MEMOIRS

OF THE

GEOLOGICAL SURVEY

OF

INDIA.

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INDIA.

VOL. XVII.

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GEOLOGICAL SURVEY OF INDIA

Blanford

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ON THE INDUS AT SEHWAN.

MEMOIRS
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GEOLOGICAL SURVEY OF INDIA.

THE GEOLOGY OF WESTERN SIND—*By* W. T. BLANFORD, A.R.M.S., F.R.S., &c., *Deputy Superintendent, Geological Survey.*

PART I.

GENERAL DESCRIPTION.

CHAPTER I.—INTRODUCTORY.

Area described.

The area to be described in the present memoir comprises that portion of the province of Sind or Sindh[1] which lies west of the Indus, and especially the hilly portions of the Karáchi and Shikárpur Collectorates, together with the curious isolated ranges of limestone hills to the east of the Indus in Northern or Upper Sind near Rohri, and in Southern or Lower Sind near Hyderabad. Eastern Sind, and especially the district of Thar and Párkar, lying north of the Ran of Kachh (Cutch), has not yet been examined in detail.

Before proceeding with the description of the province of Sind, a few words are necessary to show how important is an accurate knowledge of the geology as a guide to that of other parts of British India.

It is unnecessary to recapitulate here what has been explained fully

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[1] The names of the province of Sind and of the river called the Indus by Europeans, are really identical; and Hindu, Hindustan, and India itself are all derived from the same source, the letters S. and H. being interchangeable, and the last frequently disappearing in the process of representing Oriental names by European equivalents. The old name of the Indus is Sindhu. There is a Muhammadan story about the name of Sind being derived from Sindh, the brother of Hindh and son of Noah.

in the recently published Manual of the Geology of India[1] further than to recall the circumstance that there is a wide distinction between the geological formations found in the Peninsula of India and those occurring in the neighbouring regions, and that the two areas have had a very different geological history, the peninsula of India having probably been land ever since middle palæozoic times at least, whilst the extra-peninsular regions have frequently been covered by sea. In several parts of these extra-peninsular regions—in Burma, the Assam hills, the Himalayas, the Punjab, and Sind—tertiary rocks occur in great profusion, and in most of the regions named some of these tertiary beds contain marine fossils. This is pre-eminently the case in Sind: not only are fossils abundant, but it has long been known that more than one formation is represented, and it has for years past been suspected that a much fuller series of marine tertiary beds exists in Sind than in other parts of the British possessions in India. This suspicion has been fully verified by the examination of the province. Two other advantages are offered by the country west of the Indus—the absence of the forest, which renders surveying so difficult and uncertain in many parts of India and Burma, and the circumstance that large collections of fossils from this region have been carefully examined and described by competent European palæontologists.

Difference between peninsular and extra-peninsular areas of India.

Importance of Sind geology.

The fossils, however, although well figured and described, have hitherto been almost useless as a guide to the relations of the beds containing them in various parts of India, because the formations in Sind remained unclassified, and it was uncertain from what part of the series particular species had been obtained. In the great French work, to which numerous references will be found in the following pages, the "Description des animaux fossiles du groupe nummulitique de l'Inde," by Viscount D'Archiac and M. Jules Haime, it was clearly shown that fossils from several sub-divisions of the tertiary series were represented

Horizon of Sind fossils hitherto described uncertain.

Sub-divisions of tertiary series numerous.

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[1] Introduction, pp. ii, vii, xi, &c.

amongst the Sind collections. The examination of the country has proved that these sub-divisions are even more numerous, and extend throughout a greater duration of geological time, than was suspected.

Examination of fossils.

Unfortunately the detailed examination and description of the large collections made by the survey from the Sind rocks have only been commenced, and only the more common and conspicuous species have hitherto been clearly identified, and their position in the series determined. Still the knowledge of the position occupied by characteristic species of foraminifers, corals, echinoderms, and mollusks in the sequence must aid in the correlation of fossiliferous beds in other parts of India.

Neighbourhood of Sind rocks to European formations.

Another advantage of Sind is that it is nearer to Europe than most parts of India, and that the rocks form the eastern prolongation of a tract of tertiary beds believed to be continuous with the well-known formations on the shores of the Mediterranean.

Previous arrangements for geological survey of Sind.

For these reasons it has for many years past been desirable that the geology of Western Sind should be examined in detail. The maps of the province were completed by the Revenue Survey in 1870, but before they were quite complete, all the most important areas had been mapped, and it was proposed to commence the geological examination of the province in 1869. Owing, however, to still more urgent demands upon the survey party at first selected for the work, the seasons 1869-70 and 1870-71 were devoted to some of the coal-fields in the Central Provinces. In 1871, I was again directed to commence the survey of Sind, but the work had once more to be postponed, in consequence of my being appointed to accompany the Perso-Baluch boundary commission.

Geologists engaged in survey.

Finally, at the close of 1874, Mr. Fedden was despatched to the province, and I joined him early in 1875. The whole of the three working seasons, 1874-75, 1875-76, and 1876-77, were devoted by Mr. Fedden to the examination of Central and Western Sind, and I was engaged in the area during the greater part of the same time, a portion of the season 1875-76 being employed by me in a traverse of Eastern Sind and of the desert intervening between Sind and Rájputána. The greater portion of Lower Sind, comprising the larger area, was mapped by Mr. Fedden; the hills of the Shikárpur Collectorate, and a few detached tracts in Lower Sind, such as parts of the Laki hills, and the Habb valley, by myself. The present memoir has been compiled from Mr. Fedden's reports and my own.

Comparison of fossils collected.

Besides his work in the field, Mr. Fedden has compared and determined a large proportion of the fossils collected. Professor Rupert Jones, one of the highest living authorities on *Foraminifera*, very kindly examined a series of the nummulites and some allied forms, so that most of the identifications of this most important but difficult group may be depended upon. Professor Martin Duncan has been so good as to undertake the examination and description of the corals, but it is to be feared that the results of his labour will not be received in time for use to be made of it in the present memoir. The identifications of *Mollusca* and *Echinodermata* are by Mr. Fedden and myself.

Published notices of survey results.

Two notices of the principal results of the Geological Survey of Sind have already been published in the "Records of the Geological Survey of India[1]," and a general description of the geology is given in the Manual of the Geology of India.[2] The preparation of this Manual has, however, taken so much time that the present memoir has been delayed until two years have elapsed since the survey of the province was completed.

Previous observers.

Although much has been written on the geology of Sind, the number of previous observers, before the examination by the Geological Survey commenced, was small, and most of the published observations related to the palæontology alone.

The first, and for many years the only, description of the geology of

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[1] Vol. ix, 1876, p. 8, and Vol. xi, 1878, p. 161.

[2] Pages 445 to 476.

Sind published was that by Captain N. Vicary,[1] who in 1845 made a journey from Karáchi to Sukkur, and visited on the way some of the ranges west of Sehwán and the outer hills of the Khirthar range at the Gáj river. Unfortunately his visit to the Gáj was cut short by want of supplies, and his intentions of re-visiting the section, the importance of which he recognized, were frustrated by the news he received of the preparations for the Punjab campaign.

Vicary, 1847.

Captain Vicary, in his paper, described the rocks around Karáchi, and especially the "arenaceo-calcareous rock" found in the vicinity. This he correctly recognized as of later date than the nummulitic limestone. He was, however, mistaken in supposing that the rocks around Munga Peer (Mugger Peer) were nummulitic, and he was apparently under the erroneous impression that the "nummulitic limestone of the Hala range" extended to Cape Monze. From Karáchi he marched to Kotri by a road passing for part of the distance near the course now followed by the railway, but running much more to the northward near Jungsháhi. At first he appears to have identified the rocks correctly, but in the neighbourhood of Kotri he evidently confounded the infra-nummulitic beds (Ranikot) with the upper nummulitic yellow limestones (Nari). From Kotri to Sehwán he traversed the low hills and the plain alternately, never going far from the river Indus. He gives a section of the hill range at the Laki hot spring, but he is again mistaken in his identification of the rocks near the spring with the groups overlying the typical nummulitic limestone.

From Sehwán he went to Taháni (Treenee), on the Manchhar Lake, which he supposed to have been excavated by the Indus in former times, and thence he marched *viâ* Sháh Hassan, at the western end of the lake, to Gáza Pir. He gives an excellent description of the remarkable tufa deposits formed by the hot spring near that locality, and appears to have identified the rocks near Gáza Pir, and especially the miocene beds (his

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[1] Note on the geological structure of parts of Sind. Quart. Jour. Geol. Soc. 1847. Vol. iii, pp. 334 to 349; reprinted in Carter's Geological papers on Western India, p. 501

No. 6) correctly. From Gáza Pir he traversed the alluvial plain to the Gáj (Gauj), where he examined only the outer hills composed of pliocene (Manchhar) conglomerates, clays, and sandstones, and noticed that they rested on the non-nummulitic formation, which he correctly identified with the rock of Karáchi. He found bones in the conglomerates, and made an acute remark upon the resemblance between the beds in Sind and those of the Siwalik hills, near Náhan. From the Gáj he marched to Sukkur, across the alluvium of the Indus.

Vicary's classification.

The following is the classification adopted for the formations in Sind by Captain Vicary, a classification which has repeatedly been quoted in geological works. The series is given in descending sequence, and opposite to each group is marked the supposed equivalent in the system adopted by the survey :—

Groups of Captain Vicary.	Geological survey groups.
1. Conglomerate	Manchhar (pliocene and perhaps upper miocene).
2. Clays and sandstone	
3. Upper bone-bed	
4. Sandstone; fossils rare	
5. Lower bone-bed	
6. Coarse calcareo-arenaceous rock with *Cytherea exoleta* and *C. exarata; Spatangi*, no nummulites.	Gáj (miocene).
7. Pale arenaceous limestone with *Hypponyces*, nummulites and *Charoideæ*.	Nari (?) (Oligocene or upper Eocene).
8. Nummulitic limestone of the Hala range .	Khirthar (Eocene).
9. Black slates, thickness unknown . .	(?)

Considering how rapid was Captain Vicary's march, and how small a time—less than two months—he devoted to an examination of the country, it is remarkable how good an idea he formed of the relations of the beds. That he should occasionally have failed to identify the groups correctly, was only to be expected in a hurried journey through new formations, many of them very ill-exposed, for he was unable to follow the groups, or even to keep to the parts of the country where the rocks were well seen. It is indeed rather surprising, in the face of his repeated and perfectly accurate observation as to the position of his group No. 6, that the presence of this distinctly miocene formation should not have been recognized by palæontologists earlier than was the case, and that its characteristic fossils, such as *Clypeaster* and *Breynia*, should so long have been classed as eocene. Captain Vicary's No. 7 is much less distinctly identified. It is difficult to tell what fossils he referred to as "Hypponyces;" but from a remark of his at page 343, that portions of some broken specimens were one inch and a half in thickness, it is not improbable that he was alluding to shells of *Nerita schmideliana*, the upper surface of which is patelliform.[1] As the species is not found in the Nari beds, it is evident, as indeed is manifest from other facts, that Captain Vicary confounded part of the Khirthar group, and also some beds of the inferior Ranikot formation, with the Nari group, which is certainly his No. 7 in places, *e.g.*, at page 339. His group No. 9, "black slates," must, I think, have been some of the dark-coloured shales which are interstratified in places with the nummulitic limestone.

One part of Captain Vicary's observations was singularly unfortunate. Misled by the imperfect maps of the period, which represented one range of hills extending down the right bank of the Indus from the Punjab to the sea, he seems to have confounded every hill he saw to the westward of his journey with a mythical 'Hala range.' He thought he saw this range running out into the sea at Cape Monze; he observed it again west of Kotri; he climbed to its summit at Gáza Pir; and he penetrated its outskirts at the Gáj river. Now, this Hala range was as utter a myth as the mountains of the moon, and instead of one great range of nummulitic limestone, as Vicary seems to have supposed, there are several ranges entirely distinct from each other, and not always composed of the same rocks. Moreover, not one of these ranges is now or ever was known in the country as the Hala range. Had the matter ended here, it would have mattered little, but this mythical Hala range has a charmed life in geological works, and, with the Hydra-like vitality of error, will doubtless survive, in association with the imaginary

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[1] I formerly (Rec. G. S. I., 1876, ix, p. 10 note), having overlooked the remark quoted above, suggested that the *Hypponyces* of Captain Vicary might be *Lunulites*.

volcano of Denodhar, in Cutch, to amuse future Indian geologists. At least one-half of the fossils collected by Vicary, and perhaps by others, appear to have been labelled 'Hala range,' and all hope of discovering whence they were obtained is consequently lost. Even within the last few years I have heard some of my own collections described as from the Hala range' by European geologists.

An earlier paper of Vicary's, entitled a "Geological Report on a portion of the Beloochistan hills,"[1] refers to the ranges north of Jacobabad inhabited by the Bugti and Marri tribes. This tract is beyond the area described in the present memoir.

Carter, 1844–1861.

The only two contributions of any great importance to the geology of Sind besides Vicary's are, the first mainly, the second purely, compilations, so far as the geology itself is concerned, the only important original work in both being palæontological. The first of these is contained in a series of papers by Dr. H. J. Carter, published, for the most part, in the Journal of the Bombay Branch of the Royal Asiatic Society. It will be as well to notice these papers in order. The earliest, entitled "Geological observations on the composition of the hills and alluvial soil from Hyderabad, in Sind, to the mouth of the river Indus,"[2] published in 1844, merely contains a few notes on the rocks, and is accompanied by poor figures of a few fossils, *Nautili*, *Nummulites*, *&c.* The next paper, "On Foraminifera, their organization, and their existence in a fossilized state in Arabia, Sindh, Kutch, and Khattyawar,"[3] appeared in 1849. This paper relates solely to the structure of the organisms described, and in no way treats of their geological relations. Omitting notice of some other papers on *Foraminifera*, the next in order is a short "Note on the pliocene deposits of the shores of the Arabian Sea,"[4] published in 1853. Some specimens of the "strata from the neighbourhood of the harbour" at Karáchi, collected by Major Turner, showed that the rock consisted of blue clay, with lignite,

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[1] Quart. Jour. Geol. Soc., 1846, ii, p. 260.

[2] Jour. B. Br. Roy. As. Soc., ii, pp. 40—43.

[3] Jour. B. Br. Roy. As. Soc., iii, part I, pp. 158—173.

[4] Jour. B. Br. Roy. As. Soc., iv, pp. 445—448.

upon which rested conglomerate, and Dr. Carter pointed out that a similar formation occurred throughout the whole western coast of India, and was found also in part on the south-eastern coast of Arabia and on the African coast and islands opposite. Some of the formations thus classed together have since been shown to be of a very different age from others, and it is not quite clear whether the blue clay of Karáchi belonged to the pliocene Manchhar beds, or whether it was a sub-recent deposit, no details being given as to its mode of occurrence.[1]

It will be best to notice together Dr. Carter's two principal papers on Sind *Foraminifera,* although there is a wide difference between the dates of publication, the first having appeared in 1853,[2] the second in 1861,[3] after the publication of D'Archiac and Haime's monograph of the genus *Nummulites,* noticed below, in which (pp. 342 and 343) some of Dr. Carter's earlier identifications are reviewed and corrected, and of that of Dr. Carpenter's papers on Foraminifera, published in the Philosophical Transactions.[4] In Dr. Carter's papers the genera noticed are *Nummulina* or *Nummulites, Assilina, Operculina, Alveolina, Orbitoides, Conulites,* nov. gen. (= *Patellina*), *Orbitolina, Cyclolina* =(*Orbitolites*), *Heterostegina, Cycloclypeus, Orbiculina,* and *Orbitolites.* The species described from Sind are the following:—

Dr. Carter's Sind Foraminifera.

1. *Operculina,* sp., subsequently named *O. tattaensis* by D'Archiac and Haime. Specimens agreeing with Dr. Carter's description, and procured at the same locality by Mr. Fedden, who identified them, are considered by Prof.

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[1] If, as appears far from improbable, the clay was obtained from the bore at Ghizri, made by Major Turner, of which a section is given in a later paper of Dr. Carter's (Jour. B. Br. Roy. As. Soc., Vol. v, p. 300), the formation was probably miocene (Gáj), as it was classed by Dr. Carter in the latter paper quoted.

[2] "Description of some of the larger forms of fossilized Foraminifera in Sind, with observations on their internal structure"—Jour. B. Br. Roy. As. Soc., v, pp. 124—141; Annals and Magazine of Natural History, Series 2, Vol. xi, p. 161; Geological Papers on Western India, p. 533.

[3] Further observations on the structure of *Foraminifera,* and on the larger Fossilized Forms of Sind, &c., including a new genus and species,—Jour. B. Br. Roy. As. Soc., vi, pp. 31—96; Annals and Magazine, Natural History, Series 3, Vol. viii, pp. 246, 309, 366, 446; Pls. XV, XVI, XVII; the plates, which are of great assistance in determining the species, are omitted in the Bombay edition.

[4] 1856, pp. 181, 547; 1859, p. 1; 1860, p. 535.

Rupert Jones to be a form of *Nummulites spira*. They are, however, a very marked and peculiar variety, and may perhaps retain the name *tattaensis*. They have only been found in lower eocene (Ranikot) beds.

2. *Assilina irregularis*, Carter. This is, according to D'Archiac and Haime, *Nummulites spira*, a view accepted by Dr. Carter.
3. *A.* sp. This is *Nummulites exponens*, according to D'Archiac and Haime, a view accepted by Dr. Carter.
4. *A. obesa*, sp. nov., described in the second paper. This is very near *Nummulites granulosa*.
5. *Nummulina* sp. *Nummulites carteri*, D'Archiac and Haime.
6. *N. obtusa*, Sow.
7. *N. perforata*, D'Orb. Dr. Carter, in his second paper, records his belief that *N, obtusa* is not distinguishable, a view which is probably correct.[1]
8. *N. biaritzensis*, D'Archiac and Haime.
9. *N. sublævigata*, D'Archiac and Haime; doubtfully identified in Dr. Carter's earlier paper with *Nummularia acuta*, Sow, (*N. scabra*). In some remarks on the localities and geological position of this species, Dr. Carter notes that it is found in yellow limestone in Sind, and at Muscat and Masira in Arabia, and he suggests rightly that this yellow limestone (Nari) is newer than the great white limestone (Khirthar). It is curious that Dr. Carter appears not to have met with *N. garansensis*, the constant associate of *N. sublævigata.*
10. *Fasciolites elliptica*, Parkinson,= *Alveolina elliptica*=*Alveolina ovoidea*, D'Orb.
11. *Alveolina melo.*
12. *A.* (*Melonites*) *spheroidea.* Dr. Carter, in his second paper, considers both these last species as varieties of *A. elliptica.* Messrs. D'Archiac and Haime appear to doubt the occurrence of the first. Two forms of *Alveolina* are found in Sind, one much more common than the other.
13. *Orbitoides dispansa* (*Lycophris dispansus*, Sow.).
14. *O.* (*Lycophris*) *ephippium*, identical with the last.
15. *O. pratti.* This is also identified with *O. dispansa*; but if this is correct, the species is probably not the true *Orbitolites pratti* of Michelin.
16. *Orbitolites mantelli*, H. J. C. The species thus identified is *Orbitoides papyracea*, (*O. fortisi*). This might be gathered from the description, but it is conclusively proved by the circumstance that the species is said to be found in yellow limestone with *Nummulites sublævigata.*
17. *O.* sp. Subsequently considered a variety of the last. It is the large form of *O. papyracea*, so common in the Nari beds.
18. *Conulites cooki*, gen. et sp. nov. *Patellina cooki*,—see Carpenter's Introduction Foram., Royal Society, 1862, p. 229.
19. *Orbitolina* sp. From Buran (? Báran) river.

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[1] Prof. Rupert Jones, to whom I sent specimens of *N. obtusa*, marked them *N. perforata*, var. *obtusa.*

20. *Cyclolina peduncalata*, Carter. An *Orbitolites*, as subsequently recognized by Dr. Carter, and distinct from *O. complanata*, Lam. included by D'Archiac and Haime with doubt in the Sind fauna.

Dr. Carter's most widely known contribution to the history of Sind geology is, however, that contained in his "Summary of the Geology of India, between the Ganges, Indus, and Cape Comorin," originally published in 1854,[1] and reprinted with additional notes in 1857.[2] Western Sind is of course outside of the area as defined, but still the rocks are repeatedly mentioned, and all the information then existing about them is quoted. The information was not extensive, and in fact was little more than that supplied by Vicary. The occurrence of nummulitic limestone at Hyderabad, Rohri, Dajikote (Kot Deji), Sukkur, near Karáchi, and in the Hala range, is noticed, and Vicary's section quoted; "lower blue clay," referred to miocene in the original paper, but subsequently, in deference to D'Archiac and Haime's views, classed as eocene, is said to be found at Karáchi, a section at Ghizri being quoted; and Vicary's bone-beds and gravels are classed with the ossiferous conglomerates of Perim Island, the Nerbudda, the Godávari, and the Jumna, and placed with the blue clay in the first edition, but removed from it and considered apparently as pliocene in the second. The rocks described at Minora by Vicary are called pliocene, and it is suggested that the hills at Jhirak (Jerruck), which rest on blue clay, may be of the same formation (they are really lower eocene or Ranikot). Some post-pliocene sands, conglomerates, and clays at Karáchi are also noticed. It is unnecessary to do more than refer to a few remarks on the "evidence of volcanic disturbance and effusion subsequent to the deposits of the eocene and miocene and pliocene formations," since the whole argument is vitiated by the incorrect idea, derived from Grant, that the traps of Cutch are, in great part at least, of later age than pliocene. Of the physical geology of the country scarcely anything accurate was known at the time Dr. Carter wrote; his compilation was, however, invaluable as a record of the imperfect knowledge existing.

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[1] Jour. B. Br. Roy. As. Soc., v, pp. 179—334.

[2] Geological Papers on Western India, pp. 628—776.

D'Archiac and Haime, 1853.

The third principal contribution to our knowledge of Sind geology, although purely palæontological, far exceeds in importance any of the others. It is contained in Messrs. D'Archiac and Haime's *Description des animaux fossiles du groupe nummulitique de l'Inde,* published at Paris in 1853. It is not too much to say that this work exceeds in value and importance any other on Indian palæontology ever published in Europe, and it is scarcely necessary to add that up to the date of its publication nothing approaching Messrs. D'Archiac and Haime's work in amount of information and thoroughness had appeared in India. The authors brought to the work an extensive knowledge of European tertiary fossils, and the superb plates of figures, amongst which most of the common fossils of the Sind lower tertiaries were represented, have ever since been of the greatest service to all geologists engaged in investigating the tertiary rocks of India. Nevertheless, several of the conclusions drawn from the imperfect knowledge of the rocks then available have since required modification, and in one respect at least, in classing all the marine fossils from Sind and Cutch as lower tertiary, and in overlooking the presence of a large miocene fauna, the authors fell into an error which has largely affected subsequent researches.

Messrs. D'Archiac and Haime's work is too well known to require detailed description. All that is necessary here is to review those parts of it especially relating to Sind. The book is divided into two parts—the first consisting of a monograph of the genus *Nummulites* extending to 164 quarto pages, with eleven plates, and the second of the description of Indian nummulitic fossils (pages 165—373 and Plates XII—XXXVI). The first part is general, and of the species of nummulites described the majority have not been found in India; it is with the second part that we are especially concerned. This commences with a *Résumé Géologique,*[1] containing a very full summary of all that had been written by Indian observers, up to the date of publication, on the geology of the Indian

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[1] The *Résumé* in question is chiefly taken from D'Archiac's *Histoire des progrès de la Géologie,* Vol. iii, page 195.

nummulitic rocks. For convenience in this and in subsequent portions of the work, the nummulitic formations of India are classsd in four regions—the first comprising Cutch, Sind, and part of Baluchistán; the second the northern part of the Sulemán range and the whole Salt Range of the Punjab; the third the Subáthu country, near Simla; whilst the fourth includes "some points in the very centre of the Himalayas, and others more distant towards the east." In this last region are comprised two tracts at an enormous distance from each other—the Upper Indus valley,[1] and the Khási (Khossya) hills with Sylhet. It is not quite clear why these should be associated in one region, especially as it is noticed that the nummulitic rocks appear to extend from the second region in the Punjab, both north-east and north-west, in which direction "they surround the high valley of Kashmir." The importance of the first region, comprising Sind and Cutch, is shown at once by the fact that it furnished 336 out of the 415 species of fossils noticed in the work. A brief account is given of the geological descriptions by Burnes, Grant, and Vicary. The fossils procured from Cutch by Grant, and described by Sowerby, appear not to have been compared by Messrs. D'Archiac and Haime, although many were identified by their figures with species found in Sind and elsewhere. The most important change effected in the classification by the French palæontologists was to unite the formations distinguished in Cutch by Grant under the names of nummulitic and tertiary, and in this they were partly right; for the "tertiary" fossils of Grant comprised numerous nummulitic species, and there had doubtless been a great admixture, in his collections, of fossils from eocene rocks with others from a higher horizon. The collections of Vicary furnished the bulk of the materials for the nummulitic fauna

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[1] The only recorded observation is that of Dr. T. Thomson, who is said to have found a bluish-grey limestone, containing *Alveolina melo* and *Nummulites ramondi,* on the top of the Singhe-la (Singhi Pass), at an elevation of 4,875 metres (16,000 feet) between Zánskár and the Indus valley. On this subject see the foot-note by Mr. Medlicott to the *Manual of Geology of India,* p. 644, where it is shown that grave doubts exist as to the locality having been correctly recorded by Messrs. D'Archiac and Haime. (N. B.—Information has just been received from Mr. Lydekker, since the preceding remarks were put in type, that he has examined the locality, and that no nummulitic beds exist there.)

of India. Several of the species common to the nummulitic rocks of Europe are noticed towards the end of the brief geological summary, in which the works of different explorers are noticed.

After the geological *Résumé* comes the description of the different species, occupying 162 pages. Then there is an appendix in which several species are added to the list, and this is followed by a *Résumé Général* and a *Tableau de la Faune Nummulitique de l'Inde.* The *Resumé Général* treats of the relations between the Indian and the European nummulitic fauna, and between the fossils from different regions in India, and it also contains a critical notice of several papers on Indian tertiary geology not reviewed in the preliminary *Résumé Géologique.* The "*Tableau*" gives a complete list of all the Indian nummulitic fossils known, with their distribution and references.

In the *Résumé Général,* the authors again express their conviction that all the marine tertiary fossiliferous beds of Cutch and Sind belong to the lower tertiary "terrain," and that all should be comprised in the "nummulitic group." Dr. Carter's classification of Grant's tertiary beds of Cutch in the miocene is objected to, and it is shown that several of the characteristic fossils occur elsewhere associated with nummulites. This is quite correct; for, as already mentioned, several of Grant's tertiary fossils are from eocene beds. Messrs. D'Archiac and Haime add this very important sentence:—"We consequently continue to begin the middle tertiary formation here only with the lower beds containing bones of large mammals."[1] But still it is shown that the distribution of different kinds of nummulites may aid in establishing a succession of different beds amongst the Indian tertiary rocks; and it is suggested that the *Nummulites ramondi* and *N. leymeriei* with *Alveolina ovoidea* and *Operculina canalifera,* which abound with casts of *Nerita schmideliana,* may characterize, as in Europe, the lowest bed; that *Nummulites lucasana,*

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[1] This conclusion of Messrs. D'Archiac and Haime has unquestionably had a great influence in inducing European geologists and naturalists to class the Siwalik fauna as miocene, in opposition to the views of Indian geologists. It is strange that the miocene age of the Siwalik fauna should be still so strongly urged, although it was shown years since that Messrs. D'Archiac and Haime were mistaken in supposing that miocene marine rocks were wanting in Western India.

N. guettardi, *N. granulosa*, and *N. exponens* may perhaps belong to a rather higher horizon, and *N. garansensis* mark, as in the neighbourhood of Dax, the latest period of existence of these animals.

At the same time, some of the fossils of Sind are arranged, in accordance with the nummulites found associated with them, in three categories, the two lower of those already mentioned being united, and a third being formed of those fossils with which no nummulites are found, it being considered uncertain whether the last is higher in the series than the two others, or intermediate. It is, however, observed that the absence of nummulites in specimens of fossils is merely accidental, and insufficient to prove that such specimens are from a distinct bed. Lists of the species found associated with different forms of nummulites, &c., are given, and the majority of these are correctly classified and have been found in the positions assigned. Of course Messrs. D'Archiac and Haime were unaware that, besides the beds without nummulites overlying the nummulitiferous formations, there were other beds at a lower horizon in which nummulites were scarce or wanting. They appear, moreover, not to have attached sufficient importance to Vicary's recognition of a formation without nummulites above the other marine beds.

Other writers.

The works already quoted contain, with one exception only, all the information of any importance with reference to the rocks of Western Sind before the commencement of the survey. The exception is the recognition of distinctly miocene fossils in the Sind collections by Professor Martin Duncan and Mr. Jenkins. The following is a list, arranged in order of time, of, so far as is known, all papers and works in which the geology of any part of Western Sind is described from observation. The list might of course be indefinitely extended by quoting every writer who published an account of his travels in any part of Sind, or who referred to the observations of others. There are, for instance, several itineraries in the Transactions of the Bombay Geographical Society, but none of them add to the geological knowledge of the country. It may even be questioned whether some of the writers quoted below can be said to have described the geology of the province.

Burnes, 1835-38.

