of two of the geologists to that part of the country, after they had actually commenced their field work elsewhere...."[59] Even in 1864 when Oldham was firmly in the saddle, a government fiat forced him to abandon the geological examination of a portion of Bihar and rush to examine the coal-beds in the Punjab.[60]

The geologists, as seen earlier, were expected to perform a dual role, one as explorer (thereby as agents of imperialism), and the other as scientist busy in advancing the frontiers of geological knowledge. Oldham, no doubt, kept a very close watch on all what was happening geologically in all parts of India, and made a practice of himself examining new discoveries and advances wherever this was possible[61]. Yet the works had got jumbled up and there was no clear-cut distinction as to who should work on pure research and who be engaged in survey work. In fact both were mostly considered inseparable, but emphasis remained always on the economic side. This will be clear from the following chart submitted by Dr. W. King, Derector of the GSI to the government outlining the programme of disposal of the geologists during 1893-94:[62]

Name	*Area of work*	*Nature of work*
C. L. Greisbach	Supdt. Baluchistan, Punjab	Scientific, Economic to be done by his subordinates Mr. Smith and Edwards.
T. D. LaTouche	Offg. Supdt. Sukkur	Economic and Oil.
P. N. Bose	Dy. Supdt. Rewa	Scientific, Economic as found
F. Noetling	Palaeontologist, Burma	Scientific and Economic
C. S. Middlemiss	Dy. Supdt. Madras	Scientific and Economic
P. N. Datta	Asstt. Supdt. Central Provinces	Scientific, Economic as found
T. H. Holland	Asstt. Supdt. Headquarters.	Scientific

Thus only Holland had been assigned purely scientific work. By the 1890's the Govt. had begun to show some genuine interest in scientific aspects and therefore

wanted to divide the Deptt. into scientific and economic sections with two-thirds of the staff given to scientific and one-third to the latter. The Secretary to the Government of India, E. C. Buck, accordingly asked the GSI to adopt henceforth the following division[63]:

Scientific Section	*Economic Section*
1. C. L. Griesbach	1. T. D. LaTouche
2. P. N. Bose	2. F. Noetling
3. P. N. Datta	3. C. S. Middlemiss
4. F. H. Smith	
5. W. B. D. Edwards	
6. T. H. Holland	

The idea was thus the decentralisation of that section of the GSI which dealt with practical apart from purely scientific enquiry.[64]

Closely connected with the organisation of a scientific institution with such a vast jurisdiction is the question of what role the 'natives' were asked to play and also of what they could have played had they been given proper opportunities. Even 20 years after the establishment of the Survey, Oldham lamented the non-availability of good geologists. It took on an average nine and half months to procure a qualified geologist from England and the difficulty in obtaining them went on increasing because of the poor incentives the Survey had to offer.[65]

A perusal of the archival materials, however, make it quite clear that there was a sharp cleavage between the high administrative officers of the Government and the head of the GSI (Medlicott in particular) on the issue. A. O. Hume, Secretary to the Govt. of India, was determined to "set on foot a plan for superceding, to a certain extent, European by native agency"[66]. This he wanted to do because it would have made the survey operations much more economical. He felt that some of the natives would be quite as useful as some of the Europeans then drawing Rs. 1000/- a month; and was so insistent that he would recommend even the dismissal of the officer (Oldham and Medlicott in this case) who refused to implement his plan[67].

The high-ups in the GSI, however, continued to fulminate over this policy decision. To Medlicott the Indians appeared utterly incapable of any original work in natural science[68]. He wanted to wait until the 'scientific chord among the natives' was touched, and added almost contemptuously, "if indeed it exists as yet in this variety of the human race.... So let us exercise a little discretion with our weaker brothers, and not expect them to run before they can walk."[69]

On such fiery outbursts, the Govt.'s reaction was rather cool. The Under Secretary, C. S. Bayley, put a brief note: "Mr. Medlicott writes, as usual, intemperately, hence

no use in discussing with him a point which has been thoroughly thrashed out already"[70]. The motive was clear; why incur extra-expenditure by importing qualified geologists from England. As an official had noted earlier, "the natives are very much cheaper; if the work is to be really done thoroughly in future generations, it must be done by the natives of India"[71]. This was reaffirmed by Lansdowne in 1891 with the sanguine hope that improved educational system would gradually enable the GSI make better catches.[72]