A paper by Lieutenant (afterwards Sir Alexander) Burnes "On the Geology of the banks of the Indus," &c., was read to the Geological Society of London in 1833. Of this paper an abstract was printed in the Geological Transactions, Series 2, Vol. iii, page 491, and in the Proceedings of the Geological Society, Vol. ii, page 8. Brief mention is made of some of the rocks observed on the banks of the river in Sind in the "Cabool," by the same author, page 40: the hot spring at Laki and the abundance of fossils in the limestones are noticed.

Postans, 1843.

In a "Report on Upper Sind and the eastern portion of Cutchee," by Lieutenant J. Postans, Assistant Political Agent, published in the Journal of the Asiatic Society of Bengal, Vol. xii, page 29, under the head of minerals, the occurrence of sulphur and alum in the Marri and Bugti hills is mentioned, and of limestone at Sukkur and Rohri; but the want of stone in Upper Sind is noticed as the great peculiarity of the country.

Collier, 1850.

Surgeon C. F. Collier published a paper, in the Transactions of the Bombay Geographical Society, Vol. ix, page 99, entitled "On the nature of the soils of the Bombay Presidency." This paper comprises, page 108, a few remarks on the rocks around Hyderabad and on the road thence to Karáchi *viá* Tatta.

Buist, 1852.

The next paper is one by Dr. Buist, entitled "The Volcanoes of India," and is also published in the Transactions of the Bombay Geographical Society, Vol. x, page 139. The hot-springs at Mugger Peer and Laki are mentioned, and a crater is described as having been blown out in the "Minora hills" 2 miles west of Mugger Peer. Three views of the supposed crater are given, Plates VI, VII, VIII. No igneous rocks are known in the locality, and from the figures it is probable that the supposed crater is due to denudation of a peculiar form, very possibly affecting a hard bed resting on softer strata.

Merewether, 1852.

"A report of the disastrous consequences of the severe earthquake felt on the frontier of Upper Sind on the 24th January 1852," by Lieutenant (now Sir W.)

Merewether, appeared in the Transactions of the same Society, Vol. x, page 284. This is an account of a severe and destructive earthquake in the Marri Hills north of Jacobabad. A notice of other earthquakes felt in Sind and its vicinity in the year 1851 is added.

Frere, 1853.

In the Quarterly Journal of the Geological Society for 1853, Vol. ix, page 349, there is a letter "On the Geology of a part of Sind," written by H. B. E. (now Sir Bartle) Frere, to Colonel Sykes. In this letter mention is made of a collection of bones of mammalia procured by Mr. Arthur Young, Deputy Collector of Sehwân, from a locality "in the hills south-west of the Manchhar Lake and Sehwán, and about half-way to Sháh-billáwall, but on the east side of the Habb river." A few notes are also given of the rocks seen on the hill road between Karáchi and Sehwán, and a section of a nummulitic range, showing an anticlinal of nummulitic limestone, on one side of which, resting on the limestone, are "variegated marls and shales, or indurated mud beds," and on these again "beds of gravel and sandy conglomerate." Each of these groups is shown to be unconformable to the other. With the exception of the unconformity, which is rather unusual, and perhaps is due to an error on the part of the draughtsman, similar sections do occur in many places on the road mentioned, and the relations of the rocks are precisely as shown in the figure. The locality for mammalian bones has not been re-discovered, and it is impossible to avoid suggesting whether some mistake may not have been made about its position, and whether the bones did not really come from the Laki range. In all probability the Mr. Young who collected the bones is the same as the Dr. Young mentioned below as having presented a collection to the Asiatic Society of Bengal through Dr. Spilsbury, who made an extensive collection in the Nerbudda valley.

Carter, 1857.

Some "Contributions to the Geology of Central and Western India" by Dr. H. J. Carter, in the Journal of the Bombay Branch of the Royal Asiatic Society, Vol. v, include (page 628) a notice of Messrs. D'Archiac and Haime's work on the nummulitic fauna of India, and several additions to the previous account of the geology by the author. Several of these additions and corrections refer to Sind; but all are embodied in the second edition of Dr. Carter's summary of the geology of India, which has already been noticed.

Falconer, 1859.

In the "Descriptive catalogue of the fossil remains of vertebrata from the Sewalik hills, &c., in the Museum of the Asiatic Society of Bengal," by Dr. H. Falconer and Dr. Walker, pages 256 to 259, several specimens of bones and teeth of mastodon, rhinoceros, crocodiles, &c., are enumerated from Sind. Apparently the history of these specimens could not be traced in the Society's Journal, for the reference to the volume and page has been left without the numbers being filled in, and no notice of any Sind fossils can be found in Piddington's Index to the Geological, Mineralogical, and Palæontological papers. The specimens are said to have been presented by Dr. Young through Dr. Spilsbury, to have been brought from "Sehwán, on the north side of the Jukkeo (? Laki) hills," and to have been found in a low range of sandstone breccia composed of angular pieces of nummulitic limestone cemented with clay. The collection was probably part of the same as that noticed in the preceding paragraph. The only species identified was *Mastodon latidens.*

Carter, 1861.

Two notices published in 1861 refer to the discovery of lignite at Leilan, or Lynyan, near Kotri. The first occurs in a second series of "Contributions to the Geology of Western India, including Sind and Beloochistan," by Dr. Carter (Jour. B. Br. Roy. As. Soc., vi, page 182), and is entitled "Discovery of coal deposits in the Lyneah valley, Sind," by Captain F. Phillips. The note, however, is evidently written by Dr. Carter. It contains sections by Mr. Inman of the rocks on the sides of the valley in which the so-called coal was found, and of the shafts sunk to cut the seam. Dr. Carter comments on the unconformity shown in Mr. Inman's section between the nummulitic limestone and the beds associated with the lignite, and evidently doubts whether any such unconformity exists,—a doubt, it may be added, which has been perfectly justified by the result of further examination of the ground. He also points out the close similarity between the beds underlying the nummulitic limestone and some found at Jhirak, in Sind, and at Muscat, in Arabia. Here also, so far as the Jhirak deposit is concerned, at all events, Dr. Carter is perfectly correct, the beds at the last-named locality being identical with those of Lainyan.

The second note is a brief communication on the quality of the coal from Lainyan, also by Dr. Carter; this occurs in the Proceedings of the same Society for June 1857, and is also published in the sixth volume of the Journal, Appendix, page xxxvi. The coal is shown to be similar to that of some other tertiary formations.

The next two papers referring to Sind are those to which allusion has already been made as affording the only important addition to the palæontology of the country since the work of D'Archiac and Haime on the nummulitic fauna of India. The first of these papers, in order of appearance, was one by Mr. H. M. Jenkins "On some tertiary mollusca from Mount Sela, in the Island of Java" (Quart. Jour. Geol. Soc., xx, page 45). In this a species of *Vicarya* was described as closely allied to the type of the genus described by Messrs. D'Archiac and Haime from Sind. The fossils occurring associated with the Javanese *Vicarya,* however, pointed so unmistakeably to a later age than eocene, that Mr. Jenkins was led to enquire into the question whether some of the Sind fossils might not also be derived from a higher horizon, and he found that several, having the same matrix as *Vicarya verneuili,* were miocene forms in Europe. This probability of the existence of miocene beds in Sind was confirmed by Professor P. Martin Duncan, who furnished a note for insertion in Mr. Jenkins' paper (l. c., page 66), and who shortly after published, in the Annals and Magazine of Natural History, for April, 1864 (Ser. 3, xiii, page 295), descriptions of a considerable number of Sind corals not noticed in MM. D'Archiac and Haime's work. These descriptions raised the number of corals known to occur in the tertiary rocks of Sind from 17 to 42, and a large proportion of the additions belonged to genera unknown below the miocene, some indeed having pliocene or recent affinities. Several of the fossils were from Karáchi, and the only fossiliferous

Jenkins, 1864.

Martin Duncan, 1864.

rocks near the town are of Gáj (miocene) age. Indeed, fossil corals are extremely abundant in the Gáj beds near Mugger Peer.[1]

Lalor, 1865.

"A report on Dhur Yaroo, in the Shikárpur Collectorate," by Assistant Surgeon J. Lalor, published in the Transactions of the Bombay Geographical Society, Vol. xvii, page 302, mentions briefly some of the rocks of the Khirthar range near the locality described.

Evans, 1866.

In the Geological Magazine for 1866, Vol. iii, page 433, Mr. John Evans described some flint cores, from which flakes had been chipped, obtained by Lieutenant Twemlow, R.E., in the bed of the Indus. The cores were remarkable for their regularity. In a note to Mr. Evans, accompanying the specimens, General Twemlow stated that the cores in question were obtained "three feet below the rock in the bed of the river (Indus)." In a subsequent letter (Geol. Mag., 1867, iv, page 43,) General Twemlow gave a section on the river Indus near Sukkur, showing that above nummulitic limestone came a mass of flints covered by a recent silt deposit. The cores were found in the flint beds. The subject will be found more fully discussed in a note by the present writer, published in the Proceedings of the Asiatic Society of Bengal for 1875, page 134. Large quantities of flint cores have been found near Sukkur and Rohri, and there is a good collection in the Geological Museum, Calcutta.

Twemlow, 1867.

Gazetteer, 1874.

A very good Gazetteer of Sind was published in 1874, compiled by Mr. A. W. Hughes. The geology, however, was scarcely referred to, and the few notes upon it are by no means always correct.

Survey, 1867.

Lastly, the Survey contributions to the geology of Sind commenced with a paper, by the author of the present report, "On the geology of the neighbourhood of Lynyan and Runneekote," published in the Memoirs of the Geological Survey of

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[1] It is needless to give lists of the corals described by Professor Martin Duncan, as it may be hoped that full descriptions of the much larger collections made by the survey will shortly be published by the same naturalist who has undertaken their description.

India, Vol. vi, page 1. This paper contained the geological observations made on a hurried visit from Kotri to Lainyan and Ranikot, to ascertain the prospects of additional discoveries of coal. The position of the rocks at both places was ascertained, but nothing more was done to investigate the series of rocks occurring in the province.

Two notices, as already mentioned, have also appeared in the Records of the Geological Survey—the first in Vol. ix, pages 8—22, the second in Vol. XI, pages 161—173—embodying a brief summary of the results of the present survey.

Papers on neighbouring districts.

Of descriptions relating to the geology of neighbouring districts, the most important are the following:—A paper by Dr. Cook, entitled "Topographical and Geological Sketch of a portion of the province of Jhalawan and the eastern division of Mekran," published in the Transactions of the Medical and Physical Society of Bombay for 1860, Vol. vi, pages 1—45. This paper was noticed, and several additional details of the fossils collected were furnished by Dr. Carter, in the Journal of the Bombay Branch of the Royal Asiatic Society, Vol. vi, page 184, under the title of "Geological Discoveries in the valley of Kelát and surrounding parts in Beloochistan." To the northward of Sind the only information available is to be found in Dr. Cook's "Geological Report on a part of Beloochistan" (Transactions, Med. Phys. Soc. Bombay, v, 1859, page 105), relating to the Bolan pass; Captain Vicary's "Geological Report on a portion of the Beloochistan hills" (Quart. Jour. Geol. Soc., ii, page 260), describing the Marri and Bugti ranges north of Jacobabad; and Mr. Ball's "Geological notes made on a visit to the coal recently discovered in the country of the Luni Pathans, south-east corner of Afghanistan"—Rec. Geol. Surv. Ind., 1874, Vol. vii, page 145. The formations of Cutch are described by Mr. Wynne in the Memoirs of the Geological Survey of India, Vol. ix. The tertiary rocks of the Indian peninsula, including Kattywar and Cutch, are briefly described in the Manual of the Geology of India, Chapter xiv; the post tertiary formations in Chapters xvi, xvii, and xviii; Sind itself in Chapter xix; and the Western Punjab in Chapters xx and xxi.

CHAPTER II.—PHYSICAL GEOGRAPHY.

Surface characters of Sind.

The province of Sind consists of the alluvial plain bordering the lower course of the Indus, of the hill ranges to the westward of that stream, and of a great sandy tract to the eastward, part of the Indian desert. The country lies between the 23rd and 29th parallels of latitude, and extends from a little west of the 67th to a little east of the 71st meridian of east longitude. It is about 360 miles in length from north to south, and 275 in extreme breadth; the average width from east to west being about 170 miles. Inclusive of Khairpur and of Thar and Párkar, the area of the province is stated in the Official Gazetteer to be 57,145 square-miles.

Boundaries of province.

On the north and west, Sind is bounded by Baluchistán; on the east, by Baháwalpur, Jaisalmir, and Maláni, the last-named a district belonging to Jodhpur; and on the south by the sea and the Ran of Cutch. On the north-east alone, and for only a short distance on the right (west) bank of the Indus, is the boundary formed by a part of the Punjab. No physical features mark the limit of the province to the east, north-east, and north, though in the last direction the Bugti hills are not far beyond the boundary of the frontier district; but the western limit of Sind is formed to the northward by a lofty range of hills, the Khirthar,[1] and to the southward by the river Habb or Hab, which runs into the sea west of Cape Monze.

Political sub-divisions.

For administrative purposes, this tract of country is divided into three collectorates—Shikárpur to the north, Karáchi to the south-west and south, and Hyderabad in the centre—and comprises in addition the frontier district of Upper Sind, (ruled from Jacobabad), the district of Thar and Párkar (chief town Umarkot) east of Hyderabad, and the territory of Khairpur, a native state lying east of the Indus and south of Rohrí. The collectorate or division of Shikárpur is divided into the districts of Rohrí, Sukkur, and Shikárpur, Lárkána, and Mehar; the Karáchi collectorate comprises

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[1] They are miscalled the Hala range on many maps.

Sehwán, Kohistán, Karáchi, Jhirak (Jerruck or Jhirruck), and Sháhbandar; and Hyderabad consists of the sub-divisions of Naushahro (Nowshera), Hála, Tanda or Tando, Muhammad Khan, and the Hyderabad Taluka.

Area treated of in this memoir.

As already pointed out in the last chapter, the present memoir deals only with Western Sind and some hill tracts in the middle of the province. Eastern Sind, and especially the Thar and Párkar district, is beyond the limits of the tract here described.

Indus plain.

The plain of Sind is part of the immense alluvial flat which is watered by the Indus and Ganges and their tributaries, and which divides peninsular India from the rest of Asia. This plain is of course far inferior in geological importance to the small, hilly tracts of the province. The surface of the Indus plain consists of alluvial soil deposited by the Indus, or by streams from the mountain ranges; but large tracts to the eastward and smaller areas to the west of the river are covered with blown sand. The central portion of the plain in Upper Sind, that traversed by the present course of the Indus, is higher than the country to the westward, and than part of the tract to the eastward, and consequently a belt of marsh extends from north to south at some distance from each bank of the river; that to the eastward being traversed by a stream, the eastern Nára, fed by the overflow of the Indus flood-waters in Baháwalpur and the Rohri district of Upper Sind, whilst the western belt of marsh lies not far from the foot of the Khirthar range, and terminates to the southward in a shallow lake, the Manchhar, about 12 miles in length from W.N.W. to E.S.E., and 6 to 7 broad in the dry season, but much larger when filled by the floods of the Indus. West of this marsh, and also along the northern boundary of the province, there is a very flat plain, having an imperceptible slope from the hills, in parts absolutely destitute of vegetation, but generally bearing scattered bushes of lána (*Anabasis multiflora*) and other plants. This plain is

Marshy depressions.

Manchhar lake.

locally known as 'pat'; it is highly fertile when irrigated, but is usually barren for want of water. The surface consists of a fine light-coloured loam deposited by streams running from the hills. At the base of the hills themselves there is a slope of gravel corresponding to the Bhábar at the base of the Himalayas, and composed of detritus washed by water from the surface of the rocks: this slope frequently attains large dimensions.

"Pat."

The southern portion of the Indus plain consists of the delta, the head of which is generally placed a little above Hyderabad, where the Falaili (Fuleli or Phuleli) Channel leaves the main stream. The tide ascends the river almost as far as Tatta, or 60 miles from the sea in a direct line. The portion of the delta near the sea, extending 20 miles from the coast, is very low, and it is flooded when the river is at its greatest height in the monsoon, large tracts being overflowed at every spring tide.

Delta of Indus.

Within the area of the Indus plain, and even within the limits of the delta, there are some isolated tracts of low limestone hills. The most northern of these extends from the neighbourhood of Sukkur to the southward for nearly 50 miles, and is 17 miles broad where widest, near Kot Deji or Diji. It rises about 150 feet from the plain in the neighbourhood of the Indus. East of the Indus, in Lower Sind, there is a second smaller area of low hills, on the northern portion of which the town of Hyderabad is built. This tract of hills extends 21 miles from north to south, by about 6 miles wide. A third ridge of high ground occurs close to Tatta, and is 18 miles long from north to south, and 4 from east to west. In all these cases portions are detached and separated by alluvium from the main range, and there are some other small and unimportant patches, none of which are of any size, near the edge of the alluvial area. One of these, near Jhirak, is situated on the east bank of the Indus.

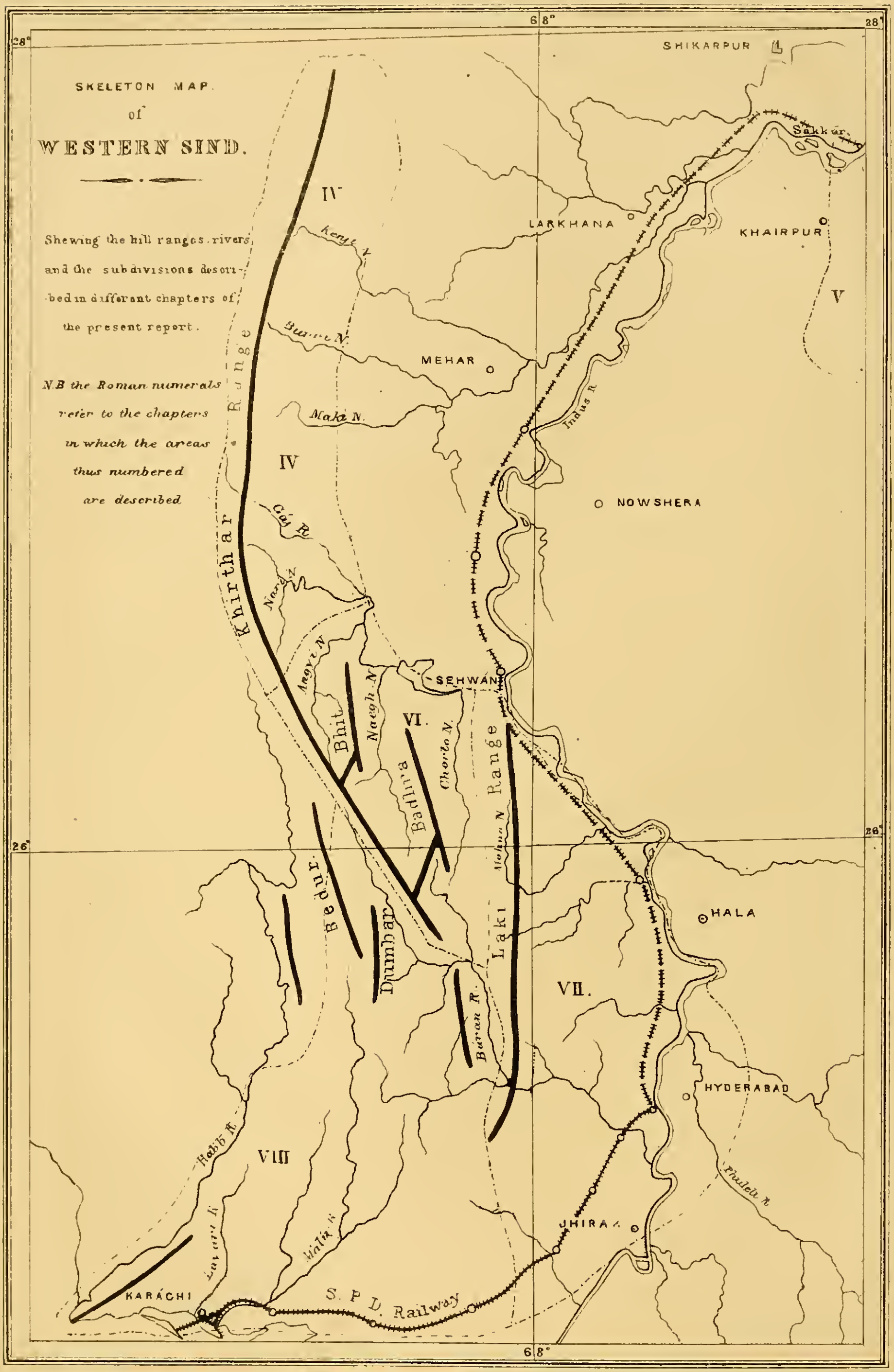
Isolated hills in Indus plain.

The rock area near Sukkur is chiefly remarkable for being intersected by the channel of the river Indus, which, strange to say, has cut its way through the limestone range between the towns of Sukkur and Rohri,

GEOLOGICAL SURVEY OF INDIA

Blanford

Memoirs Vol XVII Pl II.



On Stone by Aminullah, & S K Hº

instead of pursuing a course through the alluvial plain to the east or west of the hills. The fortified island of Bakhar, or Bukkur, in the middle of the river between the two towns, is also of rock. Nor is this all, for at Aror, 4 miles south-west of Rohri, there is another break in the limestone range, and this gap is said, on what appears to be good historical evidence, to have been a former bed of the river deserted for the present channel rather more than nine centuries ago.

Intersection of rock area by Indus.

The present memoir, as already noticed, does not deal with Eastern Sind, where, however, the rock areas which occur are mere isolated exposures, greatly concealed by an expanse of blown sand. All the principal hills of Sind lie west of the Indus, and nearly all consist of north and south ranges. On the accompanying sketch map (Plate II) the various ranges are represented by lines. Near the river, north of the town of Káshmor, the southern spur of the Sulemán range, which forms the western boundary of the Punjab, comes within the limits of Sind; but this small tract of rock has not been examined, as it is far distant from the other rock areas of the province, and is a part of a range included in the Punjab. The most important of the Sind ranges is the Khirthar, commonly, but incorrectly, called the Hala range on English maps. This range, commencing just north of the north-western extremity of Sind, forms the western boundary of the province as far south as Lat. 26° 15′, south-west of Sehwán, the general direction being nearly north and south; but, turning somewhat more to the eastward opposite Sehwán, the chain finally terminates within the province in Kohistán, nearly north-west of Hyderabad. The area of Lower Sind, south of Sehwán, and west of the Indus, comprises a number of ranges of hills, the greater portion having a general north and south direction, and all being much inferior in height to the Khirthar.

Hills of Western Sind.

Khirthar range.

Hills of Lower Sind.

The general height of the Khirthar, to the west of the Lárkána and Mehar districts, is between 4,000 and 5,000 feet, the highest peak, Kutta-jo-Kabar (the dog's tomb),

Height of Khirthar range.

being marked on the survey maps as 6,016 feet above the sea. The Gáj river rises to the westward of the range and cuts through it by an impassable gorge west-south-west of Mehar. South of the Gáj the Khirthar again rises to a height of nearly 5,000 feet, but soon sinks to a lower elevation, and to the southward rarely exceeds 3,500 feet in height. The main ridge is composed of nummulitic limestone, but there are several minor parallel ridges of newer beds to the east of the main range, and the best sections of the tertiary formations are seen on the banks of the streams draining the range.

Minor hill ranges of Lower Sind.

It has already been said that Lower Sind west of the Indus consists of a hilly tract of country. Perhaps more correctly the area may be described as consisting of parallel or sub-parallel ridges of hills, with broad undulating plains between them. It will be well to enumerate the ranges in detail; the more so as but few of them have definite names. In Sind, as in many other parts of Western India, names are given by the inhabitants of the country to all peaks and prominent hills, to passes, and to small hilly tracts, but not to ranges as a whole, and in describing such ranges it frequently becomes necessary to adopt, for the whole, terms applied by the natives of the country to only a portion.

Laki range.

The most important range of Lower Sind, from a geological point of view, is that commencing at Bhagothoro, just south of Sehwán, and extending thence to the southward for about 80 miles, until it terminates to the south of Bula or Bhule Khán's Thána. Particular portions of this range are known by various names,—Dhəran and Tiyun to the northward, Dáphro and Eri farther south, and Surjáno to the eastward of Bhule Khán's Thána,—but no general term for the whole range exists. The northern portion, however, is frequently called the Laki range by Europeans from its passing close by the town of Laki (Lukkee), and this term will be applied in the present memoir. The Laki range divides an undulating plain to the eastward, known in part as the Vera plain, from the broad valley traversed by the so-called "hill road" from Karáchi to Sehwán. The highest hills of the Laki range are near the northern extremity, but none attain an elevation much exceeding 1,500 feet above the sea. West of Mánjhand, the eastern portion of the range is traversed by a small stream called Mohan (Runneewaree and Sanwari of the map), and on this stream is situated a large fortified enclosure known as Ranikot (Rani-jo-kot), or Mohan Kot.

Badhra range.

West of the valley traversed by the hill road from Karáchi to Sehwán and south of the Manchhar lake there is a rather high ridge of limestone, nearly 30 miles long from north to south, and joining the Khirthar range close to the southern extremity of the latter. This range is called Badhra (Budhra) on the survey maps, and consists of a great anticlinal roll of nummulitic limestone. To the west of this, again, is a smaller ridge of similar formation known as the Bhit range, likewise joined to the Khirthar on the south, but only about 20 miles in length and 2,790 feet in elevation where highest. A low nameless ridge, chiefly composed of miocene rocks, runs from north-west to south-east, parallel with the south-western shore of the Manchhar lake.

Bhit range.

Country east of Laki range.

All the ranges hitherto noticed are on the eastern side of the Khirthar range, the Laki range alone extending to the southward beyond the termination of the Khirthar. East of the Laki range there are no hills of any elevation, although there is a considerable tract of broken hilly country near Kotri, and extending thence northward to Mánjhand and southward to Jhirak and Tatta. The Khirthar terminates to the southward close to a small police post called Karchát, near the banks of the Báran river. South of the Báran, a comparatively low ridge of nummulitic limestone runs north and south for about 20 miles, terminating near Bhule Khán's Thána. The next ridge to the westward is known as Dumbár, and is of no great elevation or length; it runs for about 15 miles north and south, west

Dumbár ridge.

of Tong. A much higher range, that of Bidúr, farther to the westward, forms the eastern watershed of the Habb river, and extends for a long distance to the northward, but it lies nearly throughout west of the Sind frontier.

Bidúr ridge.

South of this the country assumes a different appearance. The Habb valley is a wide plain, not alluvial, but undulating, and containing low hills of sandstone in places. To the east of the Habb valley are several broad flat plateaus of moderate elevation, composed of miocene beds and divided from each other by lower plains. Two of the principal plateaus are known as Mol and Miher, or Mahr, the latter lying to the west of the former and not extending so far north. To the southward these plateaus sink into the plain, or are broken up into low ranges of hills in the country north and north-east of Karáchi. One of the best marked of these ridges runs from near Mugger Peer, north of Karáchi, to Cape Monze. West of the Habb river there is a much higher range, rising to upwards of 3,000 feet in places, known as the Pabb range.

Habb valley.

Mol and Miher plateaus.

Pabb range.

As will be shown in the sequel, nearly all the ranges mentioned are of peculiarly simple geological construction, many of them being merely anticlinal rolls of nummulitic limestone, from which the softer overlying beds have been removed by denudation. As a rule, the anticlinals are steeper on one side, generally the eastern, and they frequently consist of a double anticlinal fold with a small synclinal between. The general direction of the ranges, as already noticed, is nearly north and south. Faults and dislocations are of rare occurrence, and those which occur are frequently parallel to the axes of the hill ranges.

Geological structure of hill ranges.

The rivers of Sind (see Plate II), apart from the Indus and its branches, are unimportant, and the majority are dry after rain. The largest is the Habb, which rises in Baluchistán, much farther north than it is represented on the maps,

Rivers of Sind. Habb river.

and after forming the western boundary of Southern Sind, falls into the sea west of Cape Monze. The only other stream of any length in Lower Sind west of the Indus is the Báran, which rises in Kohistán close to the British frontier, north of Tong, runs past the south end of the Khirthar range, and then turning southward traverses the broad valley west of the Laki range to the neighbourhood of Bhule Khán's Thána; it then turns eastward, cuts its way through the Laki range, and, after traversing the Vera plain and the low hills west of Kotri, falls into the Indus some miles south of the last-named town. Other streams are the Layári, an unimportant water-course, dry, except after heavy rain, draining the country north of Karáchi and running into the harbour; the Malir, another similar but rather longer water-course, a little further east; the Mohan, or Rani, already noticed as running from the Laki range, and joining the Indus at Sann, and three streams, which run from the valleys of Kohistán to the plain of Upper Sind, near the Manchhar lake. These are the Chorlo, west of the Laki range, a stream called Nie Naegh[1] on the Revenue Survey maps between the Badhra and Bhit ranges, and the Angyi stream, west of the Bhit.

Báran river.

Layári, Malir, and Mohan.

The water-courses running from the Khirthar range, commencing on the north, are the following. The Sain,[2] which drains the western side of the main range, north of Dharyáro, and runs into the Shadihar stream at the northern termination of the range. The Kenji is the first

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[1] The orthography of the inch and quarter inch Revenue Survey maps is so peculiar, that it is not always easy to know what the sounds intended are. Thus the word Nai (in Hindi, Nadi), a stream, is variously spelt Naee, Nye, Nyel, Nie, and Neigh! This is a good instance of what the opponents of any reform in the spelling of proper names call "spelling the name in English as it is pronounced." Even in the $\frac{1}{16}$ inch map, from which that accompanying the present report is copied, some streams are called Nai, others Nie, although great pains have evidently been taken to correct the orthography.

[2] Sainwali of map. The addition of *wali* or *wari* to the names given to streams appears to me unnecessary, as it is not generally used; indeed, so far as I could ascertain, the affix is exceptional.

stream of any size running from the west of the range. It is joined from the south, inside the outer range, by the Mogrio and the Trappen. South of these come in succession the Sita (Tooneewaree of map), Mazaráni, Sahár, Radha, Búrri, Salári, Khúrbi, and Maki Nais. Next comes the Gáj, which rises west of the Khirthar, nearly under Dharyáro, and, as already noticed, cuts through the range after receiving the drainage of a considerable tract to the westward of the hills, so that it is by far the largest stream flowing from the Khirthar. The only important water-course running from the Khirthar farther south is the Nari Nai, which drains a considerable hill tract, but does not come from beyond the main water-shed, and there is a smaller stream, the Letan Nai, between the Gáj and the Nari.

Topographical map of Sind.

The map employed as a basis for the geological lines is that prepared by the Revenue Survey, and, like most maps produced by the same survey, the object having been rather the demarcation of village boundaries than the preparation of a topographical representation of the country, the wilder and more hilly parts of the province, which are of small value and yield but little revenue, have not in general been mapped in detail. Even in the more populous parts of the country, the topography of the map is far from perfect—a circumstance perhaps due, in part, to the practice, in many parts of Sind, of changing both the locality and the name of villages; but still there are errors not to be thus explained. The mapping of the hills is very unequal. In the neighbourhood of Karáchi and of the Habb valley, the map is good and correct, and the hills are properly laid down. The same is the case throughout part of Kohistán. The Khirthar range is less well mapped; the general lines are shown, and many of the ridges properly represented, but neither the streams nor the hills are accurate in detail. The worst part of the map is that representing the Laki ranges and the low hills near Mánjhand and Kotri. These are all very imperfectly represented.

In the geological map nothing like minute detail has been attempted, and, with a few exceptions, the reduction herewith published on the small scale of 16 miles to an inch, represents only the main features of the geology. The large areas remaining to be mapped in India, and the want of detail in many of the topographical maps available, prevent the devotion of time sufficient for a close examination of any region, unless the presence of valuable minerals justifies a departure from the general rule. This is not the case in Sind. On the other hand, the geology of the Sind hills is singularly simple; many of the ranges are perfect geological diagrams, and from the absence of vegetation and the clearness of the atmosphere, the outcrop of formations, such as the nummulitic and miocene limestones, may frequently be traced for many miles on the hill-sides, with absolute certainty, from a distance. In some places the want of population, and even of water, throughout considerable areas, renders surveying difficult, and very possibly this drawback accounts for some of the deficiencies of the Revenue Survey map, especially in the case of the Laki range. In some seasons no rain falls in parts of Sind, and then whole tracts of country become only accessible by the troublesome and expensive process of carrying water from a distance. Fortunately, in the years 1874, 1875, and 1876, heavy rain fell in most districts of Sind and rendered the examination of the wilder tracts comparatively easy.

CHAPTER III.[1]—GEOLOGICAL FORMATIONS.

Section of formations in Western Sind.

The following is a general section of the formations found in Western Sind. It must be recollected that the whole section is not found in any single place; that the lower Khirthars, seen on the western flank of the Khirthar range, are not actually exposed within the province; and that they are very possibly represented by the Ranikot beds of the Laki range. The list is in descending sequence.

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[1] This chapter is copied, with a few alterations, from that published in the Manual of the Geology of India.

List of geological formations occurring in Western Sind.

Groups.	Sub-divisions.	Approximate thickness.	Supposed geological age.	REMARKS.
8. ALLUVIUM, &c....	......	?	*post-tertiary.*	
7. MANCHHAR ...	upper	5,000	*pliocene* ...	Unfossiliferous; apparently representative of the fossiliferous Siwalik group.
	lower	3,000 to 5,000	*lower pliocene or upper miocene.*	Fossiliferous, containing chiefly *Vertebrata.*
6. GAJ	......	1,000 to 1,500	*miocene* ...	Highly fossiliferous; marine; no nummulites.
5. NARI	upper	4,000 to 6,000	*lower miocene?* ...	Unfossiliferous.
	lower	100 to 1,500	*upper eocene or oligocene?*	Fossiliferous; upper limestone with nummulites.
4. KHIRTHAR ...	upper	500 to 3,000	*eocene* ...	Nummulitic limestone.
	lower	6,000?	*eocene* ...	The lower beds unfossiliferous. Base not determined.
3. RANIKOT... ...	......	2,000	*lower eocene* ...	Fossiliferous. Nummulites still common.
2. TRAP	......	40 to 90	*lowest eocene or upper cretaceous.*	Representative of the Deccan and Malwa trap.
1. CRETACEOUS ...	*a. Cardita Beaumonti* beds	350 to 450	*upper cretaceous or intermediate between eocene and cretaceous.*	
	b. Sandstones ...	700	*cretaceous*	
	c. Limestones with hippurites.	320		Base not exposed.

Total thickness.

On the river Gáj, a thickness of at least 25,000 feet of strata is exposed, none of the fossiliferous beds being of older date than eocene; but some of the unfossiliferous rocks towards the base of the section beyond the Sind frontier correspond so well with the description given by Dr. Cook[1] of strata in which he found mesozoic fossils (*Ammonites, &c.*) in Kelat, that these bottom beds on the upper Gáj, which are only seen west of the British frontier, may very probably be of cretaceous age. There is, however, no resemblance between

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[1] Trans. Med. Phys. Soc. Bombay, 1860, vi, pp. 1, 45; Carter, Jour. Bombay Br. Roy. As. Soc., vi, p. 184.

any of the lower beds on the Gáj and the cretaceous rocks of the Laki range.

Cretaceous rocks of Laki hills.

1. *Cretaceous beds.*—The only locality in Sind in which beds of older date than eocene have been identified, is in the Laki range. South-west of Amri on the Indus, a number of very dark-coloured hills are seen in this range; they contrast strongly with the cliffs of grey and whitish nummulitic limestone behind them. These dark hills consist of cretaceous beds, but the lowest member of the series is only exposed in a single spot, at the base of a hill known as Bárrah, lying about 10 miles south-west of Amri. The whole range here consists of three parallel ridges, the outer and inner composed of tertiary rocks (see section[1]); while the intermediate one consists of cretaceous beds, faulted to the eastward against the lower eocene strata, and dipping under them to the westward. Close to the fault some whitish limestone is found, compact and hard; the lower portion pure; the upper portion, often containing ferruginous concretions, is sandy and gritty, and forms a passage into the overlying sandstones. The base of this limestone is not seen; the whole thickness exposed is a little over 300 feet, and the length of the outcrop does not exceed half a mile. The limestone is fossiliferous, and contains echinoderms and mollusca, but it is so hard and homogeneous, that nothing that has been obtained from it can be easily recognised, except one fragment of a hippurite. This fossil is, however, of great importance, because it shows that the white limestone may very probably be an eastern representative of the hippuritic limestone so extensively developed in Persia, and found in numerous localities,[2] from Tehrán to east of Karmán, in longitude 58°, just 10 degrees west of the Laki range in Sind. Of course the same formation may be found in the intervening country, the geology of which is unknown. The precise position of the Persian hippuritic limestone in the cretaceous series has not been determined, but the European formation, which is very similar and probably identical, is of the age of the lower chalk (turonian).

Limestone with hippurites.

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[1] The section is represented on Plate V, fig. 2, Chapter VII.

[2] Eastern Persia, ii, pp. 457, 485.

Sandstones.

The sandstones resting on the hippuritic limestone occupy a considerable tract around Bárrah hill, and extend for about 3 miles from north to south. They are also seen at Jakhmari, about 5 miles south of Laki to the northward, and in one or two other places in the neighbourhood. They are gritty and conglomeratic, frequently calcareous, and they include a few bands of shale, usually of a red colour. The prevailing tint on the weathered surfaces is dark-brown or purple, many of the beds being highly ferruginous. On the top of the sandstones is a thick bed of dark-coloured impure limestone, containing oyster-shells, and occasionally large bones, apparently of reptiles; none, however, have been found sufficiently well preserved for identification.

Interstratified basalt.

In one place a bed of basalt, about 40 feet thick, has been found interstratified in the sandstones, and it is possible that the band may exist elsewhere. The position of this bed of basalt on the face of a hill called Bor, a little south of Bárrah, and about 13 miles north of Ránikot, is at an elevation of 300 or 400 feet above the base of the sandstones, and about twice as much beneath the main band of interbedded trap, to be described presently.

Cardita beaumonti beds.

The highest sub-division of the cretaceous formation consists of soft olive shales and sandstones, usually of fine texture. The sandstone beds are thin, and frequently have the appearance of containing grains of decomposed basalt or some similar volcanic rock, or else fine volcanic ash. A few hard bands occur, and occasionally, but rarely, thin layers of dark-olive or drab impure limestone. Gypsum is of common occurrence in the shales.

Palæontology.

The olive shales are highly fossiliferous, the commonest fossil being *Cardita beaumonti*[1], a peculiar, very globose species, truncated posteriorly, and most nearly allied to forms found in the lower and middle cretaceous beds of Europe (neocomian and gault). This shell is extremely abundant in one bed, about 200 to 250 feet below the top of the cretaceous series, but is not confined to

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[1] D'Archiac and Haime, An. foss. Groupe Num. de l'Inde, p. 253, pl. xxi, fig. 14.

this horizon. *Nautili* also occur, the commonest species closely resembling *N. labechei*[1] of Messrs. D'Archiac and Haime, but differing in the position of the siphuncle. This form appears undistinguishable from *N. bouchardianus,* found in the upper cretaceous Arialur beds of Pondicherry, and at a lower cretaceous horizon in Europe. A second *Nautilus* resembles *N. subfleuriausianus,*[2] another eocene Sind species, in form, and is also allied to some cretaceous types. Several *Gasteropoda* occur, especially forms of *Rostellaria, Cypræa, Natica,* and *Turritella,* but none are very characteristic. Two forms of *Ostrea* are common—one of them allied to the tertiary *O. flemingi*[3] and to the cretaceous *O. zitteliana*[4], but distinct from both. The only mollusk which certainly passes into the Ranikot beds is *Corbula harpa.*[5] Two echinoderms have been found—one is an *Epiaster,* an almost exclusively cretaceous genus, only one or two tertiary species having been found; the other is an aberrant form of *Echinolampas.* Two or three corals complete the list of invertebrate fossils found in the olive shales. These corals have been examined by Prof. Martin Duncan, and found to be tertiary forms, not cretaceous.

Amphicœlian vertebræ of Crocodiles.

In the lower part of the beds, with *Cardita beaumonti,* however, some amphicœlian vertebræ were found, which Mr. Lydekker has ascertained to be crocodilian.[6] All amphicœlian crocodiles are mesozoic, and the present form must be one of the latest known. So far as it is possible to form an opinion from very fragmentary materials, the vertebræ in question appear more nearly allied to the Wealden *Suchosaurus* than to any other form hitherto described. It has, however, been shown,[7] in the case of the Gondwána fauna, that the distribution of *Reptilia* in past ages was not the same in India as in Europe.

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[1] D'Archiac and Haime, *t. c.*, p. 338, pl. xxxiv, fig. 12.

[2] Ibid., p. 337, pl. xxxv, fig. 1.

[3] Ibid., p. 275, pl. xxiii, figs. 14, 15.

[4] Stoliczka, Pal. Ind., Ser. VI, p. 473, pl. xliv, fig. 7.

[5] D'Archiac and Haime, *t. c.*, p. 236, pl. xvi, fig. 8.

[6] Lydekker, Pal. Ind. Ser. IV. vol. i, pt. 3, p. 31.

[7] Manual Geol. India, Introduction, p. xxxiv, and pt. 1, p. 100.

The fossils of the *Cardita beaumonti* zone require much fuller examination and comparison than they have hitherto received; but sufficient has been ascertained to show that they have a distinctly cretaceous character, but that nevertheless they have strong tertiary affinities.

A bed of very similar mineral character, the olive group of Mr. Wynne,[1] occurs at the base of the tertiary formations in the Punjab Salt Range, and the fossils, amongst which *Cardita beaumonti* is also found, have for the most part, in Dr. Waagen's opinion, a tertiary facies, but include one species of Ammonite. There is every probability that the olive group of the Punjab corresponds to the *Cardita beaumonti* beds of Sind, and although in the preceding table the latter group has been classed as cretaceous, this classification must be understood as only temporary, for the thorough examination of the fossils may show that the preponderance of affinities is really very ancient eocene, or absolutely intermediate between the oldest tertiary and the newest cretaceous formation hitherto known. No corresponding group has hitherto been recognised in Baluchistan or in the Western Punjab south of the Salt Range.

Olive group of Punjab.

2. *Deccan trap.*—Mention has already been made of one bed of basalt intercalated in the sandstones above the hippuritic limestones: a much more important band of the same igneous rock has been traced, resting upon the *Cardita beaumonti* beds, throughout a distance of 22 miles from Ranikot to Jakhmari, about 17 miles south of Sehwán, wherever the base of the Ranikot group, the lowest tertiary formation, is exposed. The thickness of this band of trap is trifling, and varies from about 40 to about 90 feet. Apparently in some places the whole band consists of two lava flows, similar in mineral character, except that the upper is somewhat ashy, and contains scoriaceous fragments; the higher portion of each flow is amygdaloidal, and contains nodules of quartz, chalcedony, and calcite, and in places the nodules are surrounded by green earth, as

Position and thickness of trap.

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[1] Mem. Geol. Sur., India, xiv, p. 103.

is so frequently the case in the Deccan traps. Another characteristic accessory mineral, common also in the traps of the Deccan and Malwa, is quartz with trihedral terminations. The basaltic trap of the Laki hills is apparently of subaërial origin, although it rests conformably on the marine (or estuarine?) *Cardita beaumonti* beds; at least there is nothing in the igneous bed to indicate its having consolidated otherwise than in the air.

Mineral character.

The evidence that this band of basaltic rock is interstratified and not intrusive, is ample; throughout the whole distance the trap is found in precisely the same position between the lowest beds of the Ranikot group and the highest cretaceous strata, and apparently perfectly conformable to both. The close resemblance in mineral character and the similarity of geological position at the base of the tertiary beds show that this band must be, in all probability, a thin representative of the great Deccan and Malwa trap formation, and the occurrence of a second bed at a lower horizon, interstratified with rocks of cretaceous age, tends strongly to confirm the inference drawn from the relations of the traps to cretaceous and tertiary rocks in the Narbada valley, that the great volcanic formation of Western India must be classed, in part at all events, as upper cretaceous.

Evidence of interstratification.

The Deccan and Malwa traps had already been traced as far as the western portion of Cutch before their occurrence in Sind was discovered. Their existence west of the Indus extends the area in which they are known to occur by about 150 miles, the distance between Lakhpat, in Cutch, and Ranikot, in Sind.

3. Ranikot group.—The name of the lowest tertiary sub-division is derived from a hill fortress of the Sind Amirs, situated in the Laki range of hills, and known as Rani-jo-kot, or Ranikot, and also as Mohan-kot, from the Mohan stream, which traverses the fortification. The Ranikot group is much more extensively developed in Sind than the underlying cretaceous beds, for

Derivation of name.

although it is confined to Lower Sind, and although its base is only seen in the Laki range, north of Ranikot, its upper strata occupy a considerable tract of country, about 26 miles long from north to south by about 12 in breadth, north-west of Kotri, and another even larger exposure, about 36 miles long, occurs, extending from north of Jhirak (Jhirk, Jhirruk, Jerruck or Jurruk) to Tatta. In the Laki range, the Ranikot beds are seen for about 35 miles, but the outcrop is never more than 2 or 3 miles broad, and one small inlier is exposed to the west of Ranikot.

Extent.

Mineral character.

All the lower portion of the Ranikot group, including by far the greater portion of the beds, consists of soft sandstones, shales, and clays, often richly coloured and variegated with brown and red tints. Gypsum is of frequent occurrence; some of the shales are highly carbonaceous; and in one instance a bed of coal (or lignite) nearly 6 feet thick was found, and a considerable quantity of the mineral extracted.[1] The quality was, however, poor, and, from the quantity of iron-pyrites present, the coal decomposed rapidly, and was liable to spontaneous combustion when exposed, whilst the deposit was found to be a small patch, not extending more than about 100 yards in any direction. Some of the more pyritous shale is used in the manufacture of alum. The only fossils found in the lower portion of the Ranikot group, with the exception of a few fragments of bone, have been plants; some dicotyledonous leaves, hitherto not identified, being the most important. All the Ranikot beds, except towards the top of the group, have the appearance of being of fresh-water origin, and are probably fluviatile.

Fossiliferous beds.

A variable portion of the group, however, towards the top, consists of highly fossiliferous marine limestones, often light or dark-brown in colour, interstratified with sandstones, shales, clays, and ferruginous bands. These are the lowest beds in Sind containing a distinctly tertiary marine fauna. The brown limestones are well developed around Lainyan, Leilan or Lynyan, east of Band

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[1] Mem., Geol. Sur., India, vi., p. 13.

Vera and north-west of Kotri, and throughout the area of Ranikot beds near Jhirak and Tatta. In this part of the country there appears to be a complete passage upwards into the overlying nummulitic limestone (Khirthar); but in the Laki range, the upper marine beds of the Ranikot group are poorly represented or wanting, and it is evident that they were removed by denudation before the deposition of the Khirthar limestone, for the latter is seen at Hothian Pass resting upon their denuded edges.

Thickness.

The greatest thickness of the Ranikot group in the Laki range, where alone, as has already been explained, the base of the group is visible, is about 2,000 feet, but generally the amount is rather less, about 1,500. It must, however, be recollected that in this locality some of the upper marine beds are wanting, and as these marine limestones, and their intercalated shales, sandstones, &c., are 700 or 800 feet thick, in places north-west of Kotri, it is evident that the original development of the group exceeded the 2,000 feet seen in the Laki range.

Palæontology.

The following are some of the commonest or most important fossils of the Ranikot group. The large collections made by the Geological Survey have as yet only been partially examined, and the lists of fossils given can be considered only preliminary,[1] many of the commonest species being undescribed forms:—

CEPHALOPODA.

Nautilus subfleuriausianus.
N. deluci.
N. forbesi.

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[1] As in other lists in this chapter, most of the names are taken from D'Archiac and Haime's "Animaux fossiles du groupe Nummulitique de l'Inde." As already stated, p. 4, I am indebted to Prof. T. Rupert Jones for the names of the Nummulites, and of some of the other Foraminifera, which he very kindly compared and determined. The Mollusca, Echinodermata, &c., have been determined partly by Mr. Fedden, partly by myself, the greater share of the work having been done by Mr. Fedden.

Gasteropoda.

Rostellaria angistoma.
R. prestwichi.
R. fusoides.
Terebellum distortum.
T. plicatum.
Voluta jugosa.
Natica longispira.
Nerita (Velates) schmideliana.
Turritella angulata, var.
T. assimilis.

Lamellibranchiata.

Corbula harpa.
Vulsella legumen.
Spondylus rouaulti.
Ostrea flemingi.
O. vesicularis

Brachiopoda.

Terebratula, cf. *subrotunda.*

Echinodermata.

Schizaster, sp.
Hemiaster digonus.
Eurhodia morrisi.
Prenaster, sp.
Toxobrissus, sp.
Conoclypeus, sp.
Echinolampas, cf. *subsimilis.*
Temnopleurus valenciennesi.
Salenia, sp.
Phymosoma, sp.
Porocidaris, sp. (spines).
Cidaris halaensis.

Anthozoa.

Trochocyathus vandenheckei.
Cyclolites vicaryi.
Montlivaultia jacquemonti.

Foraminifera.

Operculina canalifera.
Nummulites spira var. *(Operculina tattaensis).*
Nummulites irregularis.
N. leymeriei.

Affinities of fossils.

In the above list most of the forms, such as the *Foraminifera*, the majority of the *Echinodermata* and *Gasteropoda*, are lower tertiary, but still there is a very distinct admixture of species with cretaceous affinities, such as the *Nautili*, all of which are connected rather with cretaceous than with tertiary types, the *Terebratula*, which cannot be distinguished from one of the commonest upper mesozoic species, and forms of *Salenia*, *Cyclolites*, *&c.* Cor-

bula harpa is the only form hitherto recognised that is also found in the upper cretaceous olive shales; but a variety of the same shell is also found in the Nari beds.

Infra nummulitic rocks of Baluchistán.

Cretaceous and lower tertiary rocks of Baluchistán.—All the rocks described in the last few pages as occurring below the nummulitic limestone or Khirthar group are found in Lower Sind, and, so far as is known, are confined to a tract near the right bank of the river Indus. Farther to the westward the series of older tertiary and upper cretaceous rocks has not been thoroughly examined, but the information hitherto obtained appears to show that the strata below the nummulitic limestone are very different in character from those found in Lower Sind. In Baluchistán, west of the frontier of Upper Sind, lower beds crop out from beneath the massive nummulitic (Khirthar) limestone, forming the crest of the intervening range of hills, and on the banks of the Gáj river, which traverses the range south-west of Mehar (see Plate IV, Chap. IV), a series of more than 10,000 feet of strata is exposed below the Khirthar group. The following is a rough section of the rocks thus exposed, the thickness being merely an approximation:—

Section of Upper Gáj river.

		Feet.
Khirthar	1. Massive nummulitic limestone, forming the crest of the Khirthar range	1,200
	2. Shales, marls, and clays, mostly dark-olive in colour, abounding in *Nummulites* . . .	500
	3. Hard grey limestone, with *Nummulites* . .	60
	4. Argillaceous limestone, shales and clays, olive and bluish-grey in colour, abounding in *Nummulites*	400
Lower Khirthar	5. Unfossiliferous olive and bluish-grey clays and nodular shales, no limestone bands . . .	1,500
	6. Pale-brown sandstones in thick beds with vegetable markings	1,000
	7. Fine greenish-white sandstone and shale, some of which is carbonaceous	500
	8. Dark-brown limestone and dark-green argillaceous beds, with *Nummulites*	100
		5,260

		Feet.
	Brought forward .	5,260
LOWER KHIRTHAR, —*continued.*	9. Pale-grey argillaceous limestone, with but few fossils; one band towards the base contains *Nummulites* and *Alveolinæ*	200
? CRETACEOUS.	10. Fine dark-coloured shales, unfossiliferous . .	3,000
	11. Very fine grained homogeneous thin-bedded limestones, white, red, grey, or ochrey in colour, unfossiliferous, forming a conspicuous range .	1,200
	12. Hard grey shales with calcareous bands from an inch or two to a foot in thickness . . .	2,500
	The base not exposed.	
		12,160

Difference from beds of Lower Sind.

Section near Khozdar, Baluchistan.

About this section the first point to be observed is that none of the beds below the Khirthar resemble those seen in Lower Sind sufficiently to enable any of the strata of the two localities to be identified with certainty. The sandstone No. 6 may correspond to the sands and clays of the Ranikot group, but there is no great similarity, and nothing in the above section appears to represent the fossiliferous brown limestones of the Ranikot group, the Deccan trap, the olive shales with *Cardita beaumonti* or any other of the cretaceous beds in the Laki hills. So far, indeed, as the section on the Upper Gáj river is concerned, all the rocks exposed might be referred to the tertiary epoch and classed as lower eocene; no marked break intervenes anywhere, nor are there any fossils below the argillaceous limestone with nummulites, No. 9, to show the age of the beds. But, further to the westward, near Khozdar, in Baluchistán, Dr. Cook has discovered *Ammonites*[1] in some argillaceous beds, passing upwards into red and white limestone, and it appears probable from the description that the latter is identical with the fine-grained thin-bedded limestone, No. 11, of the preceding section, whilst the argillaceous beds may be the same as No. 12.

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[1] Jour. Bombay Br. Roy. As. Soc., vi, pp. 186, 188.

The following section, abridged from that given by Dr. Cook,[1] shows the nature of the rocks between Kelat and Khozdar, the latter place lying about 70 miles north-north-west of the section on the upper Gâj river :—

		Feet.
EOCENE (KHIRTHAR)	1. Compact white or reddish-white limestone containing *Nummulites, Orbitolites, Orbitoides, Alveolina,* &c. (This is doubtless the Khirthar limestone.) Thickness unknown; probably more than	1,000
	2. Limestone strata, differing in character, compact, subcrystalline, saccharoid, at times cretaceous, containing *Nummulites (Assilina), Alveolina,* and minute indistinct *Foraminifera,* and passing downwards into coloured argillaceous strata	? 200—500
MESOZOIC	3. More or less compact fine-grained red and white limestone, interleaved with slabs of flint or chert, the upper part containing one or two massive strata of an excessively hard limestone, abounding in *Orbitoides, Orbitolina,* and *Operculina,* the lower strata becoming argillaceous and shaly, and containing (rarely) *Ammonites*	? 2,000
	4. Dark-blue fossiliferous limestone containing strata yielding lead ore (galena and carbonate of lead)	? 2,000
	5. Clay slate	? 2,500

It is true that the precise relations of many of these beds are far from clear. Thus, in the valley of Kelat the red and white limestone appears to underlie strata containing *Orthoceratites.* This may, however, be due to faulting or inversion. It is probable that several different groups of beds occur near Kelat, for amongst the fossils, besides *Orthoceratites, Ammonites* of jurassic types, *Ceratites, Crioceras, Scaphites,* and *Belemnites* occur, and whilst some of the forms are typically cretaceous, others can scarcely be newer than triassic.

It is not impossible that the limestone bands in No. 3, containing *Orbitoides* and other *Foraminifera,* may belong to the tertiary series, and

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[1] Bombay Med. Phys. Soc. Trans, 1860, vi, p. 100. The bed numbered 2 in the section is called upper cretaceous by Dr. Cook, but with a mark of doubt. This was perhaps in accordance with the views as to the classification of the beds beneath the nummulitic limestone formerly held by Dr. Carter, but subsequently modified by him.—See Jour. Bombay Br. Roy. As. Soc., iv, pp. 93, 95; v, p. 635; and "Geological papers on Western India," pp. 623, 626, 699, 700, foot-note, &c.

not to the group with which they are associated. The banded fine-grained white or red and white limestone is a conspicuous and important bed, and is probably widely developed in Baluchistán. It was found by Dr. Cook at several places south and south-west of Kelat; it occurs, as already shown, on the upper Gáj river west of the Khirthar range, forming a range of hills known as Parh, and a rock of precisely the same mineral character appears 130 miles further south on the coast, at a small hill called Gadáni, about 25 miles north-west of Karáchi. If, as appears probable, this peculiarly fine limestone or calcareous shale (for the rock in places appears argillaceous) belong to the upper portion of the cretaceous series, it will serve to mark that horizon in Baluchistán and facilitate the recognition of the indistinct limit between mesozoic and tertiary. There is, however, a great appearance of passage between all these formations.

Red and white limestone.

Returning to the beds of the Gáj section, the gradual passage upwards from the shales, marls, and clays, with *Nummulites*, Nos. 2, 3, and 4 of the section, into the massive nummulitic limestone, is worthy of notice. A similar passage takes place locally in Lower Sind, and it appears best to consider the shales and marls as the lower portion of the same group as the limestone. The 6,000 feet of rocks remaining between the nummulitic shales and the banded limestones of supposed cretaceous age may be classed as lower Khirthar; they very possibly represent the Ranikot group, but, as already noticed, there is no distinct mineralogical or palæontological connection. The nummulites found in No. 8 in the middle of this lower Khirthar group comprise *N. obtusa, N. granulosa, N. leymeriei, N. spira,* and other species common in the Khirthar limestone itself.

Khirthars of Gáj section.

It is probable that the beds below the Khirthar limestone extend throughout a large tract in Baluchistán, on the west side of the Khirthar range, for similar beds are seen from the crest of the hills cropping out to the westward as far north as Dharyáro and Kutta-jo-Kabar (the dog's tomb), the culminating point of the range due west of Lárkána.

Probable area of lower tertiaries in Baluchistán.

Again, west of the Habb river, forming the boundary of Sind near the sea, the whole Khirthar formation appears composed of shales, marls, and sandstone, closely resembling in character those of the lower Khirthar group west of Upper Sind, and an enormous thickness of similar beds is found extensively developed in Makrán.[1]

4. *Khirthar group.*—Although this group, named from the great frontier range of hills already noticed, is, when the underlying shales and sandstones are excluded, inferior in total thickness to several other sub-divisions of the tertiary series in Sind, it comprises by far the most conspicuous rock, the massive nummulitic limestone. Of this formation all the higher ranges in Sind consist. It forms the crest of the Khirthar throughout, and all the higher portions of the Laki range, of the Bhit and Badhra ranges south-west of Manchhar lake, and of several smaller ridges, and consists of a mass of limestone, varying in thickness from a few hundred feet in Lower Sind to about 1,000 or 1,200 at the Gáj river, and probably 2,000, or even 3,000, further north. The colour is usually pale, either white or grey, sometimes, but less frequently, dark-grey; the texture varies from hard, close, and homogeneous, breaking with a conchoidal fracture, to soft, coarse, and open. Ordinarily, the nummulitic limestone is tolerably compact, but not crystalline, and chiefly composed of *Foraminifera*, especially *Nummulites*, whole or fragmentary; corals, sea-urchins, and molluscs also abound, but the two latter very frequently only weather out as casts.