But how could this hope have been realised, even partially, in the absence of a comprehensive system of science education, particularly that of geology? This dichotomy was well brought out by a reviewer in 1864 when he wrote: "the difficulties are those of our own making. The Egyptians wanted bricks made without straw, and became proverbial for their folly. The Indian Govt. goes a step further and wants its bricks made not only without straw but without brickmakers. It contemplates great things in a hazy way; and looks for great results...."[73] But such criticisms would not deter the men in power who though inclined to urge the induction of natives into geological staff, could not find "sufficient reason to justify any special education for the purpose", nor found the "native character likely, with any kind of training, to fulfil the requirements of the Deptt.[74]

As the coal-explorations progressed, demands were raised 'for proper instruction in economic geology and appointment of geological professor in the colleges'[75]. Till 1850, though few persons had been appointed as geological surveyors, the government had done absolutely nothing for geological education and instruction. By training up a portion of the native youth, it was felt, could be laid open "the mineral wealth of the country, which may in after years prove a fertile source of revenue"[76]. But even the establishment of universities in the presidency towns in 1857 could not break the government's apathy to education in geology.

The GSI itself could have been used as an educating body. It argued, "no one can teach properly any science of observation who has not been himself an observer... it is to those personally engaged in the investigations of geology of this country, that we must look for any practical instruction in the science and its applications."[77] The Court of Directors, on the other hand, was toying with the idea of appointing a Professor of Natural Philosophy and Geology at the Presidency College, Calcutta.[78] Oldham was not enthusiastic about it and felt that in the absence of facilities concerning practical and field work, it would be 'utterly impossible' to teach geology in Calcutta.[79]

H.B. Medlicott, whose rigid opposition to the employment of natives has already been noted, was equally opposed to the introduction of special courses in geology and its branches like palaeontology, mineralogy and petrology. The pretext was the same, i.e. the intellectual bankruptcy of the Indians.[80] Moreaver, he pointed out that so far as the GSI was concerned, special provision for geological training in Indian colleges was not required, because the Department mustered only 15 graded officers, 'a number

too small to offer any inducement to the opening of special classes'. And the Governor-General agreed to it.[81] The geological education thus remained in doldrum and it was not until 1893 that a Professorship of Geology was finally established at the Presidency College, Calcutta, and some students began to appear at the B.A. examination with Honours in Geology.[82]

It was, thus, but natural that the pure light of science was slightly dimmed by the smoke of commercialism. Perhaps in no other branch of knowledge was this so glaring as in geology. For instance, the Memoirs were started in 1856, and up to 1901, 34 volumes had been published containing 82 parts out of which about 30 parts were devoted primarily to the study of various coal-fields in the country, apart from the numerous references to it scattered in almost all the volumes. In contrast, gold could receive full attention only in three parts. Obviously the geologists were more obsessed with the black gold. It is, however, significant that out of these 82 parts not less than 40 were devoted to the study of geological structures and physical features of several areas encompassing the length and breadth of the country. The rest dealt with isolated topics like the occurrence of laterite, lignite, ammonites, the geology of serveral rock systems, mineral statistics, earthquake, thermal springs etc.[83]

So great was the economic value of geological works that when Valentine Ball wrote part III of the *Manual of Geology of India* (London, 1881) dealing with economic geology, it was hailed as a sufficient proof to "justify the existence of the survey were any justification needed",[84] and the government granted an honorarium of Rs. 1,000/- in recognition of the expeditious and satisfactory manner in which he brought out the book.[85]

A more concrete example can be found in the exploitation of manganese ores. By 1865 the manufacture of ferro-manganese had started in England which led to a tremendous increase in the demand of its ores. Supplies from the Continental Europe fell much short of the demand. Indian mineral exploitations then came in handy. At Vizagapatanam one Mr. H. G. Turner, previously Collector of this Distt. formed a syndicate in 1891 to work the deposits of manganese of Kadur mines. In 1895 this syndicate was converted into the Vizianagram Mining Company Limited which, in search of the new 'pastures', started prospecting works in Chikvadi and Nagpur districts following up the references given in Ball's 'Economic Geology'[86]. And the result of all this was that the manganese production in India rose from a meagre 685 metric tons in 1892 to 1,41,498 in 1900; and the export of manganese from India rose from 1,000 tones in 1893 to 95,225 in 1900.[87] On top of it, these exports were made in raw conditions resulting in heavy revenue losses; but the loss to India meant a corresponding gain to Britain and her manufacturers.[88] The thread which bound together the discoverer and the manufacturer (i.e. science and industry) in Victorian England, was sadly missing here in India.