Distribution.

Throughout Northern Sind, except near Rohri, no beds are seen beneath the Khirthar limestone, and the rocks which crop out west of the Sind frontier from beneath the main limestone band have already been described. The remarkable range of low hills, surrounded by Indus alluvium, and extending for more than 40 miles south from Rohri, consists of nummulitic limestone having a low dip to the westward, and beneath the limestone forming the eastern scarp of the hills, on the edge of the alluvial plain,

Lowest beds in Rohri hills.

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[1] Eastern Persia, Vol. ii., pp. 460, 473.

a considerable thickness of pale-green gypseous clays is exposed, with a few bands of impure dark limestone and calcareous shale. No *Foraminifera* have been found in these clays, although *Nummulites* abound in the limestone immediately overlying; several species of mollusca occur, but none are characteristic, and it is far from clear whether the green clays and their associates are merely thick bands intercalated in the limestone, or whether they belong to a lower group. Probably these argillaceous beds of the Rohri hills represent some of the marls, shales, and clays forming the lower portion of the upper Khirthar group on the Gáj river.

The nummulitic limestone of the Rohri hills is softer and whiter than that of the Khirthar range, a difference doubtless due to the much smaller amount of disturbance that the rocks have undergone in the former instance. A somewhat similar, but greater, difference has been shown to exist between the Nummulitic limestone of the Salt Range and that of the Himalayas in the Punjab.

Laterite band.

In some places west of Kotri, a band of argillaceous and ferruginous rock is found close to the base of the Khirthar group. This rock weathers into laterite; it is mainly composed of brown hæmatite, and appears to be found over a considerable area near Kotri and Jhirak. It is impossible to avoid suggesting its identity with the ferruginous lateritic bed found in a similar position in Guzerat, Cutch, the Salt Range, and the Sub-Himalayan region.

Relations between Khirthar and Ranikot groups.

It has already been mentioned that in the Laki range the nummulitic limestone rests unconformably on the Ranikot group. The Khirthar group here cannot be much more than 500 or 600 feet thick, and consists entirely of limestone. To the south-east, towards Kotri and Tatta, there is no unconformity between the Ranikot and Khirthar groups, but on the contrary there is an almost complete passage between the two, and the limestone of the latter becomes much split up and intercalated with shales and sandy beds. This is even more the case further to the south-east in Cutch[1], where the whole group consists of comparatively thin beds of limestone, interstratified with shales. To the south-west, near the Habb river, the massive limestone dies out altogether, and although it is well developed in the southernmost extremity of the Khirthar range, near Karchát, about 50 miles south of Sehwán, it disappears within a distance of 25 miles,[2] and in the ranges on the Habb river is entirely replaced by shaly limestone, shales, and thick beds of sandstone. Some rather massive beds of nummulitiferous dark-grey limestone, very different in character from the pale-coloured Khirthar limestone, are found west of the Habb, but their precise position in the series is not known, and the rocks appearing from beneath the Nari group, in the place of the Khirthar limestone, consist of shales and sandstones, with some calcareous bands abounding in nummulites, and closely resembling, both in character and in the species of *Foraminifera* they contain, the nummulitic shales beneath the massive limestone on the Gáj river. It is not known to what extent the typical Khirthar limestone is developed in Baluchistán; around Kelát, to the northward, this band appears to be extensively exposed, but to the westward, near Gwádar, the rocks supposed to represent the older tertiary beds consist of an immense thickness of shales, shaly sandstones, and unfossiliferous calcareous bands, resembling the lower Khirthars of the Gáj and the beds of the Habb valley, and limestones with nummulites are of unfrequent and local occurrence. It is thus evident that the Khirthar limestone, although it is so conspicuous in most parts of Sind, and although it attains a considerable thickness, is not by any means universally distributed.

Disappearance of Khirthar limestone to south-west.

Khirthars in Baluchistán.

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[1] Mem. Geol. Surv. India, Vol. ix, p. 77.

[2] In the "Manual," p. 458, the distance was stated to be 12 or 14 miles. This was under the supposition, which is highly probable, that the shaly beds of the Piro range near Baili, west of Dumbár, represent the massive limestones of the Khirthar range. There is, however, a possibility that the shaly limestones of Baili, like those of the Laki range to the east of the Khirthar, are only the uppermost beds of the group, and that the massive limestone may occur below. So far as is known, however, on the Habb, the massive limestone is wanting. A great thickness of Khirthar beds is exposed, but all consist of shales, marls, and sandstones.

Palæontology.

The most characteristic fossils of the Khirthar group are *Nummulites* and *Alveolina*; neither the genera, nor, as a rule, the species. are peculiar, but the extraordinary abundance of individuals renders it usually easy to recognise even small fragments of the rock by the organisms preserved in it. The following is a list of the commonest or most important fossils :—

Gasteropoda.

- *Ovulum murchisoni*, and other species.
- *Cerithium* cf. *giganteum*.
- *Nerita schmideliana*.

Lamellibranchiata.

- *Pholadomya halaensis*.
- *Corbula subexarata*.
- *Cardita mutabilis*.
- *C. subcomplanata*.
- *Lucina gigantea*.
- *Astarte hyderabadensis*.
- *Crassatella sindensis*.
- *C. halaensis*.
- *Vulsella legumen*.
- *Ostrea vesicularis*, var. (*O. globosa*, Sow.)

Echinodermata.

- *Brissopsis scutiformis*.
- *B. sowerbyi ?*
- *Schizaster*, sp.
- *Eupatagus avellana*.
- *Fibularia*, sp.
- *Amblypygus*, sp.
- *Conoclypeus pulvinatus*.
- *Eurhodia calderi*.
- *Echinolampas discoideus*.
- *E. sindensis*.

Foraminifera.

- *Orbitolites pedunculata*.
- *Orbitoides dispansa*.
- *Patellina cooki*.
- *Alveolina ovoidea*.
- *A. spheroidea*.
- *Nummulites obtusa*.
- *Nummulites ramondi*.
- *N. biaritzensis*.
- *N. beaumonti*.
- *N. vicaryi*.
- *N. granulosa*.
- *N. leymeriei*.

Many of the species named, and the foraminifera especially, are characteristically eocene, and there can be no question that the nummulitic limestone of India is a continuation of the same formation in Europe. Several species pass from the Ranikot beds into the Khirthar group; indeed the principal palæontological differences between the two may be due to a change in conditions, the Khirthar being apparently a deeper water deposit than the Ranikot group.

5. *Nari group.*—The series of tertiary rocks above the Khirthar nummulitic limestone is superbly developed and very well seen in the hills on the frontier of Upper Sind, the culminating ridge of which is known as the Khirthar. The names of the two tertiary groups overlying the nummulitic formation have consequently been derived from places in this range, and the Nari group takes its title from a stream[1] which traverses the lower portion of the range, here composed almost entirely of Nari beds, for a considerable distance, and issues from the hills nearly west of Johi, and west-by-north of Sehwán. The present sub-division comprises at the base the uppermost bands of limestone containing *Nummulites;* the species, however (*N. garansensis,*[2] and *N. sublævigata*[3]), being distinct from those so commonly found in the Khirthar sub-division, and the limestone itself being usually distinguished from that of the Khirthar group by its yellowish-brown colour, and by being in comparatively thin bands interstratified with shales and sandstones. Several other fossils, too, besides the nummulites, differ from those in the Khirthar beds. Not unfrequently, however, there is an apparent passage from the white or greyish-white Khirthar limestone into the yellow or brown Nari rock, and the two groups appear, in general, to be perfectly conformable, but no intermixture of the characteristic species of nummulites has been detected, and the division between the Khirthar and Nari beds, wherever they are fossiliferous, can be recognised by the fossil evidence.

Derivation of name.

Distinction from Khirthar.

In some places the lower Nari beds consist almost entirely of brown and yellow limestones, but more frequently the limestone bands are subordinate; dark shales, and brown rather thinly-bedded sandstone forming the mass of the rocks. The limestone bands are often confined to the base of the group, and

Mineral character.

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[1] This stream rises close to the peak called Sulimáni, and runs first north, then east.

[2] D'Archiac and Haime, *t. c.*, pp. 101, 344, pl. iii, figs. 6, 7.

[3] Ibid., pp. 106, 180, pl. iv, fig. 8.

always diminish in abundance and thickness above, although they are occasionally found as much as 1,500 feet above the top of the Khirthar. The shales and fine sandstones, with occasional bands of limestone, constitute the lower Nari beds, and pass gradually into the coarser, massive, thick-bedded sandstones forming the greater portion of the group, and attaining a thickness of 4,000 or 5,000 feet on the flanks of the Khirthar range. With the sandstones a few bands of clay, shale, or ironstone, are interstratified, and bands of conglomerate occasionally occur. The Nari beds in their typical form extend throughout the eastern flank of the Khirthar range, and occupy a belt of varying width, from one or two to as much as 10 miles in breadth, between the underlying Khirthar and the overlying Gáj beds.

Break in Nari beds near Sehwán.

On the western side of the Bhagothoro hill, 4 or 5 miles south of Sehwán, there is a break in the Nari beds, and some variegated shales, clays, and sandstones, richly tinted in parts with brown and red, and representing the massive sandstones of the upper Nari group, rest unconformably on the denuded edges of the lower Nari brown limestones and shales. The break is evidently local. In the neighbourhood of Jungsháhi, 50 miles east of Karáchi, and for some distance to the northward, also, there appears a well-marked distinction between the upper members of the group, comprising a yellow calcareous sandstone with *Orbitoides papyracea,* and the lower Nari limestones with *Nummulites garansensis* and *N. sublævigata,* and a few miles north of Jungsháhi the former overlap the latter and rest upon the Khirthar limestone. To the east of the Laki range the Nari beds are entirely wanting, and it appears very possible that they have never been deposited in this portion of the Indus valley. From the neighbourhood of Sehwán to Jhirak, Manchhar beds rest, with more or less unconformity, on the Khirthar, a very faint and imperfect representative of the Gáj group occasionally intervening. But west of the Laki range, throughout Lower Sind, the Nari beds are found exposed almost wherever the base of the Gáj group is seen; they increase

Break near Jungsháhi.

Nari beds wanting east of Laki range.

in thickness to the westward, and the Habb valley, from the spot where the river first forms the boundary of British territory to the sea, consists entirely of these strata. There is, however, in this part of the country, no longer any such marked distinction between the sub-divisions of the tertiary series as is found in the Khirthar range. The disappearance of the Khirthar limestone has already been mentioned, and with it the lower Nari limestones with *Nummulites garansensis* and *N. sublævigata* also disappear, so that it is no longer possible to draw a distinct line between the two groups, for the shaly beds at the base of the Nari group are undistinguishable from similar rocks in the Khirthar, The calcareous shales, with the characteristic Khirthar nummulites, below, and the massive Nari sandstones above, are still recognizable, and the two groups can consequently still be traced, although the dividing line between them is obscured. Beds of brown limestone, too, full of *Orbitoides papyracea* (*O. fortisi*),—a fossil closely resembling a nummulite, and associated in abundance with *N. garansensis* in the typical lower Nari limestones,—occur in the Nari beds of the Habb valley; but instead of being found at the base, they appear in the middle of the group. Again, just as at the base of the Nari beds there is a difficulty in distinguishing them from the Khirthar, so the beds at the top of the former group can only be separated by an arbitrary line from the overlying Gáj beds. In the Khirthar range, the upper boundary of the Nari group, although there is no unconformity, is distinct and definite, limestones with marine fossils of the Gáj group resting immediately upon the upper Nari sandstones. But in Southern Sind bands of limestone, or calcareous sandstone, with marine fossils, some of which are well-marked Gáj species, occur in the upper part of the Nari group, whilst limestone bands with the Nari *Orbitoides papyracea* are found in the Gáj.

Present in Lower Sind.

Passage into Khirthar.

Passage into Gáj beds.

The sandstones, which form so large a portion of the Nari group, have hitherto proved destitute of animal remains, and in the typical area in Upper Sind, no beds with marine fossils are intercalated in

Palæontology.

the upper portion of the group, but the occasional interstratifications of shales and clays often contain fragments of plants, and some ill-marked impressions, probably due to fucoids, have been found in the sandstones themselves. There appears a probability that these sandstones may be of fluviatile, and not of marine origin.

In the limestones towards the base of the Nari group, many marine fossils have been obtained, the following being some of the more important :—

GASTEROPODA.

Terebellum obtusum.
Cypræa nasuta.
Voluta jugosa.
V. dentata.
Triton davidsoni.
Natica patula.
N. sigaretina.
Siliquaria granti.
Solarium affine.
Trochus cumulans.
Phasianella oweni.

LAMELLIBRANCHIATA.

Corbula harpa.
Venus granosa.
Cardium triforme.
Pecten labadyei.
Ostrea flabellula.

ECHINODERMATA.

Schizaster beloutchistanensis.
Eupatagus rostratus.
Echinolampas, sp.
Clypeaster profundus.
Cœlopleurus forbesi.
Cidaris verneuilli.

ANTHOZOA.

Trochocyathus burnesi.
Montlivaultia vignei.

FORAMINIFERA.

Nummulites garansensis.
N. sublævigata.
Orbitoides papyracea.

Although some species pass from the Khirthar, and even from the Ranikot group, into the Nari beds, the fauna is chiefly distinct, and indicates a higher horizon. The most marked change is perhaps in the *Fora-*

minifera, because they are so abundant and characteristic, yet every species is distinct from those occurring in the Khirthar group. Whole beds of limestone towards the base of the Nari group are entirely made up of *Nummulites garansensis, N. sublævigata* and *Orbitoides papyracea,* the last-named frequently of large size, some specimens being 2 to 3 inches in diameter. One of these species of *Nummulites, N. garansensis,* is of importance, because it occurs in Europe, as in Sind, in the highest strata characterized by the abundance of the genus, those beds being at the base of the miocene. *Nummulites sublævigata* is peculiar, so far as is known, to India.

Difference from Khirthar fauna.

Several of the *Mollusca* and *Echinodermata* of the Nari beds also, such as *Siliquaria granti, Solarium affine, Venus granosa,* and *Clypeaster profundus,* show distinctly miocene affinities, and some of these pass up into the Gáj group. But at the same time there are so many eocene forms present, such as *Natica patula, N. sigaretina, Ostrea flabellula, Voluta jugosa, &c.,* that it is somewhat difficult to decide to which sub-division the Nari beds should be assigned. They may, perhaps, occupy an intermediate position, similar to that of the oligocene of continental geologists.

Miocene affinities.

6. *Gáj group.*—Upon the Nari group, almost throughout Sind, there is found resting a mass of highly fossiliferous limestones and calcareous beds, usually more or less shaly, always distinctly stratified, and easily distinguished from the limestones of the older tertiary formations by the absence of nummulites. A superb section of the strata forming this group is exposed on the banks of the Gáj river, the stream which, as already mentioned, cuts its way through the Khirthar range south-west of Mehar, and in the neighbourhood of which, west of the range, the fine section of lower tertiary and cretaceous beds already noticed is exposed. From this river the present group derives its name.

General character.

On the eastern flanks of the Khirthar range in Upper Sind, the Gáj group forms a conspicuous ridge, the hard dark-brown limestone bands near the base of the formation resisting the action of denudation

Ridge of Gáj beds.

far more than the soft sandstones of the Nari beds, and rising every here and there into peaks of 1,000 and 1,500 feet, or even more, escarped to the westward, and sloping to the east; Amru, the highest summit of the Gáj ridge, being 2,700 feet above the sea. Still, the limestone bands, although so conspicuous, are subordinate, the greater part of the group consisting of sandy shales, clays with gypsum, and, towards the base, sandstones. Many of the bands of limestone appear very constant in position, and may be traced for a long distance; as a rule, they are dark-brown in colour, but one bed is white and abounds in corals and small *Foraminifera* (*Orbitoides*), whilst some of the darker bands contain *Echinodermata* in large quantities.

Estuarine passage beds between Gáj and Manchhar beds.

The uppermost portion of the group is usually argillaceous, being chiefly composed of red and olive clays with white gypsum, and these beds pass gradually into precisely similar strata belonging to the overlying Manchhar group. The passage beds contain, amongst other fossils, such as *Turritella angulata,* and forms of *Ostrea* and *Placuna,* the following:—

Corbula trigonalis.
Lucina (*Diplodonta*) *incerta.*
Tellina subdonacialis.
Arca larkhanaensis.

All of these have allies living in estuaries at the present day; *Arca granosa,* a recent representative of *A. larkhanaensis,* being one of the commonest and most typical of Indian estuarine mollusca. To these estuarine passage beds further reference will be made presently when the relations of the Manchhar to the Gáj beds are discussed.

Thickness.

The Gáj beds at the Gáj river are very nearly 1,500 feet thick, but they appear to be less developed to the northward in the Khirthar range, and not to be much more than half the thickness named west of Lárkána, where, however, they are nearly vertical, and have probably suffered from pressure. In Lower Sind, the Gáj group, like the Nari, disappears to the eastward of the Laki range, where it is either entirely wanting, or else represented by a thin band containing one of the characteristic fossils. *Ostrea multicostata,* at the base of the Manchhar group. There is, however, a very large area of Gáj beds north and north-east of Karáchi, and the appearance of the formation here is somewhat different from what it is in the Khirthar range, for the greater portion of the group consists of pale-coloured limestones, almost horizontal, or dipping at very low angles, and to the east of the Habb valley forming plateaus 400 or 500 feet high, bounded by steep scarps, which rise from the low ground of the soft Nari sandstones. A low range of hills, formed of Gáj beds, extends to the south-west, past the hot-spring at Mugger or Mangah Peer, to the end of the promontory known as Cape Monze, west of Karáchi, and the same beds form the low hills east and north-east of the town, and furnish the materials of which the houses in Karáchi are mostly built. A small island called Churna, in the sea, west of Cape Monze, also consist of Gáj rocks. To the northward the Gáj area of Lower Sind extends with very irregular outline to the neighbourhood of Tong and Karchát, almost due west of Hálá, and there are several outliers farther north, connecting the southern portion of the group with the typical outcrop in the Khirthar range. East of Karáchi, also, Gáj beds extend in the direction of Tatta, until they disappear with the other tertiary rocks beneath the alluvium of the Indus. The Gáj group of Sind appears to be represented in Cutch by a highly fossiliferous belt, containing most of the typical mollusca, echinoderms, &c. It is quite possible that the present group, as well as the Nari, never was deposited throughout the greater part of the country east of the Laki range.

Distribution in Lower Sind.

It has been already stated that the Gáj beds, throughout the greater portion of the Khirthar range, rest conformably upon the Nari group, although there is a change in mineral character, and that in Lower Sind the passage from one group into the other is gradual, calcareous bands with Gáj fossils, such as *Ostrea multicostata* and *Pecten subcorneus,* being found

Relations of Gáj group to Nari.

interstratified with the uppermost Nari sandstones. At one place, however, near Tandra Ráhim Khán, west by north of Sehwán, the outcrop of the Gáj beds, here dipping at a high angle to the westward, runs nearly in a straight line across the mouth of a valley, composed of a deep synclinal of the Nari group between two anticlinal ridges of Khirthar limestone. As the Gáj beds do not share the synclinal curve of the Nari outcrop, it is difficult to see how the two can be conformable; but an examination of the boundary between the two groups failed to show any clear evidence of unconformity. There are, however, some places south of Sehwán where the Gáj group overlaps the Nari beds and rests upon the Khirthar limestone; but it must be recollected that the Gáj group is itself overlapped by Manchhar beds in the immediate neighbourhood.

Palæontology.

The following is of course a very imperfect list of the animal remains found in this richly fossiliferous group, only the more important or common forms being noticed:—

CRUSTACEA.

Palæocarpilius rugifer.[1]
Typilobus, sp.
Balanus sublævis.

GASTEROPODA.

Buccinum cautleyi.
B. vicaryi.
Vicarya verneuilli.
Turritella angulata.

LAMELLIBRANCHIATA.

Kuphus rectus (*Serpula recta*, Sow).
Corbula trigonalis.
Venus granosa.
V. cancellata.
Tapes subvirgata.
Cardium anomale.
Astarte hyderabadensis.
Dosinia pseudoargus.
Arca kurracheensis.
Arca peethensis.
A. larkhanaensis.
Pectunculus pecten.
Pecten subcorneus.
P. bouei.
P. favrei.
Spondylus tellavignesi.
Ostrea multicostata.

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[1] Stoliczka: Pal. Ind., Ser. VII, p. 8, Pls. iv, v.

ECHINODERMATA.

Schizaster, sp.
Maretia cf. *planulata.*
Meoma, sp.
Breynia carinata.
Echinolampas jacquemonti.
Echinolampas spheroidalis.
Echinodiscus, sp.
Clypeaster profundus.
C. depressus.
Cœlopleurus forbesi.

ANTHOZOA.

Pachyseris murchisoni.
Hydnophora plana and other species.
Cladocora haimei.
Mycedium costatum.

FORAMINIFERA.

Operculina canalifera.
Orbitoides papyracea.

Character of fauna.

The commonest and most characteristic fossils of this group are *Ostrea multicostata*[1] and *Breynia carinata.* There cannot be any question that the Gáj fauna is newer than eocene; some of the species are recent (for instance, *Dosinia pseudoargus* is identical with the recent *D. exasperata*, Chemn.), and it is probable that many others, when they are compared with recent forms more carefully than has hitherto been done, will prove to be the same as living species. Several genera, too, as *Maretia, Breynia, Meoma, Echinodiscus, Cladocora,* and *Mycedium,* are unknown in the older tertiaries, and there is almost a complete disappearance of eocene forms, very few species being common to the Nari beds even. The chief doubt is whether the Gáj should not be considered as upper miocene.

The only mammal yet obtained from the Gáj beds is *Rhinoceros sivalensis*—a species found also in the Siwaliks.

Representatives of Siwaliks.

7. *Manchhar group.*—The highest sub-division of the Sind tertiary series has been named from the large lake, a few miles west of Sehwán. The group doubtless represents generally the far better known Siwaliks of Northern India, and it is probable that the upper and lower limits of the two may be the same, but the fossiliferous bands are at different horizons.

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[1] It is not quite certain whether this species is identical with the European Eocene form, but it is certainly the shell figured by Messrs. D'Archiac and Haime. A species known by the same name is found in Rhætic beds in Europe.

Mineral character and sub-divisions.

The Manchhar group of Sind consists of clays, sandstones, and conglomerates, and attains in places a thickness of but little, if at all, less than 10,000 feet on the flanks of the Khirthar range. Although it is difficult to draw an absolute line between the sub-divisions, the whole group may be divided, wherever it is well exposed, into two portions; the lower consisting mainly of a characteristic grey sandstone, rather soft, moderately fine grained, and composed of quartz, with some feldspar and hornblende, together with red sandstones, conglomeratic beds, and, towards the base, red, brown, and grey clays; the latter, however, being much less largely developed than in the upper sub-division. The conglomeratic beds chiefly contain nodules of clay and of soft sandstone, apparently derived from beds precisely similar to those of the Manchhars themselves; so far as has been observed, these conglomerates do not contain fragments derived from the older tertiary rocks, no pebbles either of the characteristic Gáj limestones or of the still more easily recognized nummulitic limestone of the Khirthars having been noticed in the beds of the lower Manchhars, although both abound in the upper strata of the group. These conglomeratic beds of the lower Manchhars are frequently ossiferous, the bones and teeth contained in them being, however, usually isolated and fragmentary.

Lower Manchhar.

Upper Manchhar.

The upper Manchhar sub-division, where it is best seen on the flanks of the Khirthar range, west of Lárkána, is thicker than the lower, and consists principally, towards the base, of a great thickness of orange or brown clays, with subordinate bands of sandstone and conglomerate. The sandstones are usually light-brown, but occasionally grey, like the characteristic beds of the lower sub-division. The higher portion of this upper sub-group contains more sandstone and conglomerate, and the whole is capped by a thick band of massive coarse conglomerate, which throughout a great part of Upper Sind forms a conspicuous ridge along the edge of the Indus alluvium. This conglomerate contains numerous large pebbles of nummulitic and Gáj limestone, together with fragments of quartzite and other rocks of unknown origin. Throughout the conglomeratic beds of the upper Manchhars, pebbles of nummulitic limestone and of the brown Gáj limestone occur, showing that these older tertiary beds must have been upheaved and denuded in the later Manchhar period, although there is a complete passage between the Gáj beds and the lower Manchhars.

There appears, however, good reason for supposing that some disturbance of the older rocks took place before the deposition of the lower portion of the Manchhar group.

Relations to older beds.

To the east of the Laki range the Manchhar beds, themselves disturbed, rest unconformably on the Khirthar group, the beds of which are vertical in many places, so that it is manifest in this case that the Khirthars had been upheaved before the deposition of the Manchhars. The presence in this locality of the lower portion of the latter group appears to be proved by the occurrence of teeth and bones of the same mammals as are found in the lower Manchhars elsewhere.

Upper conglomerate.

It is evidently far from improbable that the Manchhar group of Sind should be sub-divided into two distinct groups, the upper being perhaps the equivalent of the typical Siwaliks. Only a few fragments of bones, too imperfect for determination, have, however, hitherto been found in the upper Manchhars, so that no clue to the age of the sub-division is afforded by fossil remains. There is also a possibility that the coarse conglomerate capping the whole tertiary series should be classed apart from the underlying beds, although it appears to pass into them. The only reason for distinguishing the upper conglomerate, apart from its great coarseness and thickness, is that it, and it alone, exhibits some slight connection in its development with the existing features of the country; at least the conglomeratic band appears to be much thicker at the spot where it is traversed by the Gáj river than it is to the northward or to the southward; and this increase in thickness may be due to an accumulation of pebbles brought down by a stream which occupied in upper Manchhar times the same position as the Gáj now does. A similar increase in the development of conglomerate near the course of the present rivers has been noticed in the case of the Sub-Himalayan Siwaliks. It is, however, manifest that a great part of the disturbance which has caused the elevation of the Khirthar range is of later date than the Manchhar conglomerate, because that conglomerate has been tilted up at high angles, and appears to dip conformably with the older tertiary rocks. Nevertheless it is true that, as has been shown in the last paragraph, there must have been some change of level before the Manchhars were deposited, and it is also true that there is in places an apparent passage from the upper Manchhar conglomerate into the gravels of the slope, on the edge of the alluvium; but the latter may simply be due to the reconsolidation of pebbles derived from the conglomerate itself; and if the amount of disturbance in the interval between the upper and lower Manchhar periods was considerable, the evidence of such a break should be more conspicuous than it is. On the whole, it appears probable that the great period of disturbance which terminated the tertiary epoch in Sind commenced during the deposition of the Manchhar beds, or perhaps even earlier, but that greater changes took place after the highest Manchhar strata had been deposited than during the period of their deposition.

Disturbance of tertiary groups.

In one case a few estuarine fossils were found, near the Nari stream, in a Manchhar bed 300 or 400 feet above the base of the group. The only form recognized was *Corbula trigonalis*, already mentioned as characteristic of the estuarine passage beds between Gáj and Manchhar. With this exception, and that of some rolled oyster-shells possibly derived from a lower formation, no marine or estuarine fossils have been observed in the Manchhar beds of Upper Sind, above the passage beds at the base of the group, and there appears every reason to believe that these rocks are of fluviatile origin. The form of the pebbles in the conglomerate of the upper Manchhars is that of stream-worn, and not that of sea-worn fragments; they

Estuarine fossils in Manchhar beds.

approach an oblate rather than a prolate spheroid. Still the amount of rounding is such as could only have been produced by a rapid stream.

Manchhar beds in Lower Sind.

In Lower Sind, however, there is a very considerable intercalation of marine or estuarine beds with the Manchhars, and this evidence of deposition in salt water increases in the neighbourhood of the present coast. Around Karáchi, beds of oysters, and sometimes of other marine or estuarine shells, are found not unfrequently interstratified with the Manchhar group. There is also some change in mineral character, the sandstones becoming more argillaceous, and associated in places with pale-grey sandy clays and shales. The passage into the Gáj beds is very gradual, calcareous bands with Gáj fossils, such as *Ostrea multicostata* and *Pecten subcorneus*, being found some distance above the base of the Manchhar group.

Relations to Gáj group.

Although, on account of the change in mineral character, there is, except in the neighbourhood of the coast, no difficulty in drawing a line between Manchhar and Gáj beds, everything tends to show that there is no break in time between the two, the lower portion of the upper group being an estuarine or fluviatile continuation of the underlying marine beds. But the great thickness of the Manchhar group in Upper Sind alone would suffice to prove that a considerable period of time must have elapsed during the deposition of this formation, and it is far from improbable that the lower Manchhar beds may be upper miocene, whilst the upper Manchhar strata are pliocene.

Distribution.

The Manchhar beds extend along the edge of the alluvium, and form a broad fringe to the Khirthar range, throughout Upper Sind, from west of Shikárpur to the Manchhar Lake; but the breadth of the outcrop varies greatly, being as much as 14 miles where broadest west of Lárkána, and diminishing both to the north and south. As already noticed, the Manchhar group is thickest just where its outcrop is widest; but the breadth of the area occupied by the beds is not due simply to their vertical development, but chiefly to their forming a synclinal and anticlinal roll before disappearing beneath the alluvial plain; whereas in other parts of the range the same beds are exposed in a simple section, all the strata dipping to the westward. To the north the section is complicated by faults, but to the south the thickness of the Manchhar group diminishes greatly, and west of Sehwán, near Tandra Ráhim Khán, although both upper and lower sub-divisions of the group are developed, and the uppermost conglomerate is exposed, the whole thickness of the Manchhar strata cannot be much more than about 3,000 feet. The Manchhar beds are seen west, south, and east of the Manchhar lake; they are well developed, and occupy a large plain to the east of the Laki range, and west of the nummulitic limestone tract near Kotri and Jhirak; they re-appear in many places in the different synclinal valleys to the west of the Laki range, and they occupy a considerable tract of country east and north-east of Karáchi. But throughout these areas in Lower Sind the rocks are not nearly so well seen as to the northward, the soft sandstones and clays of the Manchhar group having been denuded into undulating plains, covered and concealed in general by the pebbles and sands derived from the neighbouring hills, which are formed of the comparatively hard older tertiary rocks; and it is far more difficult than it is in Upper Sind to distinguish the different portions of the group, or to form a correct idea of the thickness of strata exposed.

Relations to Makrán group of Baluchistán.

The Manchhar beds extend along the edge of the sea, west of Karáchi, almost to the end of Cape Monze, but no representative of this formation is seen for a considerable distance to the westward of the Cape. The few exposures of rocks seen near the shores of Sonmeáni Bay are older tertiary, or perhaps cretaceous, and the greater part of the country consists of alluvium, a low cliff near the coast, north of Gadáni, being composed apparently of sub-recent deposits. But west of Sonmeáni Bay, in the neighbourhood of Hingláj, a well-known place of Hindu pilgrimage, there are high hills of hard greyish-white marls or clays, occasionally intersected by veins of gypsum, usually sandy, and often highly calcareous. With this clay or marl, bands of shaly limestone, dark calcareous grit, and sandstone, are interstratified, but they usually form but a small portion of the mass, although their greater hardness renders them conspicuous. This marl formation extends for many hundreds of miles along the coast, and is well seen at Rás Malán, Ormára, Pasni, Gwádar, near Jáshk, at the entrance of the Persian Gulf, and on the Persian shores of the gulf itself. The headlands of Rás Malán, Ormára, and Gwádar consist of great horizontal plateaus, surrounded by cliffs of whitish marl or clay, and capped by dark-coloured calcareous grit, Rás Malán especially being a table-land rising abruptly to a height of 2,000 feet from the sea. These remarkable rocks have been called the Makrán group[1] from the name usually applied to the littoral tracts of Baluchistán.

The Makrán group is of marine origin, and abounds in mollusca, echinoderms, &c., most of the species apparently being the same as those found in the neighbouring seas at present. The collections made at Gwádar, Jáshk, and other places, have not been sufficiently compared to ascertain whether any are common to the Gáj beds of Sind, but by far the greater portion are distinct; none of the characteristic Gáj fossils, such as *Ostrea multicostata, Breynia carinata, Echinolampas jacquemonti, &c.*, have been noticed in the Makrán group, and the latter appears to be of later age than the miocene Gáj beds. Although there is no resemblance between the typical Manchhar beds and the characteristic rocks of the Makrán group, nor, from the widely different conditions under which the two formations must have been deposited, would any similarity in mineral character be probable, some of the soft argillaceous shaly sands in the Manchhar beds near Karáchi closely resemble some similar beds in the Makrán group near Gwádar. As the coast of Baluchistán has never been examined geologically, all that is known of its structure having been ascertained by brief visits to a few points separated from each other by intervals of from 50 to 100 miles, it is uncertain to what extent the rocks of Sind extend to the westward, and whether any representatives of the Gáj group, especially, exist in that direction; but there appears a considerable amount of probability that

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[1] Rec. Geol. Surv. India, v, p. 43; Eastern Persia, ii, p. 462.

the marine Makrán group in Baluchistán may represent the fresh-water Manchhars and Siwáliks on the edge of the Indo-Gangetic plain.

Palæontology of Manchhar group.

The only fossil remains of any importance hitherto detected in the Manchhar group are bones of mammalia, and all that have been recognized belong to the lower Manchhars; the upper sub-division of the group, as has already been mentioned, having hitherto furnished only a few bones, in too poor and fragmentary a state of preservation for the species, or even the genera, to be determined. The few estuarine shells which have been found in the lowest Manchhar beds in Upper Sind, and a portion at least of the marine fossils procured from a similar horizon near Karáchi, appear to be Gáj forms, and to indicate a close connection between the lower Manchhars and the underlying group. In places, and especially in the neighbourhood of the Laki range, silicified fossil wood is found in abundance in the Manchhar beds, stems of large trees being of common occurrence. The majority are dicotyledonous, but some fragments of monocotyledons are also found.

The following is a list of the species of *Vertebrata* hitherto identified from the lower Manchhar group:[1] it should perhaps be repeated that the remains are extremely fragmentary, and chiefly consist of single teeth and broken portions of bones. No remains of *Quadrumana, Chiroptera, Insectivora, Rodentia, or Cetacea,* have hitherto been found, and the fauna is chiefly remarkable for the prevalence of artiodactyle ungulates, allied to pigs, or intermediate between pigs and ruminants.

MAMMALIA.

CARNIVORA.

Amphicyon palæindicus.

PROBOSCIDIA.

Mastodon perimensis.
M. latidens.
M. (*Trilophodon*) *falconeri.*

Dinotherium pentepotamiæ.
D. indicum.
D. sp. nov.

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[1] These have been named by Mr. Lydekker, Rec. Geol. Surv. India, ix, pp. 91, 93, 106; x, pp. 76, 83, 225; xi, pp. 64, 71, 77, 79, &c.; Pal. India, ser. X, pt. 2, pp. 7, 25, 44, 64, &c.

UNGULATA.

PERISSODACTYLA.

Rhinoceros palæindicus.
* *R.* sp. near *R. deccanensis.*
Acerotherium perimense.

ARTIODACTYLA.

Sus hysudricus.
* *Hemimeryx,* sp.
* *Sivameryx,* 2 sp.
Chalicotherium sivalense.
Anthracotherium silistrense.
* *Hyopotamus palæindicus.*
* *Hyotherium sindiense.*
Dorcatherium majus.
D. minus.

EDENTATA.

* *Manis sindiensis.*

REPTILIA.

Crocodilus, sp.
Chelonia, sp. indet.
Ophidia, sp. indet.

Relations of fauna.

Species marked with an asterisk have not been found elsewhere. The majority of the genera are extinct, *Rhinoceros, Sus,* and *Manis* being the only living types, and the last-named has only been recognized from a single digital phalange, so that the generic identification is far from sufficient. Both *Rhinoceros* and *Sus* existed in miocene times, whilst *Amphicyon, Anthracotherium, Hyopotamus,* and *Dinotherium,* are not known to occur in Europe in beds of later date than miocene. The genera *Hemimeryx* and *Sivameryx* are peculiar; both are allied to the Siwalik *Merycopotamus.*

Siwalik species.

The species found also in the pliocene Siwaliks are *Rhinoceros palæindicus, Acerotherium perimense, Chalicotherium sivalense, Sus hysudricus,* the two species of *Dorcatherium, Mastodon latidens,* and *Mastodon falconeri*; but as the presence of these forms in the Manchhar beds is inferred for the most part from fragments, the identifications are by no means quite certain, whilst the general facies of the fauna, the absence of characteristic living forms like *Equus, Bos, Antilope, Cervus,* and, *Elephas,* and the presence of several extinct genera

Absence of living genera.

not hitherto detected in the Siwaliks show that the mammaliferous beds of Sind are of older age than the typical Siwalik strata. It should be recollected, moreover, that the precise horizon at which the Siwalik forms are found is but rarely known with accuracy; that some of the Siwalik strata are as old as the lower Manchhar, if not older, and that a portion at least of the older types of mammals are from beds low in the Siwalik series. None of the remarkable series of types allied to the giraffes and *Sivatherium*, nor of the peculiar bovine and antilopine forms, so characteristic of the Siwalik fauna, have as yet been found in Sind; the only ruminant detected in the Manchhar beds is the miocene *Dorcatherium*, and the place of the more specialized *Pecora* appears to have been occupied by the less specialized even-toed ungulates allied to the pig. While, therefore, it is probable that some extinct types, such as *Anthracotherium* and *Hyopotamus*, which are not known in Europe above the lower miocene, existed in India at a somewhat later period, together with species which survived till pliocene times, it is evident that the lower portion of the Manchhar group can scarcely be considered of later date than upper miocene. The palæontological evidence is in accordance with the geological, and both show the close connection between the lower Manchhar beds and the Gáj group.

Absence of Siwalik forms.

Relations of Sind tertiary beds to those of neighbouring provinces.—With the exception of the olive group of the Punjab Salt Range, supposed to represent the *Cardita beaumonti* beds of Sind, no definite extension of the Sind beds below the Deccan trap has been clearly traced into the neighbouring provinces. The upper members of the Sind series, however, are apparently identical with those found in Cutch, and probably, now that the typical fossils are known, the same sub-divisions may be traced into Guzerat. The following are the beds in Cutch, as classified in Mr. Wynne's Memoir on the Geology,[1] with the corresponding groups in Sind as already defined :—

Relations between Sind and Cutch tertiaries.

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[1] Mem. Geol. Surv. India, ix, p. 48.

	CUTCH (Kach).	SIND.
TERTIARY	Upper Tertiary.	Manchhar (pliocene).
	Argillaceous group.	Gáj (miocene).
	Arenaceous group.	Nari (upper eocene).
	Nummulitic group.	Khirthar (middle eocene).
	Gypseous shales.	? Ranikot (lower eocene).

It is highly probable that the "sub-nummulitic" group of Cutch, associated by Mr. Wynne with the underlying traps, is also represented by the Ranikot beds, part of which closely resemble it in mineral character. The traps of Cutch are much thicker than in Sind, and are doubtless equivalent not only to the thin bands in the latter province, but to a considerable proportion of the associated upper cretaceous formations. The identifications of the tertiary sub-divisions have been made by Mr. Fedden, by whom the tertiary portion of Cutch was geologically mapped.

Tertiaries of Baluchistán.

Rocks of Sulemán range.

The series in Baluchistán is too poorly known for anything to be added to the identifications already noticed between the lower Khirthar beds, together with their associates west of the Khirthar range, and the rocks near Kelat, and between the Manchhar and Makrán groups. To the north of Sind the rocks of the Búgti and Mari hills have been briefly described by Captain Vicary [1] and a section across the Sulemán range by Mr. Ball.[2] In both of these sections representatives of Manchhar and Khirthar beds are easily traced, but neither Nari nor Gáj can be identified by description or fossils.[3] Mr. Ball described beds which he considers of Sewalik age resting upon sandstones and clays which he suggests may be Náhan. Both these sub-divisions are clearly representatives of the Sind Manchhar group, and the lower is described as resting upon nummulitic limestone (Khirthar).

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[1] Geological Report on a portion of the Baluchistán Hills. Q. J. G. S., 1840, ii., p. 260.

[2] Geological notes made on a visit to the coal recently discovered in the country of the Luni Patháns, south-east corner of Afghanistán; Rec. Geol. Surv. India, vii, p. 145.

[3] A few of the fossils mentioned by Mr. Ball, l. c., p. 153, are Gáj forms, but the identification is very questionable. I examined the fossils, but could detect only Khirthar species.

There is a possibility that representatives of the Nari group overlie the older Khirthar limestone. Mr. Ball's visit was hurried, and he may have overlooked some minor sub-divisions; but it is clear that if representatives of either Gáj or Nari beds occur, they are inconspicuous. Indeed, there is no evidence of miocene marine beds having been traced north of Sind,[1] but there is a probability that Nari beds occur in the Punjab, and that they may be traced in the Sulemán Range.

Beneath the nummulitic limestone, Mr. Ball found a great thickness of shales and sandstones, with some thin bands of coal. These beds do not contain many fossils, but one, *Ostrea flemingi,* is a characteristic Ranikot form, and the beds are probably equivalent to the lower Khirthar of Baluchistán.

Tertiaries of Punjab.

Almost throughout the Northern Punjab representatives of the Khirthar nummulitic limestones may be traced. They occur in the Salt Range, in the Afridi hills, Hazára, the neighbourhood of Murree, the outer slopes of the Pir-Panjál in Jamú, and near Simla, where they form the Subáthu group of Mr. Medlicott.[2] Mr. Wynne considers the "hill nummulitic limestones" found in the Himalayan ranges older than the nummulitic limestone of the Salt Range, but the *Foraminifera* of both, so far as known, are Khirthar species. It is impossible to say which of the various sub-divisions found in the Punjab tertiaries correspond with those constituting the tertiary series above the Khirthar group in Sind, except that it is probable that the Manchhar group of the latter area is represented by the Siwalik series comprising upper, middle, and lower (or Náhan); the unfossiliferous

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[1] A single valve of *Lucina* (*Diplodonta*) *incerta* is said by D'Archiac and Haime (An. Fos. Num. de l'Inde., p. 240) to have been found in the Salt Range. The species has only been obtained in Gáj beds in Sind, but it may range into older rocks. Mr. Medlicott (Memoirs of the Geological Survey of India, vol. iii, pt. 2, p. 100) notes the existence of *Ostrea multicostata* in the Subáthu group; and Mr. Ball found the same fossil with *O. flemingi* in the lower sandstones of the Sulemán range, but the species, although so common in the Gáj group as to be characteristic, ranges into the Nari group, and is in Europe an eocene species.

[2] Mem. Geol. Surv. India, iii, pp. 17, &c.

Náhan group being the equivalent to the fossiliferous lower Manchhar beds, whilst the unfossiliferous upper Manchhars correspond to the ossiferous middle and upper Siwalik beds. No sufficient fossils have been found in the Kasauli or Dagshai sub-divisions of the Sirmúr series to show how far these groups are representative of the Gáj and Nari beds, and the same may be said of the Murree group of Mr. Wynne, the lowest portion of which, however, appears to be of Khirthar (eocene) age, as it contains interstratified limestones with Khirthar nummulites.[1] The rocks of the Siwalik series cover a very large area in the Northern Punjab,—much larger even than that occupied by the eocene beds,—and are traced uninterruptedly across the western and northern portion of the province from the southern extremity of the Sulemán to the Sub-Himalayan ranges east of the Punjab, and thence almost throughout the outer hills of the Himalayas to Assam, so that there is a great belt of later tertiary rocks extending round the border of the hill ranges west and north of the Indo-Gangetic plain.[2]

Additional notes on Sind tertiary series.—Before quitting the subject of the Sind tertiaries, there are two or three points to which attention may be directed. These points are chiefly of interest with regard to the geology of more extensive areas, but the knowledge, gained in the last few years, of the sequence in Sind, and of the peculiarities of the upper mesozoic and tertiary series there exposed, together with the great imperfection of our acquaintance with all the neighbouring regions, renders it desirable that these geological features, although they may not be peculiar to the Sind area, should not be overlooked when the characters of the region are compared with those of other parts of India.

Absence of general breaks below pliocene.

The first of these points is the general conformity of the whole series, from cretaceous (perhaps even middle cretaceous) to pliocene. The lowest bed, the hippuritic limetone, passes into the cretaceous sandstones, and these again into the olive

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[1] I am indebted to Mr. Lydekker and Mr. Wynne for specimens, and amongst them I recognize *N. beaumonti* and *N. granulosa,* both Khirthar species.

[2] For further information on the tertiary beds of India, see Manual, Introduction, pp. l, liv., and Chaps. xiv, xxi, xxii, xxiii, xxviii, and xxix.

shales with *Cardita beaumonti.* The Deccan trap and the Ranikot beds at the base of the eocene period follow in regular and conformable succession, and the break, shown by the Khirthar limestones resting on the denuded edges of the upper Ranikot beds in the Laki range, is merely local, for a few miles to the south-east the two formations pass completely into each other. At the top of the Khirthar limestones also, although there is a sudden and abrupt change in the fauna, no unconformity has been detected at the base of the Nari group, whilst Nari beds in many places, and especially in South-Western Sind, pass uninterruptedly into the miocene Gáj beds, and there is again a complete passage from the latter into the Manchhar group. In the middle of the Manchhar formation there may be a break proved by some slight indications of unconformity, and by the appearance of detritus derived from middle and lower tertiary beds in the upper sub-division; but the unconformity if any exist, is probably local. There is an unquestionable local break in the middle of the Nari beds, but in general they form a conformable sequence throughout.

Great post-pliocene disturbance.

With the Manchhar beds, however, the sequence ends, and, in the evidence of great disturbance having taken place in Western Sind since the upper Manchhar beds were deposited, there is an abrupt and startling change from the phenomena exhibited on the other side of the Indus valley. We are in fact brought into the presence of one of the great facts which divide with so trenchant a line the geology of the Indian Peninsula from that of neighbouring countries. The eocene nummulitic limestone, even in the middle of the Indus Valley around Sukkur and Rohri, never dips at more than 5°, and rarely at more than 1° or 2°; the tertiaries of Cutch, Kattywar, and Surat, pass upwards almost without a break into the coast alluvium; the laterite of Western India, probably of tertiary age at least, lies undisturbed upon the flat cretaceous basalts; and the difficulty in drawing a line between older and newer forms of laterite alone suffices to show how destitute of violent disturbance the geological history of peninsular India has been in cenozoic times. It is unnecessary here to do more than refer to the older mesozoic and palæozoic rocks of the Indian Peninsula, but it is a fact that the pliocene beds of Sind and the Himalayas are more disturbed than the ancient azoic Vindhyans of Bundelkhand. The uppermost Manchhar rocks on the edge of the alluvial Indus plain are frequently vertical, and rarely dip at lower angles than 30° or 40°, and it is manifest that the great anticlinal ridges of the Sind mountains have been largely formed in post-pliocene times.

Direction of disturbance.

In the notes on the physical geography of Sind, it was shown that the ranges of hills in the province are simple anticlinals with parallel axes, all running nearly north and south. This probably proves that the action of disturbance has been unusually simple, and has consisted of a distinct lateral thrust from one direction. To the westward in Baluchistán, and to the northward in the Punjab, there is a complete change in the direction of the ranges.

Alternation of marine and fresh-water beds.

The cretaceous rocks appear to have been marine, with the possible exception of the unfossiliferous sandstones above the hippuritic limestone, but at the base of the Sind tertiary rocks, in the Ranikot beds, proofs of the immediate neighbourhood of land are afforded by the presence of terrestrial plants. It is probable that the thin band of Deccan trap at the base of the Ranikot group is of subaërial origin in Sind as elsewhere, and that the lower Ranikot beds themselves are fluviatile. The upper portion of the Ranikot group, the whole of the Khirthár, and the lower Nari beds, are marine, and the nummulitic limestone may have been deposited far from land, whilst it is certain that a considerable portion of this limestone formation is too pure to have accumulated in a sea into which sediment in any quantity was poured by rivers or washed from a coast line. But, as has been shown above, the Khirthar limestone in lower Sind contains intercalated sandstones and shales, showing the admixture of detritus derived from land, and the great limestone band itself disappears in the south-western part of the province, near the Habb river.

The thick upper Nari sandstones, and the still thicker Manchhars, have, again, the character of fluviatile deposits, but the intervening Gáj group is marine, and in part perhaps estuarine.

Thus, throughout the tertiary series of Sind there is evidence of frequent alternations of marine and terrestrial conditions, the last marine beds known being of miocene date. To the northward, on the flanks of the Himalayas, the tertiary marine beds tend to disappear or diminish; even the nummulitic limestone, the only marine formation which appears to be persistent throughout the greater part of the extra-peninsular area in India, being much less developed in the Sub-Himalayan ranges than it is in the neighbourhood of the Lower Indus Valley.

Alluvium of Indus.

8. *Post-tertiary deposits.*—Although by far the largest part of Sind is covered by sub-recent formations, the deposits are of small interest. The greater part of the province consists of the alluvium of the river Indus, and is a part of the great alluvial tract of Northern India. The Indus alluvial deposits only differ from those of the Ganges in being rather more sandy as a rule, and perhaps somewhat paler-coloured. The older form of alluvium, forming the "*bhángar*" of the Ganges,—an argillaceous earth containing nodular carbonate of lime (kankar) and grains of iron peroxide,—has not been observed in Sind. This absence may be connected with the facts that marine conditions appear to have prevailed in the Indus valley at a comparatively recent period, whilst the Ganges valley has probably been land from a remote epoch.[1]

Gravels, &c., in Sind hills.

The post-tertiary formations in the Sind hills consist of gravels, sands, and clays, which frequently occupy large tracts between the ridges. Coarse gravel, often consoli-

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[1] For a discussion of this subject see "Manual," Part i, pp. 393, &c. It should be stated that the views above expressed as to the antiquity of land conditions in the Ganges plain are opposed to the opinions of many geologists.

The evidence in favour of marine conditions having existed in the Indus valley is noticed in the Manual, p. 394. See also Jour. As. Soc. Beng., 1876, xlv, Pt. 2, p. 93; Rec. Geol. Surv. India, x, pp. 10, 21. The observations were made in Thar and Párkar, east of the Indus, and outside of the area described in the present Report.

dated into a calcareous conglomerate, forms a low slope, sometimes 2 or 4 miles in breadth, at the base of each range. This slope often covers a large portion of the intervening valleys. On the flank of the Khirthar range, the deposit of gravel is usually well developed, being naturally highest where streams issue from the range. Frequently, too, within the range, remains of an old gravel deposit are seen covering portions of the country at a considerable elevation above the streams, and sometimes, as near the Gáj, masses of gravel are seen capping isolated hills and ridges in the neighbourhood of the main range. Such caps usually exhibit a low dip away from the higher hills, and are manifestly undenuded remnants of old gravel deposits.

All such masses of gravel are more conspicuous in a barren country like Sind than in better wooded regions, and similar formations occupy an enormous area in Persia and other parts of Central and Western Asia; the great development of such deposits being apparently connected with the paucity of the rainfall and the absence of rivers of sufficient size to carry away the débris washed to the foot of the hills, the rainfall being sufficient to wash down such detritus where the slope is high, but not where the fall is diminished.

Plain north of Karáchi.

The great plain north of Karáchi is much covered by deposits of gravel and sand, often consolidated into hard conglomerate by carbonate of lime, derived from the pebbles of eocene and miocene limestone, of which the mass is largely composed. Near the coast, oysters of recent species, and a few other marine shells, are occasionally found in the conglomerate.

Blown sand.

Blown sand is found in many places on the plain of the Indus, but is far more abundant to the east than to the west of the river. In the former direction it occupies the vast tract known as the Indian desert.

PART II.

DETAILED DESCRIPTIONS.

CHAPTER IV.—THE KHIRTHAR RANGE FROM THE NORTHERN EXTREMITY OF SIND TO THE NARI NAI.

Importance of sections in Khirthar range.

There are several reasons for commencing the description of the geology of Sind with the Khirthar range. The sections exposed in that range are superb, and afford by far the best epitome of tertiary geology hitherto observed in India. All the rocks from the Khirthar or eocene group upwards are well developed, and the different groups are much better distinguished from each other than they are in Lower Sind. For the complete study of the series exposed west of the Indus, however, two sections should be examined—that in the Khirthar range for the Khirthar and overlying groups, and that in the Laki range for the beds below the Khirthar or nummulitic limestone.

Main range and minor ridges.

The highest range of the Khirthar consists throughout of a great ridge of nummulitic limestone, anticlinal in places, but elsewhere forming only the eastern portion of an anticlinal roll, the axis of which lies west of the British frontier. This main ridge is continuous throughout, except where cut through by the Gáj river. The lower ranges, consisting chiefly of newer tertiary beds to the eastward of the main ridge, are irregular, and are formed by minor rolls of the strata, or by the harder beds; there is, however, throughout a considerable portion of the range, a ridge formed of the uppermost Manchhar conglomerate, along the edge of the Indus alluvium.

Commences at northern end of eastern ridge.

The description of the Khirthar range commences at the northern end of the eastern ridge, near the small town of Kitchi, just north of the British Frontier. At Dharyáro, due west of Lárkána, the main range is divided into two of about equal elevation, the western of which lies outside the British territory; the Sain, or Sayin, stream (Sainwali Nai of map) runs between the two ridges. The eastern ridge terminates in the plain a little north of Kitchi, and consists, near its northern extremity, of a perfectly simple anticlinal roll of nummulitic (Khirthar) limestone, on the surface of which rest patches of the brown limestone belonging to the lower part of the Nari (upper eocene or oligocene) group.[1] These patches are for the most part much too small to be marked on the published map, and they have not been surveyed in detail.

Hot spring of Lakha Pir, near Kitchi.

About 6 miles south of its termination, the range is traversed by a small valley, in which is a hot spring known as Lakha Pir, with a temperature of 112.° The water issues in the bed of the stream, and is strongly impregnated with sulphuretted hydrogen, like the spring of the same name at Laki, near Sehwán. At the spring no fault can be traced in the rocks, which are of Khirthar limestone, and dip at from 20° to 40° eastward, but the spot is nearly on the line of a great dislocation, which is well seen a little further south, and extends for 40 miles in a southerly direction.

Khirthar limestone near spring.

Close to the spring the rocks consist of unfossiliferous pale-coloured limestone in very thin strata, quite unlike the usual Khirthar beds, but a little further west these rocks rest upon massive *Alveolina* limestone of the usual character. The beds dipping to the eastward, above those seen at the spring, are also of the usual type. Altogether about 3,000 feet of Khirthar beds must be exposed here, perhaps more.

Reversed dips in Nari and Gáj beds.

At the entrance of the valley, through which the water of the spring runs out to the plain on the east, about 4 miles north-west of Kitchi, the beds are turned sharply over, and the rocks of the Nari group come in with a reversed dip, which can be traced for some miles to the southward, on the eastern flank

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[1] By a mistake which was not noticed in time to be corrected, these patches, and also a small fringe of Nari beds at the extreme northern end of the range, have been coloured as Gáj on the map herewith issued. The same mistake has been made in the case of two Nari outliers on the higher portion of the Khirthar range further south.

of Miágwan mountain, a mass of limestone, rising to an elevation of 5,093 feet, just inside the British Frontier; Gáj (miocene) beds also appear, with the same reversed dip, in the valley of a small stream, the Mitha Nai (Mithooware of inch map), close to Kitchi. The rocks are very ill-seen, being much concealed by fragments of nummulitic limestone, which have fallen from the hills above. The Nari beds appear to be turned over again to the westward, and then faulted against the Khirthar limestones; but the section is obscure and probably complicated by several faults.

First appearance of Manchhar beds.

At the northern extremity of the range, no rocks above the Nari limestones are seen, the Khirthar beds, with patches of Nari[1] resting on them in places, rising directly from the alluvial plain; but Manchhar beds (pliocene) appear at the base of the range a little north of Kitchi, where the conglomerates which usually cap the group form a ridge of almost vertical strata running nearly north and south. Gáj beds appear at the same place. Many copious springs of water issue from the eastern or outer side of this ridge, and are used for irrigation. One of these springs, which supplies the village of Kitchi, has a temperature of 85.° It is not easy to see why the springs originate at this spot. Where the conglomerates first appear, there is not nearly room to the westward, between them and the older Gáj and Nari beds, for the whole thickness of the Manchhar group, as developed immediately to the southward. Either a great thickness of the beds is cut out by a fault, or the conglomerates must be unconformable to the remainder of the group; for it is improbable that the beds of the latter thin out in so short a distance.

Springs.

Part of Manchhar wanting.

Miágwan.

On the ascent of Miágwan from Súrk, nummulitic (Khirthar) limestone appears about half way up, all the lower slopes being composed of Manchhár beds. Near the boundary both rocks are squeezed and turned up. Some Nari beds are seen greatly crushed at one spot, and fragments of Gáj limestone

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[1] Coloured as Gáj on the accompanying map by mistake.

also occur, but in such a manner as to show that both are probably only fragmentary masses squeezed into a fault. The faulting is of course, in reality, more complicated than it is represented on the map.

Khirthar and Nari beds of Dharyáro ridge.

The Khirthar limestone on the top of Miágwan is nearly horizontal, and continues so along the range to Dharyáro (close to Kutta-jo-Kabar). To the eastward the rock turns sharply over on Miágwan and for some distance to the south, as on the Drib stream. To the westward the limestone dips towards the Sain stream, which runs in the bottom of a synclinal, and there is a smaller synclinal east of the main water-shed in the upper valley of the Kenji. The crest of the range appears to consist throughout of grey Khirthar limestone, but on all the slopes Nari beds appear, being conspicuous from their brown colour; broad patches of these brown limestones occur on both sides of the Sain valley, whilst large horizontal or nearly horizontal masses form the terraced hills known as Larkane-jo-Man and Kuni-jo-Man. Similarly large patches occur in the upper valley of the Kenji, above Chúshang, and in a similar form, that of flat-topped hills, only the brown limestones at the base of the group remaining. On the flanks of Dharyáro and the range to the southward, the same brown limestone extends up the slopes of the hills, far above the limit of the overlying Nari sandstones, every stream course which runs down the hill side cutting deeply through the brown Nari rock into the grey or white Khirthar limestone beneath it. The bed of Khirthar limestone forming the upper portion of the range at Dharyáro and in its neighbourhood is very thick, 1,000 feet at least, and almost devoid of distinct stratification.

Dharyáro plateau.