The results of the Geological Survey can be looked for both in India and out of it. In India, in the economic benefits of the Empire; and out of India, in the influence

they had on the advancement of geological science. The former of these is naturally that to which any government would have attached greater importance. The coal-fields in themselves would justify the existence of the survey, from an economic point of view, apart from other benefits.[89] Though the government was naturally most interested in the economic aspects of the works of the GSI, there had never been an attempt to convert it in a mere prospecting or mining department. The Government of India did recognise purely scientific work as an important duty of the survey[90] and regarded the advancement of science not only as a thing to be desired and encouraged on its own account, but as furthering and rendering more valuable the economic results of the survey, by improving the instruments with which it worked. It has already been seen how the Court of Directors insisted for a professorship in geology at the Presidency College; and how the government later pressed for induction of the natives despite vehement remonstrances from senior geologists like Medlicott and Blanford. All this seems to establish above reproach the Government's bonafides. That these improvements were made with an eye over the economy, is a natural result of the in-built mechanisms of an imperial power.

The sweat and blood of the geologists working in India had thus produced the desired results. But this would not have been so had they not been provided with a platform, that is the GSI. The government had of course, its own motives, the imperial axe to grind; yet the institutionalisation of geological works proved to be a historic development—a milestone in both the history of science and the history of imperialism.

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[9] Fermor, L.L., *op. cit.*, p. 36.

[10] *Records of the GSI*, Vol. IX, Cal. 1876, p. 27.

[11] Fermor, L.L., *op. cit.*, p. 118.

[12] Memoirs of the GSI contain detailed reports on complete surveys and investigations dealing either with a particular region or with a particular mineral in one or more regions.

[13] *Memoirs of the GSI*, Vol. I, pt. I, 1856.

[14] Oldham, T., *The Coal Resources and Production of India Being Return Called for by the Secretary of State for India*, App. V, Calcutta, 1867, p. xlvii-lxx.

[15] *Selections from the Records of the Govt. of India* (hereafter called Selections) Home Department, No. lxiv, Cal. 1868, p. 42.

[15] (a) Since then the coal output never looked back; from half a million tons in 1870, it rose to six million tons in 1900, and 13 million tons in 1908. See *Transactions of the Mining and Geological Institute of India* (hereafter called Transactions), Vol. v, pt. 1, 1910, p. 19.

[16] Oldham, T., *op. cit.*, pp. 26-28.

[17] This link between coal and iron was later well-hammered by Prof. W.R. Dunstan in his report on Indian coal prepared at the Govt.'s request in 1896. See, *Nature*, Vol. 58, Aug. 1898, p. 380; Revenue, Agriculture and Commerce Deptt. (hereafter called RAC), *Coal & Iron*, prog. nos. 1-3, Aug. 1899, pt. A, preserved in the National Archives of India (hereafter called NAI).

[18] *Selections*, *op. cit.*, p. 42.

[19] *Asiatic Researches*, Vol. xviii, pt. I, 1829, p. 245.

[20] NAI, *Home Public*, Prog. Nos. 122-24, July, 1869, pt. A.

[21] *Selections*, *op. cit.*, p. 40.

[22] Oldham, T., *op. cit.*, pp. 20-22. Later further experiments were made in England to test the coking qualities of Bengal coal. Refer, NAI, *RAC*, *Coal and Iron*, prog. nos. 21-49, Nov. 1898, pt. A.

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[42] NAI, *RAC*, *Geographical Branch*, Prog. Nos. 1-5, May 1871, pt. A.

[43] NAI, *RAC*, *Surveys*, Prog. Nos. 20-21, Sept. 1891, File No. 32, pt. A.

[44] An example of such losses can be found in Oldham's regret while outlining the geological structure of the Khasi hills; "The want in this country of books of reference or collections for comparison, compelled me, after a preliminary examination to submit a selection of fossils collected, for careful examination and description in England. These were unfortunately lost at sea, and until the data for such comparison can be again procured any report on the district must unavoidably be very incomplete." *Memoirs of the GSI*, Vol. I, pt. 2, 1858, p. 100. The publication of this part of the Memoirs itself was delayed by the loss of maps which had been stolen during transmission by post, and which could be replaced with considerable difficulty and much loss of time. Ref. *Annual Report of the Supdt., GSI*, *op. cit.*, p. 2.

[45] *Transactions*, Vol. V, pt. 1, 1910, pp. 31-32.

[46] *Annual Report of Supdt. GSI*, *op. cit.*, p. 5.

[47] *Ibid.*

[48] *Transactions*, *op. cit.*, p. 37.

[49] *Calcutta Review*, Vol. IV, No. 7, 1845, pp. 163-64.

[50] *Memoirs of the GSI*, Vol. I, Cal. 1856, p. V.