The small plateau of Dharyáro is about 5,000 feet above the sea, and consists of a flat expanse of arable ground, nearly a mile in length, surrounded by barren limestone rises. Kutta-jo-Kabar, the culminating peak of the range, lies just south of the plain and about 1,000 feet above it. There is no apparent outlet to the Dharyáro plain; the surplus rain water evidently finds its way out through clefts in the limestone. Of these there are several on the plateau, some of them being broad fissures partly filled up by earth below, and with "swallow holes" down which water evidently runs, in the bottom. The accumulation of soil on this and similar plateaus is probably due to the want of an outlet.

Junction of Manchhar and Khirthar beds on Lalan stream.

In the lower ranges east of the main ridge the geology is rather more confused than it is further south, owing to disturbance and some faulting. On the Lalan stream, about 4 miles north of the Kenji, the Manchhars are distinctly seen to be faulted against the Khirthars. That the junction is a fault is shown by the rocks being completely smashed, and by fragments of Nari sandstone being mixed up with them.

Remarkable faults along the west of the Piro range.

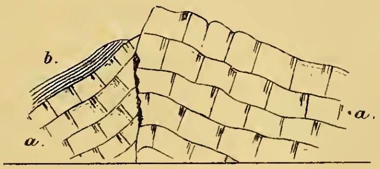
There can be but little doubt that this fault is a continuation of that seen west of Kitchi and again on the slope of Miágwan. On the continuation of the same line a fault is seen crossing the Kenji Nai at Lakha-jo-Kandi, and may be traced to the southward along the western side of the Piro range, a lower ridge near the base of the main Khirthar chain, to beyond Kárch, or for more than 20 miles from the Kenji Nai, whilst the extension to the northward, if the fault, as appears probable, is continuous throughout, would add 25 miles more. It is true that the fault was only followed south of the Kenji Nai; to the northward the ground is so rough that more time than could be spared would have been required to trace the line of dislocation; but so far as could be made out, the northern extension of the fault is on the same line as the southern. The most remarkable fact about this fault is that the throw at the Kenji Nai and to the southward is to the west, whilst to the north the throw is in the opposite direction, or east. It is certain that the amount of the throw varies greatly; at Lakha-jo-Kundi, on the Kenji Nai, it does not, in all probability, exceed 300 or 400 feet, whilst at Bedo, about 8 miles further to the south-south-west, the throw appears to be about 2,500 feet. South of this, along the Piro range, the amount again diminishes, but throughout the Kárch valley, Khirthar rocks are brought against Nari beds. Towards the head of the Kárch valley, the fault appears to terminate in a sharp synclinal of the Nari beds, which is again seen on the southern side of the great limestone cleft known as the Sahár Dát,[1] where the Sahár stream traverses the southern continuation of the Piro range, which a little further south joins the main Khirthar range to the westward, the synclinal which separated them dying out. Water appears in several streams, *e.g.*, Mogrio and Trappen, along the line of this fault, the general direction of which, south of the Kenji Nai, is from 15° to 35° west of south, to the northward nearly north and south.

Faults in neighbourhood of Dharyáro.

The southern portion of this fault is evidently along a synclinal, but the synclinal disappears to the northward long before the throw is reversed. Amongst the higher ranges the tendency appears to be towards faulted anticlinals. In many places north of Dharyáro the east face of the main range consists of a cliff, from the crest of which the beds dip at a low angle westwards on the top of the range; whilst from the bottom of the cliff there is a steeper dip to the eastward, and the presence of a fault is shown by the occurrence of Nari beds on the eastern slope.

Fault near Chusháng.

Although faults are not numerous, they were perhaps more commonly observed in the range north of Dharyáro than to the southward. One is seen running north-east—south-west, west of the gorge cut by the Kenji stream at Chusháng. This fault is just such a broken anticlinal as that represented above, and it is continued for some distance up the gorge of the stream above Chusháng. Another small fault, seen in a cliff



Section of faulted anticlinal, Khirthar range.
a, Khirthar; *b*, Nari.

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[1] Dát in Baluch means gorge, and is especially applied to the deep clefts cut by streams through the Khirthar limestone. The name of the Sahár stream is omitted on the Revenue Survey map.

Reversed fault.

on the Kenji stream a little below Chusháng, is reversed; it has only a throw of 30 or 40 feet, and it traverses Nari beds, but it is chiefly remarkable for its low angle; it underlies to the eastward at a slope of only 40° from the horizon.

Sections of Kenji Nai.

On the Kenji Nai the Gáj beds come in at the foot of the first high range. They dip at a very high angle to the eastward, like the overlying Manchhar beds, and their outcrop is consequently narrow. They appear to be not more than 600 or 700 feet thick, much thinner than they are a little further south,—an appearance due, perhaps, in part to compression caused by disturbance, but there is very possibly a thinning out also. Towards the top more than one bed of white gypsum is seen in the Gáj group, associated with deep red and olive shales containing *Corbula trigonalis*, *Tellina subdonacialis*, and a *Turritella*. These beds appear well developed, but the lower portion of the group, beneath a conspicuous hard limestone band with echinodermata and corals, does not appear more than half the thickness; it is in the Sita Nai, 6 miles further south.

The Nari sandstones have a lower dip than the Gáj, and after some distance the former roll over again and dip westward. Two bands of brown limestone with *Nummulites sublævigata*, *N. garansensis* and *Orbitoides papyracea* are seen at the anticlinal, each 3 or 4 feet thick, and separated by 300 or 400 feet of sandstones from the more massive brown limestones at the base of the Nari group. Just beyond the anticlinal is the fault at Lakha-jo-Kandi already mentioned, at a spot where a stream joins from the south. Beyond the fault the Kenji runs from the north, and as the throw is here to the westward, higher Nari beds come in dipping to the south. The stream cuts through Nari beds as far as Chusháng, where the Khirthar limestone crops out, and the Kenji has cut a gorge through the limestone. Part of this gorge is occupied by a deep pool of water known as Chusháng Dhandh.

One of the most interesting points in the Kenji section is the occurrence of bands of fossiliferous limestone in the Nari group at an elevation of 300 or 400 feet above the usual beds at the base of the group.

Resemblance between Nari and Manchhar beds.

In this part of the hills there is a great resemblance between the Nari and Manchhar beds, and it is highly probable that both were deposited under similar conditions. The Nari rocks are harder than the Manchhar, but the sandstones in both are often of similar grey colour and structure. The shales in the Nari beds are usually darker than the Manchhar clays, but in the Kenji stream some nodular orange-brown shales are seen in the former, of precisely the same colour as the clays in the latter, and purplish-red clays, precisely like those of the Manchhar beds, are associated with the limestone bands near the base of the group.

Section on Sita Nai.

There is nothing worthy of notice in the two streams, Mogrio and Trappen, traversing the hills of Gáj and Nari beds south of the Kenji Nai. On the Sita Nai (Tooneewaree of map), an excellent section of the Gáj beds is seen at the entrance to the gorge through the hills, the lower portion of the group being especially well exposed. The upper portion consists, as usual, of sandstone, limestone, and clay; the section towards the base is the following: descending—

		Feet.
1.	Brown calcareous sandstone	
2.	Hard brown limestone with *Breynia carinata, Echinolampas, Cœlopleurus, Schizaster,* &c. This is a conspicuous hard bed, always containing numerous echinoderms, and well developed to the southward	6
3.	Light-green argillaceous and calcareous sandstone with corals, which are seen on the weathered surface	6
4.	Grey limestone	1
5.	Light-brown limestone	2
6.	Thin alternations of shales and impure hard brown limestone .	10
7.	Dusky olive shales and very thin lenticular layers of white sand	15
8.	Pale-greenish sandy calcareous rock, containing *Ostrea, Pecten,* and *Foraminifera,* interstratified with bands of carbonaceous shale	10
9.	Whitish, greyish, and greenish-white rubbly limestone with large corals, especially in the upper portion . . .	30
		80

		Feet.
	Brought forward...	80
10.	Dark-olive shales with calcareous bands containing oysters, &c.	30
11.	Pale-olive calcareous sandstone weathering brown . . .	10
12.	Olive-green, red-ochrey and purple shales (some of them containing iron pyrites and with an efflorescence of alum) and rather hard whitish sandstone. Some of the shales are fossiliferous and contain *Leda, Ostrea, Turritella,* &c. Approximate thickness	100
		220

Section on Sita Nai.

Above this the Sita Nai traverses a deep glen between cliffs of the massive Nari sandstones. At least 3,000 feet of these beds are exposed, and then comes a considerable thickness of dark-coloured shales (700 or 800 feet) associated with the characteristic brown limestones. These last beds form the Piro range, round the north end of which the Sita stream runs in a deep curve, exposing a fine section of the shales in the cliff north of the stream. West of the Piro range, which rises rapidly to the southward, runs the fault already described, bringing down the upper Nari sandstones to the west of the range. These dip eastward at from 10° to 20°, and continue for about 2 miles till the Khirthars crop out at the foot of the main range, the brown limestones at the base of the Nari group running up the slopes as usual. Most of the water in the Sita stream comes from hot springs (temp. 91°) situated not on the fault west of the Piro range, but on the eastern side of the latter.

Piro range.

In the Piro range, south of the Sita Nai, Khirthar limestones appear from beneath the Nari beds near Bedo, and again to the southward, where the next stream, the Mazaráni Nai, cuts through the ridge by an impassable gorge. From this point the crest of the Piro ridge consists of Khirthar beds, except just north of the Sahár Dát. West of the Piro ridge, the Kárch valley, running nearly north and south on the upper part of the Mazaráni stream, is cut out of the soft Nari sandstones.

The section of the Gáj beds on the Mazaráni Nai is poor, and presents no peculiarities. The dip is lower than farther north. The area occupied by the Manchhar beds is here wider than anywhere else along the flank of the Khirthar range, and the country between the Kenji and Búrri streams perhaps affords better sections of these beds than the ground farther south. Still there is never a complete exposure of the strata as there is in the case of the older tertiaries. The softer beds of the Manchhars are, as a rule, very ill seen, and occupy large flats covered with gravel between low ridges formed of the harder rocks.

Manchhar beds between Kenji and Búrri streams.

North of the Kenji Nai the Manchhar beds dip eastward for some distance from the base of the higher ranges; then they roll up and dip westward with a much lower dip; and they again turn over near the plains. The synclinal and anticlinal roll becomes more marked on the Kenji Nai. Here, resting upon the Gáj group, the lower Manchhar beds, consisting of more than 3,000 feet of grey sandstones, are followed by 1,500 to 2,000 feet of orange clays (upper Manchhar), all dipping at 70° or 80° to the east. Then comes a synclinal, to the east of which but few clays are seen; they may be cut out by a fault, but no other evidence of faulting was noticed at this spot. The beds dip west for about 3 miles at angles of from 5° to 15°. They then turn over again and dip eastward, and the clays of the upper sub-division appear at the edge of the alluvium, dipping east at about 40°. The section is, however, incomplete, the upper conglomerate not appearing, although it comes in about 3 miles further south.

Manchhar beds on Kenji Nai.

On the Mazaráni Naí, the dips are lower, the outcrops consequently wider, and east of the synclinal there are broad gravel plains; whilst immediately south of the river, the section west of the synclinal is completed by the appearance of the conglomerate forming the uppermost of the Manchhar beds, so that a perfect section of the Manchhars occurs between the outcrop of the Gáj and the synclinal axis; the latter being occupied by alluvium to the east of the conglomerate ridge; whilst further to the eastward the anticlinal

Manchhar beds on Mazaráni Naí.

of Manchhar beds stretches southward into the alluvium, as a great promontory, as far as the Búrri Naí. The conglomerate at the top of the Manchhars is not seen on the eastern side of the alluvial bay, although it re-appears to the eastward of the anticlinal on the edge of the great plain. The absence of this conglomerate east of the synclinal may, like the paucity of upper Manchhar clays in the corresponding position on the Kenji river, be due to a fault along the synclinal axis. Near Lakha Pir, north of the Mazaráni stream, a much greater thickness of beds appears to be exposed east of the anticlinal than west of it.

The large tract of country occupied by Manchhar beds around Lakha Pir and Sháh Godria, east of the synclinal, is of small interest. It consists, like most of the Manchhar country, of low barren hills of soft sandstone, with gravel flats between. The uppermost conglomerate forms a ridge along the edge of the alluvium, but the beds underlying it are here sandstones; whereas a few miles to the south-west they are mostly clays.

Passage beds between Gáj and Manchhar on Dredhak stream.

The section on the Dredhak stream south of the Mazaráni is good, exposing Nari and Gáj beds well, all dipping eastward at about 25° to 30°; but there is nothing to which to call particular attention, except the prevalence of ill-preserved fucoids in the Nari sandstones and the passage beds between the Gáj and Manchhar. These latter are particularly well seen at a spot called Lehro-jo-garok, where they must be at least 200 feet thick, and consist of grey, olive, and brown clays and sandstones, calcareous beds, and red clays. Some are fossiliferous. At the base occur clays with *Corbula trigonalis*; above these is a hard calcareous band abounding in *Placuna*. This bed also contains *Ostrea multicostata*, the common Gáj species. Below the *Placuna* bed is a thin band with a small *Ostrea* or *Anomia*. About 100 feet above the *Placuna* bed is a stratum abounding in large oysters.

Gáj beds of Amrú, &c.

The Búrri stream (Burije of map) runs between the two high peaks of Amrú and Hashim (Hashun of map), partly composed of Gáj beds. To the south of the

Mazaráni Nai, the outcrop of the Gáj group begins to form a conspicuous ridge, cut through by every steam flowing from the main range to the westward, but, between the valleys, rising into conspicuous peaks, with a steep scarp to the westward, and with their eastern surface corresponding to the dip of the beds. The highest of these peaks is Amrú, 2,716 feet above the sea, Hashim, the next peak to the southward, being but little lower. The precipitous western scarps of these hills consist of Nari sandstone, whilst their eastern slopes are composed of the brown fossiliferous Gáj limestones and their associates. The limestones contain the common Gáj echinoderms, *Breynia carinata, Echinolampas jacquemonti, Clypeaster* and *Cœlopleurus forbesi.*

Ridge of Gáj beds.

From the summit of any of these hills, the outcrop of the Gáj beds can be seen extending for miles to the north and south with the greatest regularity. The general strike is very constant and nearly due north and south. At Amrú there is a slight change in the strike, and consequently some of the dips are high. To the northward the angle of dip is about 20° to 25°; to the south it is rather lower, there being a gradual diminution in the slope of the beds. But at Amrú the Gáj rocks are inclined at 45°, or, in places, even more. In the gorge of the Búrri Nai between Amrú and Hashim, there is a fine section of Gáj and Nari beds dipping at 45°; but in the next stream to the south of Hashim, a tributary of the Búrri Nai called the Kúpri,[1] and on Hashim itself, the dip becomes only 20° to 25°, and this soon diminishes to the westward, as it does farther north to the west of Amrú, where horizontal Nari sandstones form high hills between the Gáj peaks and the main range.

Nari beds on Kúpri Nai.

On the Kúpri stream, the lower Nari beds, which must be 1,500 feet thick, consist of greenish-grey shales and light-brown sandstones in thin beds, with the usual brown limestones, containing *Nummulites garansensis* and *N. sublævigata,* towards the base. The sandstones contain pellets of clay, and numerous fragments of plants, but nothing which can be determined. All these beds

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[1] On the one-inch and quarter-inch maps, this branch is marked as Booreewaree.

are very regularly and evenly stratified. Towards the higher Khirthar ranges they dip steadily to the eastward at considerable angles, but further east they roll over more than once, and are much contorted and crushed. The massive sandstones of the upper Nari group are much less disturbed; they form a simple synclinal on the hill-sides above the contorted shales; then they turn over to the eastward in a low anticlinal, and dip at an angle of 10° to 15° for some miles till they disappear beneath the Gáj beds. With these massive sandstones some shales are associated, and the sandstone beds occasionally contain nodules of clay and ferruginous concretions.

Lower Nari limestone on higher ranges.

Amongst the higher ranges around Dodo-jo-kacha, near the head of the Kúpri and Búrri streams, the lowest bed of Nari limestone often covers large portions of the surface, as around Dharyáro. The Nari bed is often but two or three feet thick, so thin that it is cut through by every petty stream course.

Nari beds on Súr stream.

The shales at the base of the Nari group which are so thick on the Kúpri Nai diminish considerably in thickness on the Súr, the next stream to the southward, and are no thicker than they are farther to the north.

Hot springs.

Near the head of the Súr, at Mutráni, there is a warm spring,—temperature 83.° The water issues in Nari beds. On the next stream to the south (all these streams unite to form the Salári), the Shikáni, there is another spring, but it is cold. There is a copious hot-spring on the main or southern branch of the Salári, but it was not visited. The waters of this spring ceased to flow for three years after an earthquake in 1871, but subsequently re-appeared in greater quantity than before.[1]

Nari, Gáj, and Manchhar beds on Salári Nai.

The Nari and Gáj beds on the Salári and its tributaries present no peculiarities. The conglomerate at the top of the Manchhar group is found on the Búrri Nai, but disappears on the Salári and Maki. It re-appears further south near the Gáj river.

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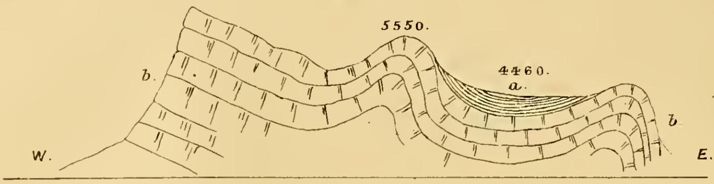
[1] I am indebted to Mr. H. E. Watson, of the Sind Commission, for this information.

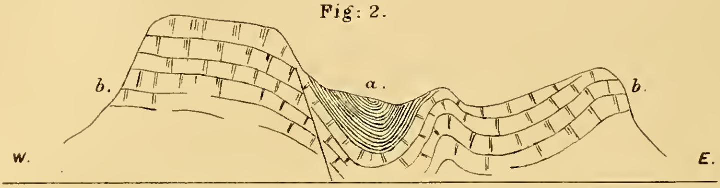
Fig. 1.



Section at Bandoji Kabar.

a. Nari beds. b. Khirthar

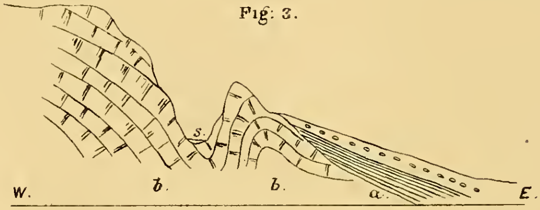
Fig: 2.



Section at head of Salári stream.

a. Nari beds. b. Khirthar.

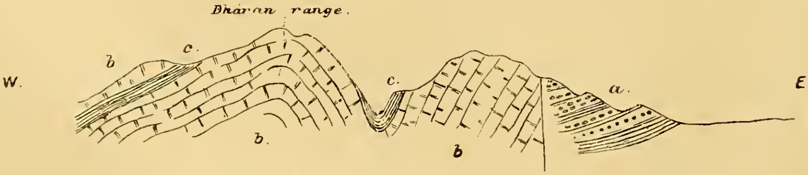
Fig: 3.



Section across Sulphur-spring ravine at Laki

a Manchhar, b. Khirthar, s. position of spring.

Fig: 4.



Section across Dháran Range at Dháran Lak.

a Manchhar group b. Khirthar limestone. c Shales interstratified with ditto.

S. K. H.

Nari beds on higher ranges.

At Bando-ji-kabar, near the head of the Salári stream, Nari beds[1] come in upon the Khirthars of the higher range, and extend thence to the southward, occupying the trough of a synclinal between two ridges of Khirthar limestone. The general section is shown in the annexed sketch (Pl. III, fig. 1). The synclinal of Nari beds is continued across the head-waters of the Salári and Maki streams to beyond Harár. It is much complicated and cut up by faults, the sharp synclinals and anticlinals being frequently accompanied by fracture and slipping. Thus at the head of the Salári the section is of this kind (Pl. III, fig. 2), or there may be a fault east as well as west of the Nari synclinal.

Khirthar ridge.

Between the Salári and Maki streams, and again south of the Maki stream, the ridge of Khirthar limestone to the east of the Nari synclinal has a precipitous scarp to the eastward, probably a fault, and it is near the base of this scarp that the Salári hot-spring, already mentioned, rises. Even this outer ridge is double in places and contains a crushed synclinal, in which little patches of Nari beds occur here and there. The Damria towers,[2] two round turrets built apparently for the purpose of guarding a pathway, are on the edge of the eastern scarp.

Harár.

Harár, at the head of the Maki Nai, is about 3,000 feet above the sea, and is a very singular and beautiful place. It is on a low part of the main range which slopes upwards on the western side to an elevation of between 5,000 and 6,000 feet. To the east is a steep scarp, overlooking the lower ranges of Nari, Gáj, and Manchhar beds, and the Maki Nai cuts its way to the low ground through lofty cliffs of Khirthar limestone. The slopes of the main Khirthar range west of Harár are covered with Nari beds. How these beds are cut off to the eastward is not clear, but south of Harár an immense mass of Khirthar limestone rises, surrounded by

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[1] Coloured by mistake as Gâj on the map.

[2] For a description of these towers by Dr. Lalor, see Sind Gazetteer, p. 493. They are there called Danna towers, but on the map Doomria. The correct name, as I learn from Mr. H. E. Watson, is Damria.

precipices. At the bottom of the hollow is a copious warm spring (temperature 82°).

South of Harár.

South of Harár the rocks are greatly crushed. The Nari beds dip sharply to the eastward, and are abruptly cut off; this being repeated more than once. There has evidently been a great squeeze and some faulting. The Nari beds continue about 2 miles south of Harár; thence to the Gáj only patches occur on the top of the Khirthar.

Nari outcrop on Maki Nai.

The Nari outcrop is comparatively narrow on the Salári and Khurbi (Koorbee) streams, where the dip is nearly the same as that of the overlying Gáj beds; but to the south again on the Maki Nai, as further to the north, the dips in the Nari beds are lower, and the outcrop much broader. It should be noted that the average breadth of the Gáj outcrop on the map is much greater than the thickness of the group would alone account for, partly because the hard limestones near the base of the Gáj beds cover the long eastern slopes of hills, the mass of which is formed of the Nari sandstones. The diminution in breadth of the Nari outcrop is also in part due to the lower beds being turned up sharply close to the Khirthar outcrop at the base of the main range.

Gáj and Manchhar beds on Maki Nai.

The Gáj beds on the Maki Nai are composed, as usual, of limestones, with shales and sandstones near the base, and brown and reddish sandstones, many of them calcareous, and clays above, the uppermost beds being variegated clays, with some grey sandstones forming a passage into the Manchhar group. The latter, so far as it is seen, is chiefly composed of sandstones; the clays, which elsewhere form so large a proportion of the formation, are inconspicuous, and the bands of conglomerate are few in number and of small importance. At the base, there is a well-marked ridge of the characteristic grey sandstone, which can be traced for many miles north of the Gáj.

Passage beds between Gáj and Manchhar.

This grey sandstone bed on the Lárkanda (a tributary of the Maki Nai to the south of the main stream), and on the Maki Nai itself, rests upon clays of various colours,—

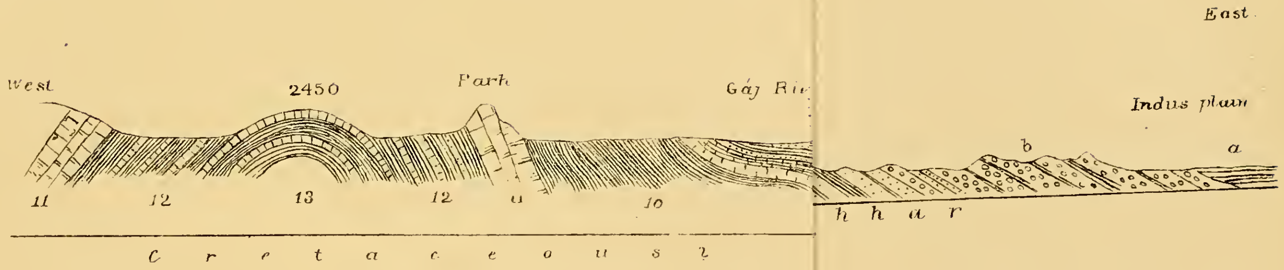
Plate IV.

General Section of the Khirthar range on the Northern bank of the Gaj river

Approximate Scale, vertical and horizontal, 1 inch = 1 mile

a Alluvium of Indus plain; b, Manchhar conglomerates, c. Manchhar sand-stones and clays, d, Gaj beds, e, Upper Nari, f, Lower Nari; The numbers affixed to different beds of the Khirthar group and to all lower strata are explained in the text

late IV.



a, Alluvium

Indian red, buff, yellow, and olive,—with bands of sandstone, forming the estuarine transition beds between the Manchhar and Gáj groups. These beds are very well seen from the Maki to the Gáj, and on both streams, and they are more fossiliferous here than they usually are. On the Lárkanda Nai the uppermost bed beneath the grey sandstone is a thin band of calcareous grit containing a species of *Ostrea,* perhaps a variety of *O. multicostata,* and a little below is another oyster bed containing a larger kind. In the underlying clays are found *Corbula trigonalis, Arca larkhanaensis,* two species of *Turritella* (one of which is a form of *T. angulata*), a *Scalaria, Buccinum cautleyi,* &c. These occur in a band of argillaceous limestone weathering into clay. Another bed, a few feet lower, contains *Lucina* (*Diplodonta*) *incerta,* and *Tellina subdonacialis.* The beds are best seen in a small stream running into the Lárkanda Nai from the southward.

Gáj river section.

The section on the Gáj river is one of the best in the hills; it is easy of access, the bed of the stream affording a practicable path for camels as far as the outcrop of the Khirthar limestone, and all the beds being finely developed.. The Gáj beds themselves are magnificently exposed in a great cliff nearly 1,000 feet high. The Nari beds are also well seen. The section was examined rather more carefully than most of the other stream beds, and the rocks in Kelat west of the main range were visited.[1] The section may be most conveniently described in descending sequence, commencing at the edge of the plains. The accompanying section (Pl. IV) shows the general relations of the beds.[2]

The conglomerate, which is absent at the top of the Manchhar on the Salári and Maki streams, re-appears in great force on the Gáj and for

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[1] These, it should be remembered, are not easy of access, as the channel of the stream is impassable, and the path over the hills is very steep and bad.

[2] This section is taken a little north of the Gáj. It crosses the main Khirthar range where the latter is about 4,000 feet high near the Kapwi pass, and about a mile north of the river, and traverses Sur hill, the section for some distance west of the hill being oblique to the line of dip. It then passes through Chatia hill station composed of Gáj beds. West of the Khirthar the distances are merely approximative.

some miles to the northward and southward. This bed is particularly well seen to the north of the Gáj, and occupies a ridge between a tributary water-course and the gravel slope on the edge of the alluvium. The dip of the conglomerate is about 25°, and the breadth of the outcrop more than half a mile. The conglomerate is coarse, most of the pebbles being 3 to 6 inches in diameter, and many larger; they are evidently stream-worn, not marine, being very oblate spheroids or ellipsoids; some, 3 or 4 inches in diameter, are not much more than an inch thick. The majority of the pebbles are of nummulitic limestone, especially close to the river. Three miles farther north there appeared to be a larger proportion of hard sandstone and quartzite fragments. The greatly increased thickness of this conglomerate near the Gáj river, and the corresponding development of the Siwalik conglomerate on the Himalayan range, near the places where great rivers run out, has already been noticed in Chapter III.

Manchhar group of Gáj section.

Below the conglomerate there is a great thickness of red, brown, and buff sandstones, with some clays and occasionally conglomeratic bands. The dip becomes higher, about 45° to 50°, diminishing again to 30° near the base of the Manchhar beds. The whole thickness of the group cannot be less than 7,000 to 8,000 feet. In the lower portion reddish yellow and variegated argillaceous beds prevail, with brown and grey sandstones and conglomerates; the latter are frequently ossiferous, especially close to the bottom of the group. These conglomerates contain nodules of cream-coloured clay and of soft sandstone, but no nummulitic limestone. Some sub-angular fragments of purple quartzite, micaceous slate, and gneiss were, however, found; it is difficult to say whence they can have been derived. In one of the ossiferous bands casts of a small spiral shell were discovered by Mr. Fedden; the genus could not be determined with certainty. Amongst the remains of *Vertebrata* found here[1] were teeth of *Mastodon*, *Dinotherium*, *Rhinoceros*, bones of genera allied to *Merycopotamus*, frag-

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[1] Partly by Mr. Fedden, partly by Hira Lal, one of the native assistants attached to the Survey.

ments of crocodile skulls and tortoise plates. A few large oyster shells were also found; they were much rolled, and had perhaps been derived from lower beds. The ossiferous bands and the lower Manchhars generally are best seen to the south of the river, but no continuous section is exposed. The bone locality mentioned by Vicary[1] is on the left bank or north of the river; but remains were nowhere found by the survey, despite much search, in such abundance as from his description would be inferred to exist.

Beds between Manchhar and Gáj groups.

The transition beds between the Manchhar and Gáj groups are best seen in a small cliff on the left (north) bank of the river at some wheat fields, about 3 miles from the edge of the hills. It should be noticed that the river has cut through the hill ranges a broad level water-course, in places upwards of a mile wide, filled usually with coarse gravel, but in some places covered with soil, and not unfrequently overgrown with trees and bushes. The estuarine strata at the top of the Gáj beds are, as usual, variegated clays, red, brown, olive, &c., in colour, with sandy shales and calcareous sandstone. A few bones were found in these beds. *Turritella angulata*, *Corbula trigonalis*, and *Arca larkhanaensis* occur as usual, and with them Mr. Fedden procured *Vicarya verneuili*, a *Nucula* near *N. studeri*, and other fossils. In beds rather lower down, a slate-coloured shale yielded some small crabs, including amongst others the genus *Typilobus*, described by Dr. Stoliczka[2] from the tertiaries of Sind and Cutch. The horizon of this fossil was previously unknown, and was incorrectly supposed to be eocene.

Section of Gáj group on Gáj river.

Above this the course of the river runs through Gáj beds for 4 or 5 miles, the dip, which was at first 25°, becoming much lower, and in the lower beds of the Gáj group being not more than 8.° The very fine cliff section of the group is on the south (right bank) of the river, about 5 miles from the plain to the eastward. The uppermost beds are not here exposed, but not more

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[1] Quart. Jour. Geol. Soc., 1847, iii, p. 347.

[2] Pal. Ind., Ser. VII, p. 14, pl. III, figs. 3—5.

than 200 to 250 feet can be deficient. In the upper part of the cliff some variegated clays with a band of pure white gypsum are very conspicuous. The following section was roughly measured, chiefly by aneroid :—

Section of the Gáj beds (*descending*).

1.	Sand and sandy-clay, greenish-grey and pale-brown in colour, calcareous and nodular in parts, abounding in *Ostrea multicostata*	80
2.	Hard, brown, calcareous sandstone, compact and obliquely laminated	10
3.	Sandy clays, olive and Indian-red in alternate bands . . .	50
4.	Pale brown calcareous sandstone and gritty limestone, hard and compact	6
5.	Pale brown and grey sandy clay	20
6.	Pale brown calcareous sandstone	5
7.	Pale brownish-grey sandstone and sandy clay	50
8.	Gypsum much mixed with clay	3
9.	Sandy clay in thick bands, alternately coloured Indian-red and greenish-grey, and some gypsum	60
10.	Gypsum nearly pure	3
11.	Sandy clay like No. 9	60
12.	Whitish argillaceous limestone, abounding in fossils, *Ostrea multicostata*, *Pecten*, fragments of crabs, echinoderms, *Bryozoa*, &c.	3
13.	Pale brown calcareous sandstone, with casts of *Turritellæ* . .	20
14.	Pale brown and greenish sandy shales, containing near the base a hard, calcareous band with *Turritellæ*	30
15.	Very fine-grained yellowish-brown sandstone, calcareous and argillaceous, containing *Cardium anomale*	1
16.	Whitish clay	10
17.	Pale brown and greenish sandy shale, with occasional bands of light or dark-brown, hard, calcareous sandstone . . .	90
18.	Impure gritty limestone of variable texture and thickness, laminated and false bedded, and brown in colour	20
19.	Sandy beds, shaly, but ill-exposed	70
20.	Massive, soft, light brown sandstone	40
21.	Laminated, pale-brown, gritty sandstone, weathering dark-brown on the surface	10
22.	Light-brown sandstone and sandy shales, like No. 19, soft and disintegrated at the surface	90
		731

	Brought forward...	731
23.	Light-brown, calcareous grit and sandstone passing into impure gritty limestone, very distinctly but obliquely laminated, and containing rolled fragments of a ferruginous and argillaceous rock-like laterite. This is apparently the principal echinoderm bed	30
24.	Sandy shales with thin bands of brown argillaceous limestone, consisting of a ferruginous clay cemented by carbonate of lime. These bands contain spines of echinoderms and fragments of mollusca	150
25.	Fine dark-bluish and greenish-grey shales, nodular in places, with an efflorescence of feathery crystals (? sulphate of alumina) where exposed and cracked	50
26.	Interstratifications of similar shales to the last, with bands from a few inches to 2 feet thick of coarse, brown limestone containing spines of echinoderms	10
27.	Shales like No. 25	50
28.	Fine greenish-grey shaly sandstone, with minute spangles of mica; lower portion not seen	50
	N. B.—In this lower portion, and not exposed in this section, is one of the most characteristic beds of the group. It is a white limestone, hard and nodular, usually abounding in *Foraminifera*, and containing corals in considerable numbers, some of them very large. This bed is well seen in the bed of the river about a mile lower down.	
29.	Coarse, brown limestone, gritty, very hard, and obliquely laminated, containing small ferruginous and argillaceous concretions, and abounding in spines of echinoderms. The thickness of this bed on the Gáj varies from 20 to 50 feet	35
	N. B.—This is the bed near the base of the Gáj group, which forms a conspicuous scarp throughout the Khirthar range, and aids so much in enabling the lower boundary of the group to be recognized and mapped. It forms the peaks of Amrú, Hashim, Chatia, Láli, and several other conspicuous hills, and angular fragments of it are scattered over the country near its outcrop.	
30.	Olive clays varying in tint, some paler, some darker, with a few hard calcareous bands a foot or more in thickness, and more numerous above than below. In the clays *Corbula trigonalis*, *Turritella angulata*, and a small oyster, a *Nucula*, and other fossils occur	120
31.	From the last bed to the base of the group similar clays, with one or two hard calcareous bands, occur. These beds are only seen some distance up the river, above the outcrop of the Nari beds .	130
		1,356

Total thickness of Gáj group.

If, to the above, 150 feet be added for the thickness of the beds omitted at the top of the measured section, the whole vertical development of the Gáj group in this locality will be 1,500 feet. This is, perhaps, rather over than under the truth, but the amount in excess must be very trifling.

Prevalence of shales.

There are two points in this section deserving of notice. Although, wherever the Gáj beds are exposed on hill sides, they appear to consist chiefly of limestone, here, where all the beds are equally well seen, the greater portion is shown to be composed of sandy clays and shales, the hard limestone beds, although far more conspicuous, being only subordinate. It will be shown farther on in Chapter VIII, that this is not the case in the Habb valley and the country near Karáchi.

Estuarine fossils in lower Gáj beds.

The second is the interesting circumstance that in the lowest Gáj beds, as in the highest, there is some evidence of estuarine conditions, the mollusca found in the lower strata comprising *Corbula trigonalis* and *Turritella angulata,* two of the most typical fossils of the passage beds between Gáj and Manchhar. This is quite in accordance with the resemblance between Nari and Manchhar sandstones and the probably fluviatile origin of the upper Nari beds.

Nari beds, Gáj river section.

There is no marked break at the base of the Gáj beds, and, so far as can be judged, no unconformity. The calcareous bands disappear in the lower group, and so do the clays, but there are sandstones in both, quite undistinguishable from each other mineralogically. The line of division has been drawn where the Gáj marine fossils disappear. Below the Gáj beds, the characteristic thick brown sandstones of the Nari group appear in force. The boundary of the two groups north of the river is complicated by irregular dips, and has been sketched in from the peaks near the Gáj, so it may not be quite correct. In general, the hard limestones near the base of the Gáj group can be traced with certainty for many miles, but near the river a roll in the strata interferes with the regularity of the outcrop.

Nari beds.

The Nari beds on the Gáj cannot be less than 6,000 feet in thickness; they occupy the river channel for more than 6 miles. The breadth of the river bed diminishes greatly, and the cliffs are higher than in the upper tertiary rocks. Towards the main range to the westward the dip gradually increases, and the lower Nari beds are inclined at an angle of 35°, like the underlying Khirthars. These lower Nari strata, shales, and shaly sandstones, with, at the base, the yellow and brown limestone bands containing the usual foraminifera, are of no great thickness. They run up the surface of the main ridge of Khirthar limestone as usual. Corals are common in one of the hard brown limestone beds.

Limestone blocks.

For some distance from the main range immense blocks of Khirthar limestone are found in the stream. Some of these blocks are as large as houses, 20 or 30 feet, or even more, in diameter, and some occur 2 or 3 miles from their source. There appears no reason to attribute the transport of these blocks to any non-existent cause. The masses are too large to have been transported by the stream, but they have probably been carried down slopes by the slow processes of denudation. The blocks are found on both sides of the range.

Old gravel terrace.

The following is doubtless a partial explanation of the occurrence of these blocks. North of the Gáj, and at an elevation of 1,500 to 2,000 feet above the stream, immense masses of limestone debris are found unconsolidated and sloping to the eastward. South of the river, a hill called Terg, standing isolated a short distance east of the main range, is conspicuously capped by a portion of a similar unconsolidated mass; the unconformity between this and the Nari beds of which the hill is composed is very marked. These masses are evidently the remains of an ancient gravel slope, doubtless formed before the river had cut its channel to anything like its present depth. The blocks of limestone above mentioned may have found their way down this slope, and thence into the stream beds below.

The river has cut its way through the Khirthar limestone by a very

Gorge in Khirthar limestone.

narrow cleft with vertical sides, so filled up by immense masses of limestone that it is impossible to climb through the gorge. The thickness of the main bed of Khirthar limestone does not appear to be more than 1,200 feet, or considerably less than it is farther north. The underlying beds are well seen west of the main range in Kelát. The range may be crossed either north or south of the gorge: the northern pass, which is the lower of the two, but very steep, is known as Kapwi; the southern as Shekalwi. The section seen on the Gáj, west of the frontier, which has been already given in a general form in Chapter III,[1] is partly seen in the bed of the Gáj for a distance of between 3 and 4 miles from the frontier, and the continuation is exposed west of the river (see Plate IV). The following are additional details of this section.

Section of lower Khirthar group on Gáj river.

The massive nummulitic limestone,(1)[2] forming the high ridge of the Khirthar, contains, towards the base, some layers of clays and shales. The lower portion of the limestone is dark coloured as a rule, and abounds in nummulites, amongst which a large planulate species (*N. lyelli?*) is conspicuous. A large *Alveolina* is also common. Below these limestones there is a considerable thickness of shales and clays,(2) calcareous in parts, and containing nummulites, which weather out in such quantities as to cover the surface, and which are beautifully preserved. These beds are usually dark olive in colour; and although they are soft and crumbling on the surface, they are probably a hard argillaceous limestone below. Beneath these shales is a bed of hard limestone(3) at least 60 feet thick, the upper portion being homogeneous, grey, and in thin bands, unfossiliferous as a rule, although a crab was obtained from it, the lower part abounding in nummulites, seen in section on the weathered surface. This hard bed is conspicuous from the top of the range, whence it is seen to dip under the massive Khirthar limestone.

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[1] See p. 41.

[2] These numbers refer to those in the section, (Pl. IV), and are the same as those of the beds enumerated at page 41, Chapter III.

Section of lower Khirthar group on Gáj river.

Underneath the hard limestone band there are 300 or 400 feet of argillaceous limestone, shales and clays (4), greenish, olive, and bluish-grey in colour, and, like the similar beds above, abounding in nummulites, which weather out in large quantities. The principal forms recognized in both beds were *N. obtusa*, *N. vicaryi?* (a large form near *N. obtusa*, but with a distinct keel), *N. granulosa*, *N. spira* (less common), *N. leymeriei*, and a small species which is probably a variety of *N. scabra*. There is also a saddle-shaped variety of an *Orbitoides*, probably *O. dispansa*.

The next beds in descending order are olive and bluish-grey clays and nodular shales (5), unfossiliferous and without any limestone bands. The beds must attain a considerable thickness, for no others are seen for 2 miles at least in the Gáj, except an occasional bed of sandstone; they dip at high angles, but as they roll about, and are somewhat contorted, their thickness is difficult to estimate. From beneath them thicker bands of sandstone (6) crop out, and closely resemble the beds of the Nari group, except in being rather harder. They are massive, pale-brown in colour, and they contain nodules of ferruginous clay, whilst the surfaces of the different strata exhibit numerous impressions of vegetable fragments, none of which, however, were found sufficiently definite to be recognized. Below these brown sandstones come fine greenish-white sandstone and shales (7), comprising one bed, a foot thick, of highly carbonaceous shale.

Just beneath this coaly band is another bed of dark-brown limestone, and some dark-green argillaceous beds (8), with nummulites (*N. obtusa*, *N. vicaryi?*, *N. carteri?*, *N. granulosa*, *N. leymeriei*, *N. scabra?*, *N. spira*, and the ephippial *Orbitoides*). The nummulites in the clays are beautifully preserved. These beds must be at least 3,000 feet lower than the last (4), in which nummulites were noticed, and 5,000 feet below the base of the Nari group.

Next come some whitish-grey argillaceous limestones (9), in which fossils are rare; a fragment of an echinoderm, however, was noticed in them, so they must be marine. Towards the base there is a thin band, 2 feet thick, of limestone, with *Nummulites* and *Alveolinæ*. This band has a peculiar brecciated appearance, not unfrequently seen on the Khirthar limestone, which sometimes looks as if made up of fragments cemented by a calcareous matrix. The *Alveolinæ* occur in the matrix. These rocks are seen on the right or western bank of the Gáj, just above the spot where the river, after running for miles from north to south parallel with the main range, turns eastward towards the frontier.

Section of lower Khirthar group on Gáj river.

West of the river, just above the bend, there is a plain about three-fourths of a mile broad, and entirely composed of dark-coloured shales (10), of which a very fair section is seen in a stream. They are of fine texture and dark colour, and dip steadily east at a high angle (about 50° to 60°).

The remainder of the section is seen on the small stream just mentioned, the rocks west of the Gáj continuing to dip to the eastward steadily for about 2 miles, before they roll over. West of the plain there is a craggy range, known as Parh, composed of rocks of a pinkish colour. This range has precipitous sides, corresponding to the dip of the rocks, to the eastward. The cliffs are marked by equidistant faint horizontal lines caused by jointing, and this range of hills is conspicuous from the Khirthar, being the first well-marked ridge west of the main range. The rocks of the Parh Range consist of very fine-grained thin-bedded limestones (11), sometimes shaly, white, grey, cream-coloured, ochrey or red in colour, dipping about 70° to the eastward.

Beyond this range again, to the westward, there is a valley nearly three quarters of a mile broad, composed of hard grey shales with calcareous bands at short intervals of a foot or two apart (12), some quite thin, others a foot or more thick. The dip gradually diminishes to 40° at the commencement of the next range of hills, which is an anticlinal, the beds rolling over to the westward. The lowest beds seen are some black shales (13). The next range to the westward was not visited, but it evidently consists of the shaly limestone (11), and it dips west, but beyond this again there

Section below Khirthar group on Gáj river.

appears to be a synclinal, and the Sowet hills, farther west, are composed of several ridges forming an anticlinal, which sinks down and disappears beneath higher beds farther south. Far to the westward a high range, called Khuda, looks as if formed of Khirthar limestone.

In this section at least 10,000 feet of strata must be exposed below the main Khirthar limestone, yet nothing resembling the Ranikot beds can be seen, still less any rocks resembling the Deccan trap, or the cretaceous beds of the Laki range. It has already been shown in Chapter III that the lower portion of the section, comprising the beds numbered 11 and 12, is probably cretaceous, as *Ammonites* have been found in similar beds in Kelát.

The rocks beneath the Khirthar limestone extend for a considerable distance, both north and south, along the western side of the Khirthar range. They were seen from Dharyáro, and may extend much further north, but they were only examined at the section just described on the upper Gáj.

Khirthar ridge south of Gáj river.

From the Gáj to the Shakalwi pass, a distance of 2 or 3 miles, the Khirthar ridge is simple, consisting merely of grey Khirthar nummulitic limestone, scarped to the west, and dipping east-south-east at about 35°. There is a low saddle (height by aneroid about 3,500 feet) at Shakalwi, and then the range rises to Mamtál; thence to the southward there is for many miles a broad ridge of Khirthar limestone lying nearly flat, with more or less level ground on the top, a precipitous scarp on the western side towards Kelát, and a steep cliff to the eastward. On this tableland patches of lower Nari limestones occur every here and there as usual, but all appear to be small and unimportant. The valley running south from the peak, called Chang Dang on the map, appears to be chiefly, if not entirely, composed of Khirthar beds. Further south, the range near Phúnsi has a long slope of Khirthar limestone to the eastward, corresponding with the dip of the rock.

South of the Gáj river the Gáj beds occupy a considerable area, the dips being very low, although higher near the eastern and western boundaries of the group than in the intervening space. The outcrop is in places upwards of 5 miles broad. The breadth of the Nari outcrop, on the other hand, is much contracted. Further south, on the Nari Nai, the low dips of the Gáj group are replaced by an abrupt anticlinal, the Gáj beds have been denuded to the westward, and are only represented by a narrow outcrop, seldom exceeding half a mile in breadth, whilst the Nari area expands to a breadth of between 6 and 7 miles. The continuation of the anticlinal to the southward forms the Kukadáni ridge, at first entirely composed of Nari beds, but further south the Khirthars crop out, and at the head of the Nari valley the Kukadáni and main Khirthar range unite in a rather high peak known as Ghúrru. Thus the whole upper plain of the Nari stream consists of Nari beds, with the exception of one small inlier of Khirthar limestone brought up by a fault south of Káro Kot.

Nari and Gáj beds south of Gáj river.

Kukadáni range.

North-west of Káro Kot the Nari beds at the base of the Khirthar range are greatly crushed and contorted, and the boundaries are most irregular, but throughout the upper part of the Nari valley the Khirthar range appears to be a great roll of nummulitic limestone, and the Nari beds come in at moderate angles of 5° to 10° at the base of the hills. The limestones at the base of the Nari beds are unusually well developed. South-west of Káro Kot they are at least from 200 to 300 feet thick, or much more than on the Gáj, and the whole of this thickness appears composed of limestone, mostly of a brown colour, with *Orbitoides papyracea*, &c., the shales usually found associated not being seen towards the base.

Nari beds in Nari valley.

The water in the Nari Nai comes from a hot-spring (temperature 91° Fahr.) which rises in the bed of the stream about one and a half miles south of Káro Kot.

Hot-spring.

A fair section of Gáj and Manchhar beds is seen in the Nari Nai; both groups dip at a high angle. The coral bed of the former is well exposed, and one band of limestone near the base of the group abounds in *Bryozoa*.

Section on Nari Nai.

Manchhar beds on Nari Nai.

The conglomerate at the top of the Manchhars forms a low ridge, but the bed has nothing like the thickness shown at the Gáj. Beneath this conglomerate there is a great thickness of pinkish and buff clays and marls, followed in descending order by the lower Manchhar grey sandstone, with Indian-red, buff, and brown sands, marls and clays, and the usual conglomeratic bands, with occasional bones, near the base of the group. In one of these beds, a short distance south of the stream, and 300 or 400 feet above the base of the group, some bones and teeth of mammalia and reptilia were procured, and with them a few ill-preserved mollusca. The bed consists of a very dark sandstone, with numerous fragments of clay and pebbles, or concretions of soft limestone. One of the shells is a *Cerithium*, approaching *Vicarya* in appearance, another is *Corbula trigonalis*. This is an additional link between the Gáj and Manchhar beds, and appears to show that locally, even in Upper Sind, estuarine conditions existed in Manchhar times. In Southern Sind near the coast the interstratification of marine or estuarine beds in the Manchhar group is of common occurrence.

Estuarine fossils in Manchhar beds.

CHAPTER V.—HILLS NEAR SUKKUR AND ROHRI.

General character.

Before proceeding farther south into Lower Sind, it will be most convenient to describe the remarkable range of isolated hills near Sukkur and Rohri. These hills form a rocky area, surrounded on all sides, except the south, by the alluvial plain of the Indus, and slightly broken up at their northern extremity, where they are intersected by the river. To the south the rock is covered up by blown sand, but the latter, farther to the southward, appears to rest on alluvium.

Rocks exposed.

The rock exposed consists of white and yellowish nummulitic limestone, much softer and less compact than in the Khirthar Range, but containing the nummulites characteristic of the Khirthar group. On the western side of the hills, from about 6 miles south of Rohri to the neighbourhood of Kot Deji, green clays, with gypsum, dark-brown limestone, and very soft rubbly white limestone, without nummulites, crop out from beneath the nummulitic limestone. These beds were at first thought to be possibly representative of the Ranikot group, but no fossil evidence has been found in favour of this view; and strata, precisely similar in mineral character to the most conspicuous bed of the formation, the pale green clay, occur occasionally, interstratified with the Khirthar group, in the Laki Range and near Hyderabad. The green clays and associated beds of the Rohri Hills are consequently represented as Khirthars in the accompanying map.

Physical characters of range.

To the north of the Indus, near Sukkur, only a few isolated hills are met with, the most northern being barely 3 miles from the river, but the range extends south of Rohri for nearly 50 miles. It is throughout of small elevation, no portion of it probably rising more than about 200 feet above the alluvial plain. Throughout the range, as far south as Kot Deji, there is an escarpment along the western side of the hills, and the beds dip thence with a steady gentle slope, rarely exceeding 2°, and in many places less than 1°, to the eastward. Towards the southern termination of the range the dips are even lower, and appear to form a low anticlinal, dipping to east-by-south on the eastern margin of the hills, and west-by-south on the western edge. Altogether, although the rock area towards the south is 15 or 16 miles broad, it is doubtful if more than 400 to 500 feet of nummulitic limestone is exposed throughout. Perhaps 100 feet of the beds below the limestone may be badly exposed east of the villages of Trimmo and Hisbháni.

Highest beds seen. Nummulitic limestone.

The highest beds seen are those occurring on the eastern side of the hills, near the village of Janoji. They consist of white limestone, containing numerous nummulites, especially *N. spira*, *N. granulosa*, and a rather thick lenticular form with radiating striæ, which may perhaps be *N. vicaryi*. These nummulites weather out in large quantities and cover the surface. The rock containing them decomposes easily, and the rises composed of it weather into flat-topped craggy hummocks. The appearance of these is so characteristic, that hills formed of this bed may easily be recognized by their form. Such are seen at Sapoinwali Tekri, and again 12 miles farther south at Sahibneh, south-by-west of Janoji, and close to the frontier of Khairpúr. At the latter place some small nodules of ironstone occur in the limestone, and are found scattered about the surface. They are not in sufficient quantity to have any value.

Limestone with flints.

Below this highly fossiliferous nummulitic limestone there is found, throughout the Sukkur and Rohri Hills, a thickness of, perhaps, 200 to 300 feet of very hard limestone, generally more or less yellow in colour, of fine texture, but not solid as a mass, being much fissured and cracked. As a rule, this bed is not fossiliferous, but sometimes it contains *Alveolina* and small nummulites in considerable quantities, especially in its upper portion. The most remarkable character of this bed, however, especially towards the base, is the occurrence of large masses of flint, many of which precisely resemble, in every respect, those of the English chalk. Some of the nodules at Sukkur exceed a foot in diameter. These flints contain sponges and less frequently *Foraminifera.*

The hard limestone just described forms the upper part of the hills, both at Sukkur and at Rohri, and at both places the bed includes, about 30 feet above its base, a layer, about a foot thick, of yellow marl, or argillaceous limestone. In this bed at Rohri, close to the Deputy Collector's bungalow, *Echinolampas sindensis* occurs in abundance.

The same limestone with flints occupies the surface throughout the greater part of the range south of Rohri, the higher beds being only seen, as already mentioned, towards the eastern edge of the range, whilst those lower in the series are only exposed on the western scarp. The surface of the limestone consists in general of a series of low slopes, corresponding in direction to the dip of the rock. The flints weather out and cover the surface throughout a large area; cores and the flakes split from them being scattered about in abundance in some places.

Lowest beds of limestone with nummulites.

The lowest portion of the nummulitic limestone in the Sukkur and Rohri Hills consists of white limestone, abounding in nummulites, and closely resembling the higher bed seen on the east side of the hills. The lower limestone is partly rubbly, partly uniform in texture, but throughout soft and easily decomposed, allowing the *Foraminifera* it contains to weather out, so that they occur in large quantities strewed over the surface. The most common are *Nummulites granulosa, N. spira; N. vicaryi,* and *N. lyelli.* A large form of *N. spira,* closely approaching *N. carteri* in appearance, forms a layer of some little thickness, 40 or 50 feet above the base of the limestone. A peculiar, globose, thick, smooth oyster, with a straight hinge line and winged at the side, the upper valve sometimes rising into a blunt spine, is very common. It appears to be a form of *Ostrea vesicularis* (*Gryphæa globosa,* Sow.). Casts of *Ovulum, Conus,* &c., also occur.

The whole bed varies in thickness from 60 to about 100 feet. As already mentioned, the outcrop is chiefly confined to the scarp on the west side of the range.

Beds below nummulitic limestone.

The beds below the nummulitic limestone form a low slope between the limestone escarpment and the alluvium, on the wertern side of the range, from about 6 miles south of Rohri to within 4 miles of Kot Deji. These beds are very ill-exposed, their surface being much concealed by the detritus of limestone washed down from the overlying beds. Their uppermost portion consists of pale green clay, with large quantities of gypsum in bands and veins, and with occasional layers of a deep red clay. Beneath 40 or 50 feet of clay there is a dark band of dusky-brown limestone, and then more clay. The lowest beds seen were only observed south-east of Trimmo, and consist of fine hard calcareous shale, buff or pinkish in colour, with impressions of a *Cardita,* resting on soft white rubbly limestone abounding in fossils, principally casts, and associated with shaly limestone containing a band, barely a foot thick, of bright silvery-yellow argillaceous limestone, containing a *Pinna* and other fossils.

Fossils in lower beds.

All these lower beds are more or less fossiliferous, but the fossils are usually badly preserved. In the clays, impressions of *Leda, Cardium,* and other bivalves are found. The dark limestone contains casts of a *Cardita* or *Arca,* whilst the rubbly limestone furnishes *Pinna,* several bivalves like *Lucina,* together with *Cerithium, Rostellaria,* and *Natica longispira,* the last species, the only one specifically identified, being common to the Ranikot beds. No nummulites nor other *Foraminifera* were found, nor were any *Echinodermata* noticed.

A few additional details of the geology will be given in the following paragraphs. The description commences at the north end of the hills.

Sukkur.

The rocks at Sukkur form more or less detached hills, and dip at a very low angle to the east or east-by-north. To the eastward and capping the hills to the westward is the hard yellowish limestone with flints: this rock is much fissured, the fissures being filled with a mixture of gypsum and red clay, which appears to have been deposited in the hollows. The band of yellow marl is conspicuous about the middle of the European station. The rock below this band is rather softer than above, and the flints appear rather less numerous and smaller. Below the marl, after about 20 or 30 feet of comparatively harder rock, the soft limestone with numerous nummulites is reached, and is well exposed on the sides of all the hills near the Shikárpúr road. This bed weathers away so much in parts that some of the layers overhang hollows left by the decomposition of the softer portions.

The western boundary of the rock area and the small outliers to the westward are scarped and well marked, but to the eastward, where the limestone dips at a very low angle under the alluvium, the limit is less distinct. Rocks occur in one or two places on the Sháhdád-wáh, or Sukkur canal, and there appear to be some rocks under water east of old Sukkur.

Old channels of Indus.

A break intervenes between the hills, on which the European station is built, on the bank of the river, and others a little further north. The first break may possibly be an old river channel. An old channel far better marked exists at Aror or Alor, about 4 miles south-east of the present river bed. There is another valley traversing the range only a mile south-east from Rohri, and this may also mark a former river channel; but if so, the bed of the river must have been considerably higher than it now is, or else the surface must have been lower, for there is rock in place throughout the breadth of the valley. In an alluvial country it is not easy to understand that the river can have been at a higher level than it now is.

Ancient traditions of Aror.

The river channel is said to have passed by Aror, then the chief city of Sind, and the residence of a king, prior to the middle of the tenth century of our era. The city is said to have been destroyed by an earthquake, and the course of the river changed to its present channel about A. D. 962.[1] It is probable that a river passed by Aror, but it is rather doubtful whether the whole of the Indus could have been confined to so narrow a bed.

Cores in bed of Indus.

The flint cores found in the bed of the Indus have already been noticed in Chapter I[2] of this report. The explanation of the supposed occurrence of these cores in the nummulitic limestone is probably that the rock, as already noticed, is much fissured, and the fissures are filled with a mixture of gypsum and clay, in which, in all probability, the cores are imbedded.

Bakhar. Rohri.

The island of Bakhar (Bukkur) and some other islets in the channel of the river Indus between Sukkur and Rohri are composed of limestone. The same appears at Rohri, the section being precisely similar to that at Sukkur. The bed of *Nummulites spira*, var., is well seen on the west side of the hills south of the town, the shells being about 1½ inches in diameter. Rock is seen here and there to the east of Rohri in the channel cut to supply water to the Eastern Nárra.

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[1] *Sind Gazetteer*, p. 116; Bellasis, Jour. Bombay Br. R. A. S. v., pp. 413, 467; Manual of the Geology of India, i, p. 418.

[2] Page 20.

Along the eastern edge of the hills south of Rohri there is nothing of importance to record. For a considerable distance the boundary is easily traced, then sand-hills, scarce for the first 20 miles from the river, gradually increase in extent, until they cover the surface, and only occasional patches of rock can be detected amongst them. The southern boundary of the rock area is consequently very difficult to determine. Between the eastern Nárra and the Mir-wáh, the large canal running to the west of the Rohri hills, the country, 50 miles south of Rohri, is a wilderness of sand-hills without water. The few outcrops of rock which occur do not rise into ridges as they do farther north, and the dips are very low, the beds being almost horizontal. The map, too, is far from accurate. The southern boundary of the rocks on the map is consequently only an approximation, but, so far as could be ascertained by enquiry in the country, no rocks are known to occur farther south.

Eastern margin of hills.