[51] NAI, *Home, Public*, Prog. Nos. 26-28, June 1868, pt. A.

[52] *Records of the GSI*, Vol. I, Calcutta, 1868.

[53] These volumes were received well. Ref. *Calcutta Review*, Vol. 69, No. 137, 1879, pp. xi-xii.
[54] But it was Ball's work which stole the limelight, obviously because of its economic value. See *Calcutta Review*, Vol. 75, No. 149, 1882, p. xiii.
[55] *Nature*, Vol. lxii, May 1900, p. 105.
[56] NAI, *RAC, Surveys*, Prog. No. 1 (emphasis mine), Jan. 1872, pt. A.
[57] *Memoirs of the GSI*, Vol. I, pt. 1, p. VI.
[58] Markham, C.R., *op. cit.*, 2nd ed. 1878, p. 216.
[59] *Annual Report of the Supdt. of GSI*, Cal. 1858-59, p. 1.
[60] Oldham, T., *op. cit.*, p. xlvii.
[61] Fermor, L.L., *op. cit.*, p. 67.
[62] NAI, *RAC, Surveys*, Prog. No. 1, Oct. 1893, File No. 174.
[63] *Ibid.*, prog. no. II.
[64] *Ibid.*, prog. nos. 11-13, July 1894, File No. 128.
[65] *Ibid.*, prog. no. 1, Jan. 1872, pt. A.
[66] *Ibid.*, prog. nos. 15-19, Oct. 1872, pt. A, K.W.
[67] *Ibid.*
[68] This he wrote obviously oblivious of the fact that a few enlightened Calcuttans had already established an institution, first of its kind in Asia—i.e. Indian Association for the Cultivation of Science, at Jadavpur in 1874.
[69] NAI, *RAC, Surveys*, prog. no. 25, Sept. 1880, pt. A.
[70] *Ibid.*, prog. no. 3, Aug. 1886, pt. A., K.W.
[71] *Ibid.*, prog. nos. 25-33, Sept. 1880, K.W.
[72] *Ibid.*, prog. no. 7, Sept. 1891, File No. 25, pt. A.
[73] *Calcutta Review*, vol. 39, no. 78, 1864, p. 438.
[74] NAI, *RAC, Surveys*, Prog. nos. 1-6, Sept. 1882, K.W. File No. 103, pt. A.
[75] *Calcutta Review*, Vol. 12, no. 23, 1849, p. 233.
[76] *Ibid.*, p. 235.
[77] *Calcutta Review*, Vol. 32, no. 63, 1859, p. 150.
[78] Despatch from the Court of Directors, No. 6, dated 13th Sept., 1854, See *Selections*, No. lxxvi, Cal. 1870, p. 29.
[79] *Ibid.*, p. 59.
[80] NAI, *RAC, Surveys*, prog. no. 3, Sept. 1882, pt. A.
[81] *Ibid.*, prog. no. 5.
[82] Mitra, Sarat Chandra, Original Scientific Research in Bengal, *Calcutta Review*, Vol. 103, no. 205, 1896 , p. 336.
[83] In sharp contrast to this earlier phase, during 1903-1947 one finds only 7 articles on coal, 8 on earthquakes and seismic problems, about 12 on various minerals and ores, and interestingly enough, about 7 articles on petrology—all this out of 43 volumes containing about 75 parts. The rest deal with structural and physical studies. These informations have been culled from the *List of GSI Publications*, Cal. 1975, pp. 1-16.
[84] *Calcutta Review*, Vol. 75, no. 149, 1882, p. xiii.
[85] NAI, *RAC Surveys*, prog. nos. 14-23, April 1882, File No. 47, pt. B.
[86] Fermor, L.L., History of the Indian Manganese Industry, *Memoirs of the GSI*, Vol. 37, pt. III, Calcutta, 1909, pp. 420-23.
[87] *Ibid.*, pp. 450-55.
[88] Fermor calculated that the total value of the manganese production during 1892-1906 was about £ 2,437,461. Had this one been converted into ferro-manganese in India itself, the least value to India would have been £ 11,448,582. India thus suffered a loss of £ 9,011,119 as a price for not manufacturing ferro-manganese in the country. See *Ibid.*, pp. 536-42.
[89] Anon. Fifty Years of GSI, *Nature*, Vol. lxxii, May 31, 1900, p. 105.
[90] This is true particularly for the last quarter of the 19th century when the Govt. asked for a clear-cut division of the GSI cadre into scientific and economic branches, Ref. NAI, *RAC Surveys*, Prog. nos. 1-2, Oct. 1893, File No. 174.