The western boundary of the hills is, as already stated, escarped and well defined as far south as Kot Deji, the beds of the scarp consisting of the easily decomposed white limestone with *Nummulites*. The clays below the limestones are first seen a little south of the Aror valley, about north-30°-east of a village called Dodanka. Near Trimmo there is what appears at first sight to be a channel cut through the hills, similar to that at Aror, but rocks occur almost throughout.

Western margin of hills.

About Akbarpur, south-east of Trimmo, the lowest bed of the nummulitic limestone is seen dipping at a considerable angle. It is clear that the limestone is in position or nearly so, and does not consist of reconsolidated fragments, because no debris of flints, or of the higher beds of limestone, are intermixed. The dark calcareous beds, interstratified with the clays below the limestones, are often seen disturbed and turned on end. In both cases the disturbance is doubtless due to the washing away of the soft clays or to their having yielded when wet. The limestones appear quite conformable to the clays.

A little south of Akbarpur and north-east of Pir Koka, the fossiferous limestone forms low rises. The green clays and their associates may be traced along the base of the hills to a village called Mithunjo on the inch map, and perhaps a little further south. Near Mithunjo they are well exposed between the two limestone hills called Maleki Khánwári and Sherawári Tekri, and the clay here contains *Leda* and other bivalves.

Neighbourhood of Kot Deji.

About Kot Deji there are numerous detached hills. Those at the town itself are escarped, and are apparently connected with the main range by rock, no alluvium intervening, for limestone crops out every here and there amongst the sand-hills, east of the town. Some isolated rises west of the Mir-wáh, or Khairpur canal, appear completely surrounded by alluvium.

South of Kot Deji there is no escarpment, and the rock dips to the south-west, or is horizontal, and forms low rises, much as to the eastward, greatly covered and concealed by sand-hills. The latter gradually increase in height, until, beyond the neighbourhood of Búsdár, only isolated patches of rock can be found.

Blown sand.

The blown sand of these hills is of a pale greyish tint, and appears to consist mainly of quartz. It contains some mica. This blown sand covers an enormous area to the east of Sind; but the country is beyond the limits of that described in the present report.[1]

CHAPTER VI.—SOUTHERN KHIRTHAR, BHIT AND BADHRA RANGES WITH THE NEIGHBOURHOOD OF MANCHHAR LAKE.

Area described.

The present chapter deals with the area immediately south and south-east of that described in the last but one, and treats of a tract of country extending from the plains of Upper Sind, near the Manchhar Lake to the Báran river, and from the western frontier to the valley traversed by the hill road

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[1] For an account of the blown sand in the Indian desert, and the peculiarities of the sand-hills, see Jour. As. Soc. Bengal, xlv, 1876, pt. 2, p. 86; Rec. Geol. Surv. India, x, p. 20; Manual, i, p. 436.

between Karáchi and Sehwán. This tract comprises the southern portion of the Khirthar Range, here a simple anticlinal of Khirthar limestone, running from north-north-west to south-south-east, and two other anticlinals of the same rock, known as Bhit and Badhra, running north and south, and joined to the Khirthar at their southern extremities. There is also a low detached ridge of Gáj beds, known as Gamrak, running from west-by-north to east-by-south, at a distance of 5 or 6 miles from the southern shore of the Manchhar Lake.

The tract of country now described is comprised within the limits of sheet 5 of the quarter-inch map, and in sheets 38, 39, 40, 51 and 54 of the inch survey. The description commencees at the north-west corner, close to the valley of the Nari Nai.

Gáj beds on Kukadáni Nai.

The Gáj beds are well seen on the Kukadáni Nai (Kukrani Nai of ¼-inch map, Dhoree Kook of 1-inch). They still consist largely of sandstone. Farther south, near Khair Muhammad, the hills become lower and separated by broader flats. Near Kúba Jagu Jamali, west of Khair Muhammad, in a low ridge of Gáj beds dipping at about 35° to 45°, fossils are found in great abundance, and amongst other species *Dosinia pseudoargus*, *Venus* (or *Tapes*) *subvirgata*, *Cardium anomale*, *Arca kurracheensis*, and *A. peethensis* occur, together with many *Gasteropoda*. The fossils are found in calcareous bands, but sandstones prevail.

Gáj beds in Angyi stream.

The ridges of Gáj and Manchhar beds run across the country in the direction of the strike of the beds to Tandra Rahim Khân, where they are intersected by the Angyi (Ungyee) stream, and thence in a south-by-east direction to Pir Gázi at the eastern base of the Bhit Range. On the westernmost ridge of Gáj beds, north of the Angyi, *Cœlopleurus forbesi* is very abundant. The diminution of thickness in the Manchhar beds at this spot, compared with their development farther north, has already been noticed in a previous chapter; the whole of the section appears represented; there are conglomerates at the top, then orange clays (Upper Manchhar), and towards the base the lower Manchhar grey sandstones, yet the whole breadth of the outcrop is only a little more than half a mile, the dip being 60° to 80°. Most of the section is concealed, but the thickness of the Manchhars cannot exceed 3,000 feet altogether.

Apparent unconformity between Nari and Gáj beds in Angyi valley.

A glance at the map will show the steady strike of the Manchhar and Gáj outcrop across the valley of the Angyi Nai. The beds dip east by north at angles varying from 35° to 80°. The valley itself, however, is entirely composed of Nari beds dipping in a synclinal, pretty regular to the east of the stream, but much broken to the westward. At first it appears as if there must here be complete unconformity between the Nari and Gáj beds, and as if the great anticlinal fold of the Bhit range were of prior age to the deposition of the Gáj rocks. A careful search along the Nari and Gáj boundary, which is, however, by no means clearly exposed, has failed to show any distinct evidence of want of parallelism, but it is difficult to believe, if the anticlinal and synclinal folds, to which the lofty Bhit range and the Angyi valley are due, are of later date than the deposition of the Gáj beds, that the outcrop of the latter could remain so straight as it is, and so little in conformity with the undulations of the underlying rocks.

Angyi Valley.

Up the Angyi valley[1] the beds are best exposed near the base of the range on each side, the Khirthar, culminating in the Gurú ridge (Ghooroo on the ¼-inch map) to the west, and the Bhit to the right. The level ground of the valley is chiefly composed of the soft sandstones of the Upper Nari beds, but these are frequently concealed by broad expanses of recent gravel. Near the border of the valley there is some very salt ground with an efflorescence of chloride and sulphate of sodium, apparently produced by a zone of sandstone a little above the fossiliferous lower Nari beds. The chief rocks seen in the middle of the valley are outcrops of ferruginous sandstone bands.

In the upper part of the valley some faulting occurs, and the Nari

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[1] All the notes on the Angyi valley are from Mr. Fedden's reports, as are those on the Naegh valley, and a large proportion of those on the country, between Jhángár and Pokran.

beds to the west of the stream dip towards the Khirthar rocks at a high angle. Further north than this, at a pass called Gari-jo-lak,[1] the rocks are greatly shattered and broken. In the valley, near this pass, is a warm spring issuing at a temperature of about 90°. There is much calcareous tufa about the spring, containing, as usual, impressions of plants and some fresh-water shells (*Melania*).

Bhit range.

The Bhit range is a great anticlinal saddle of Khirthar limestone with Nari beds resting upon it on both sides. The culminating point is a trigonometrical station 2,700 feet above the sea, but for a long distance north and south the top of the range is nearly level. East of the Bhit ridge, near Pir Gázi, a Mussalman shrine near a very fine hot-spring, the Gáj and Manchhar outcrop runs for some miles along the base of the hill. At Pir Gázi the Manchhars and Gáj beds are well seen, and consist of a series of low parallel ridges dipping east-20°-north at a high angle (50° to 60°). A conglomerate bed is seen close to the village itself, and is the uppermost Manchhar bed exposed; the remainder of the Manchhar group is apparently even thinner than it is at Tandra Ráhim Khán, which is only about 4 miles distant to the north-north-west. The conglomerate bed of Pir Gázi probably is the uppermost Manchhar conglomerate; but it differs somewhat from the ordinary type, and contains but little Khirthar limestone. The Gáj beds succeed below the Manchhar group, and a band abounding in *Echinodermata* is seen well exposed on the bank of the small stream running from the hot-spring. Amongst the fossils found here, besides the common *Cœlopleurus forbesi* and *Echinolampas jacquemonti*, were a *Schizaster*, a *Maretia*, scarcely if at all distinguishable from the recent *M. planulata*, and a fine *Meoma*. The Nari beds are also well exposed.

Section at Pir Gázi.

Hot-spring.

Towards the base of the Nari beds the hot-spring gushes out, which has been described by Vicary, and which is so remarkable for the enormous quantity of calcareous tufa deposited. The water issues in a hollow at some elevation above

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[1] *Lak*, a pass.

Extensive deposits of calcareous tufa.

the main valley, between ridges of lower Nari and Khirthar beds, and the level, or nearly level surface of the hollow, for some distance from the spring, consists entirely of calcareous tufa, which terminates in a cliff, 200 feet high (by Aneroid), and several hundred yards in length. The water from the spring descends this cliff in a raised channel, formed by the deposit of tufa; and older channels, each raised above the general surface, may be traced here and there upon the face of the cliff. All these features were well described by Vicary,[1] who visited this place in 1845.

There can be no reasonable doubt that the enormous mass of calcareous tufa seen has been deposited by the present spring. But on the surrounding hills there are other masses of tufa, at a higher level than the spring. These probably mark ancient points of issue.

The Naegh valley.

A large stream, the Naegh Nai, runs from the south past Pir Gázi. The valley of this stream, although chiefly composed of Nari beds, does not consist of them so exclusively as the Angyi valley does. In the first place alluvium extends up the valley for a long distance, and should perhaps be shown farther to the southward than is indicated on the map. In the northern part of the valley, near Pir Gázi, the alluvial ground is contained in a deep synclinal fold of the Manchhar beds, steeper on one side than the other, the dip being 50° to 60° west of the valley and 35° to 40° to the eastward; but farther up the valley alluvium rests upon both Gáj and Nari beds.

Rocks near Sháh Rúhi.

The Gáj outcrop crosses the valley about 7 or 8 miles above Pir Gázi, the actual crossing being concealed by alluvium. Hence to the eastward the direction of the strike of the main Gáj outcrop is east by south. At Sháh Rúhi (Gulám Sháh), about 13 miles from Pir Gázi, there is a slight anticlinal roll in the middle of the valley and the lower Nari beds; the yellow limestones with *Nummulites* and *Orbitoides* are brought to the surface, but farther up the valley southerly and westerly dips bring in higher beds.

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[1] Quart. Jour. Geol. Soc., 1847, p. 344.

Hot-spring near Sháh Rúhi.

There is a large hot-spring at Sháh Rúhi (temperature 100°), and the hill close by is thickly covered with calcareous tufa, a sheet of the same formation extending over the country to the west and south-west. The channels in which the water of the spring flows for purposes of irrigation are all converted into stony conduits by the deposition of carbonate of lime, and some of these channels are seen standing above the surface, where the latter has been lowered by denudation, like masonry aqueducts.

Around Pir Bingi, about 1½ miles south-east of Sháh Rúhi, and on the opposite side of the valley, there are five small thermal springs along the base of the great limestone hill-range (Badhra). The only one of which the temperature was measured was at 92° Fahr. Another spring occurs west by south of Sháh Rúhi, near the foot of the Bhit range. The temperature is comparatively low.

Upper Naegh Valley.

Throughout the Upper Naegh Valley the upper beds of the Nari group are well represented along the base of the Badhra range, some thousands of feet of soft unfossiliferous sandstone being exposed. A few hundred feet below the top of the group there is a coarse friable variegated quartz grit formed of subangular fragments. Above the Nari beds there are several hundred feet of Gáj strata, occupying an isolated area, about 14 miles long from north to south, and upon these again, there is, in one place, a patch of Manchhar beds extending about 8½ miles from north to south. All these rocks dip to the westward, and are cut off by a large fault, bringing up Khirthar beds against Gáj and Manchhar, along the eastern base of the Khirthar range, which forms the western side of all the Upper Naegh Valley, the Bhit range having coalesced with the main ridge. A little Nari rock occurs west of the fault.

Gáj beds of Upper Naegh Valley.

The Gáj beds crop out to the eastward of their area in a ridge called Káro Phang,[1] the upper portion of which and its western slope are formed of dark brown calcareous grit passing into gritty limestone. This bed is from 20 to 40 feet thick;

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[1] Phang is a Baluch word applied to a ridge or water-shed.

it has a tendency to split into thin flags; it exhibits oblique lamination, and it may be the same as a very similar hard band, No. 29, in the Gáj section.[1] About 300 feet of beds are seen below it on the eastern scarp of the Káro Phang. The grit contains a few Pectens and other fossils, mostly fragmentary, and below is a yellowish marly bed with *Breynia carinata* and a band of large oysters.

Hot-spring.

A hot-spring occurs in the Gáj area at a place called Kándhi. The temperature is between 85° and 86°, the water is strongly impregnated with lime, and there are extensive deposits of calcareous tufa, some of them, as at Pir Gázi, at a considerable elevation above the present point of issue. This spring is situated in a ravine, but is much choked by detritus, and the flow is small.[2]

Faults east of Naegh Valley.

The fault above mentioned as cutting off the Manchhar and Gáj beds at the base of the Khirthar range can be traced for about 16 or 18 miles, running north-north-west to south-south-east, and appears to die out at both ends. Farther north there is another fault running north and south for several miles along the base of the Bhit range. This fault, which also appears to die out at both ends, is between Nari and Khirthar beds. The anticlinal forming the range is much steeper on the eastern side than on the western.

Badhra range.

The Badhra range is another anticlinal of nummulitic limestone, a repetition of that of Bhit, but on a larger horizontal scale, the similarity even extending to the termination at the southern extremity in an anticlinal roll, from which higher beds dip on all sides, whilst an axis of Khirthar limestone continues to the south-west and joins the main Khirthar range. Between this secondary ridge and the southern termination of the main ridge is a

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[1] See *ante*, p. 93.

[2] Mr. Fedden, from whose report the description of the whole Naegh Valley, except the neighbourhood of Pir Gázi, is taken, suggests that all these springs have formerly been much more copious than they now are, and that the present spring is almost exhausted. He heard of an ancient spring, now no longer flowing, in a ravine on the flank of the Bhadra range. The former large supply of water would account for the enormous size of the tufa deposits.

hollow occupied by higher beds. To the south of the Badhra range also, as beyond the southern extremity of that of Bhit, there is a tract of upper tertiary beds faulted against the eocene limestone of the Khirthar range.

Upper tertiary beds near Manchhar Lake.

From the northern extremity of the Badhra range, Nari, Gáj, and Manchhar beds extend in succession to the Manchhar lake, and the Manchhar beds skirt the western extremity of the lake and form a long promontory stretching northwards into the alluvium. This promontory extends past Chhíni, as far as Mir Khán, but the rocks are only seen here and there, and are much concealed by sand and gravel. There is, however, a very fair section exposed on the road between Sháh Hassan, at the western end of the Manchhar Lake, and Pir Gázi. The beds form an anticlinal, and this is interesting, because it shows how local these folds are, for there is no corresponding undulation in the Gáj outcrop to the southward, and yet the roll in the Manchhar beds must, of course, affect the underlying Gáj. Such a feature as this is, of course, in favour of the view that the apparent unconformity of the Gáj on the Nari beds a little farther west in the Angyi valley is not real.

Manchhar beds near Sháh Hassan.

Near Sháh Hassan grey sandstones are seen, but to the westward conglomerates occur with soft marls, all dipping eastward, but turning over again farther west. In the conglomerates are pebbles of both Khirthar and Nari rocks, the *Alveolina* and nummulitic limestone of the former, and the characteristic ferruginous bands of the latter, both occurring in plenty. But by far the largest number of the pebbles consist of a bright yellowish-brown calcareous sandstone, speckled with black, and evidently derived from the Gáj beds.

Unconformity between Gáj and Manchhar.

It may fairly be assumed that, despite the prevalence of grey sandstone, so characteristic elsewhere of a low horizon in the Manchhar group, all the conglomerates here seen are of Upper Manchhar age; for wherever the whole section is exposed, no Khirthar, Nari, or Gáj fragments have been noticed in lower Manchhar conglomerates. The evidence of great denudation of the Gáj beds during the deposition of the Manchhar group, is more complete at this spot than elsewhere. Whether such evidence is connected with the absence of Gáj beds to the south-eastward, is difficult to say.

Manchhar, Gáj, and Nari beds south of Manchhar lake.

The slopes between the southern border of the Manchhar and the ridge of Gáj beds to the southward are composed of Manchhar beds, which crop out at the surface here and there, but are generally covered by a great thickness of subrecent gravel and conglomerate. The ridge is composed of the ordinary dark-brown Gáj limestones and calcareous sandstones abounding in fossils; *Echinolampas jacquemonti, Breynia carinata, Echinodiscus, Pecten favrei,* and *Ostrea multicostata,* being amongst the commonest forms. To the south of the ridge, the Nari sandstones are well exposed, the greater portion consisting of soft thick beds, but there are bands of ferruginous sandstone having a peculiar appearance, simulating scoriæ, and containing fragments of ochrey clay; and below these again rusty brown sandstones, interstratified with white sands, mottled with purple in places, in very thick beds. Below these again are massive light-brown sands and sandstones with ferruginous bands, containing concretionary brown iron-ore. Towards the base of these, there is a bed of rather calcareous brown sandstone, containing *Nummulites garansensis* and *N. sublævigata.* This band is several hundred feet above the brown limestones at the base of the Nari beds, and the latter are seen as usual at the foot of the Badhra range. This is a similar case to that noticed on the Kenji Nai (p. 80), and serves to show the connection between the brown limestones with nummulites and the sandstones of the Nari group. Not far to the eastward, as will be shown in the next chapter, the upper Nari beds are unconformable to the brown nummulitic limestones with *N. garansensis.*

Valley south of Jhángár.

From Jhángár, the large village south of Manchhar lake, the hill road to Karáchi runs southward through the long and wide valley that intervenes between the Laki range to the eastward and the Badhra, Khirthar, and other ranges farther south, to the westward. South of Jhángár the greater part of the country for many miles is covered by alluvium, or by subrecent gravels and conglomerates. Beneath these deposits, the Manchhar and Gáj beds disappear on the western side of the valley, but the Manchhars come in again on the eastern side, where the Gáj group is either wanting or represented by a very thin band. A few miles south by west of Jhángár some soft sandstones and shaly clays, with bands of white clay, are seen in ravines, but it is difficult to determine with certainty to what group they belong. Anticlinal rolls of Khirthar limestone, forming low hills, crop out from beneath the Nari beds forming the middle of the valley further south. One small ridge of Khirthar beds occurs 7 miles south of Jhángár; another, and much longer ridge, the Lúnda hill, close to the camping ground of Chorlo (Choterah of inch and ¼-inch maps), is formed by a double roll, a slight synclinal on the top, with an anticlinal on each side, the outer slopes being very steep. The brown limestones at the base of the Nari beds are seen on the outer slopes of these hills, running up the hill-sides as usual; and near the base of the Nari group, there appears here a band of brown limestone, containing in abundance a very large *Echinolampas*, apparently unnamed, having some resemblance in general form to the Khirthar species, *E. discoideus*. The junction of the Khirthar and Nari beds is particularly well seen near the Chorlo encamping ground on the western flank of Lúnda hill. Brown limestones, as usual, rest upon white; the uppermost white bed is rather saccharoid, and contains *Echinolampas discoideus*, *Kuphus* in abundance, conspicuous on account of its fragments consisting of tubes about half an inch in diameter, an *Orbitoides*, and several species of *Nummulites*. Upon this rests a hard compact ochrey or yellowish brown limestone ringing under the hammer, breaking with a sharp conchoidal fracture, and containing several nummulites and an *Orbitoides* (*O. dispansa ?*). This bed, despite its colour, appears to belong to the Khirthar group. Above this again come the usual Nari brown limestones, with *Nummulites garansensis*, *N. sublævigata*, and *Orbitoides papyracea*.

Lúnda hill.

Junction of Nari and Khirthar.

The bed with the large *Echinolampas* is interstratified with the brown nummulitic limestones of the Nari group.

Gáj beds near Chorlo.

A very small patch of Gáj beds, in which *Ostrea*, *Pecten*, and *Placuna* occur, is exposed about half a mile north of the camping ground at Chorlo, on the west of the road to Jhángár. This patch is too small to be marked on the map herewith issued. West of Lúnda hill the Nari beds are concealed, close to the hill itself, by talus and blown sand, and immediately to the eastward is a broad torrent bed, filled with pebbles of nummulitic limestone, and no rock is seen in place. To the east of this, Manchhar beds occur, and extend nearly to the foot of the ridge east of the valley; they appear in places to rest upon Nari beds, whilst in other parts of the boundary, a thin but unmistakeable representative of the Gáj group,[1] with its characteristic fossils, intervenes. These Manchhar and Gáj beds are a continuation to the southward of those seen in the section at Bhagothoro, south of Sehwán, a section which will be described in the next chapter.

Ground east of Lúnda hill.

Neighbourhood of Maliri.

For nearly 20 miles from the neighbourhood of Chorlo, almost to Pokran Lándi, in the valley between the Badhra and Laki ranges, no upper tertiary beds occur, the ground being composed of Nari beds with inliers of Khirthar limestone; and the latter rock occupies the whole, or nearly the whole, breadth of the valley at Maliri,[2] the halting place between Chorlo and Pokran. The boundaries between Nari and Khirthar are really much more complicated than they appear on the map; but not only is anything like detailed mapping impracticable for want of a better topographical survey, but it is very difficult in this part of the country to determine with precision the limit of the Khirthar and Nari groups. The massive Khirthar limestone becomes much broken up into shaly and marly beds, which are greatly developed in some hills called Dullh

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[1] These narrow bands of Gáj rocks are too small to be represented on the accompanying map.

[2] Not marked on the accompanying map. It is near the spot called Wand Bira.

on the 1-inch map, east of the road between Chorlo and Maliri. These shaly beds abound in fossils. Besides *Nummulites, Patellina cooki,* some corals, and several species of echinoderms; *Corbula subexarata, Cardita depressa,* and several other Lamellibranchs, *Nerita schmideliana,* a large *Cypræa,* two species of *Voluta, Turritella affinis, Solarium affine,* and a *Rostellaria,* were found at this locality.

Passage beds between Nari and Khirthar.

The marly shales pass up into light yellow and brown limestone, with a coral zone abounding in several species of coral. A little above this is a band containing *Pecten* in abundance, and the beds gradually assume the character of the brown Nari limestone. About this horizon there is found a small rather convex species of *Ostrea,* often met with in the bottom Nari beds, and just above it, or associated with it, *Nummulites garansensis* and *N. sublævigata* are generally found. The *Pecten* and the coral zones may be considered as the uppermost Khirthar beds, or as forming a transition between the Khirthar and Nari groups. These zones are tolerably constant in this neighbourhood and to the southward as far as Trak, a distance of about 60 miles, but to the southwest, on the other side of the Khirthar range, the uppermost Khirthar beds are very different.

Fault near Maliri.

There seems to be some faulting hereabouts just west of the small dharmshála at Maliri, at the foot of a low anticlinal ridge of Khirthar limestone. Nari beds occur, dipping sharply to the eastward, and containing *Orbitoides papyracea, Cardita subcomplanata,* and a *Turbo* with its operculum; whilst a few hundred yards farther east, at the dharmshála, Khirthar limestone occurs, containing *Nummulites granulosa,* and dipping west at a low angle. There may be merely a sharp synclinal, but probably a small fault intervenes.

Southern end of Badhra range.

The Badhra ridge terminates to the southward, a little north of Pokran, and the Nari beds lap round the extremity of the ridge, as already mentioned, a small patch of Manchhar, without any Gáj beds below it, occurring west of the southern spur. The low anticlinal of Khirthar limestone, which joins the Badhra to the Khirthar range, is but 1½ miles across, but it forms the water-shed between the Naegh valley and that of Pokran; the latter, it should be added, is drained by water-courses running to the Báran river.

Neighbourhood of Pokran.

Near Pokran, upper tertiary beds appear at each side of the valley, the middle being formed of lower tertiary rocks, principally Nari. On the western side of the camping ground there is an anticlinal formed by an inlier of Khirthar limestone, containing *Nummulites obtusa*, &c., and appearing along the top of a ridge, on the flanks of which the brown Nari limestones with the usual *Foraminifera* and *Pecten labadyei* appear. Here also, north of the water-course which runs past the camping ground, the bed containing the large *Echinolampas* is well seen, and this band is frequently exposed in the country between Pokran and Chorlo. Near the road shaly calcareous grits and ferruginous sandstones are seen, and many *Gasteropoda* and some corals occur. Farther eastward, soft sandstones come in, belonging to the upper Nari horizon.

South of the camping ground, there are several isolated conical hills of black ferruginous gritty sandstones belonging to the Nari group, and capped by subrecent conglomerates, a mass of pebbles partly cemented together by carbonate of lime. These subrecent conglomerates, it should be noticed, are largely developed in this neighbourhood, and are often found left isolated by denudation at a considerable elevation above the flat ground of the valley.

East of Pokran.

In the plain to the east of Pokran, Manchhar beds come in; a thin band of Gáj, only a few feet in thickness, but containing *Ostrea multicostata* and an abundance of a large oyster, intervening between the Manchhar and Nari groups. The Manchhar rocks extend hence to the south-west, along the eastern side of the valley. At the foot of the eastern hills all the beds are turned up very sharply, and the Khirthar limestone crops out.

West of Pokran.

On the west side of the little anticlinal ridge near Pokran, the succession of rocks is similar, but the Manchhar beds are more largely developed. There is a broad expanse of desert plain, about 5 miles wide from east to west, chiefly composed of Manchhar beds, the surface being mostly covered with gravels derived from the disintegration of conglomerates. Gáj beds are seen thinly represented at the base of the Manchhar group, and the latter forms first a slight synclinal and then a broad anticlinal with low dips. West of the plain, near the base of the Khirthar Range, the first rock seen, after quitting the gravels, is *Alveolina* limestone (Khirthar) dipping eastward, and between this and the main range the rocks are much confused. There is evidently a considerable amount of faulting here.

The anticlinal just mentioned becomes more developed to the southward, and brings up Nari beds west of the police post at Karchát, where Gáj and Nari beds are seen highly tilted, the axial portion of the fold having been weathered out in the form of an imperfect amphitheatre, around which the outcrops of the different beds form concentric ridges. The oval is incomplete, for the west side is cut off by a fault.

Southern extremity of Khirthar range.

This is close to the southern termination of the Khirthar range. The southern spur is a massive anticlinal of Khirthar limestone, rising, according to the Great Trigonometrical Survey measurement, to a height of 2,388 feet above the sea. The Báran valley to the west and south of the range will be described in Chapter VIII.

CHAPTER VII.—THE LAKI RANGE, INCLUDING THE BHAGOTHORO, DHĀRAN, TIYÚN, MERI, LOHI, DAPHRO, ERI, AND SURJĀNA HILLS, TOGETHER WITH THE COUNTRY BETWEEN THE RANGE AND THE INDUS, THE HYDERABAD HILLS, AND THE TRACT OF HILLY COUNTRY NEAR JHIRAK AND TATTA.

Area described in this chapter.

A much larger and more important area will be described in this chapter than in the last, for all the exposures in Sind of beds lower than the Khirthar nummulitic limestone and its associated beds are comprised within the tract herein discussed. The sections of the Laki range are of remarkable interest, as they comprise, besides the Ranikot beds, a representative of the Deccan trap, and two or three very interesting groups below the trap, the lowest being clearly of cretaceous age, and the upper either very high cretaceous, or intermediate between cretaceous and tertiary.

The area includes, in the first place, the whole of the range known under a multiplicity of names, but collectively termed the Laki range,[1] extending from just south of Sehwán to the Surjána and Sor Hills; secondly, the tract of hilly country between the Laki range and the Indus, the detached hills of Hyderabad east of the river, the expanse of lower tertiary rocks between Jhirak, Jungsháhi, and Tatta, and the isolated rises in the alluvial area near the last-named town.

Laki range.

The Laki range is one of the usual anticlinals, much complicated, however, by faults and supplementary foldings, and composed in places of several parallel ridges

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[1] The frontispiece to this Report represents the northern extremity of the Laki range as seen from the Indus near Sehwán, and is copied from a drawing by my colleague, Mr. A. B. Wynne, to whom I am indebted for the opportunity of illustrating the present memoir by a view of one of the most interesting localities in Sind. The original sketch having been taken at sunset, only the outlines of the hills are shown. The ridge in front of the others is that of Bhagothoro, and the anticlinal axis forming the ridge is shown by the slopes, corresponding to the dips of beds, on each side. The high peaks behind to the right are those of the Tiyún range, composed of Khirthar limestone dipping westward, or toward the right hand; they are very craggy and irregular in outline. Behind Bhagothoro is seen another portion of the Tiyún range, and the distant hills to the left are those near Jakhmari.

separated from each other by valleys of various widths. East of the range there is a broad synclinal occupied by Manchhar beds, on the edge of which the Nari beds are, except at one locality far to the northward, absolutely wanting, and the Gáj beds either absent, like the Nari, or represented by a very thin band often not more than a few feet in thickness. East of this again is a very gentle and broad anticlinal, in the middle of which the Ranikot beds are well exposed. To the southward the dips are very low indeed, and the geology becomes very simple—an expanse of Khirthar beds to the westward, from beneath which the Ranikot group crops out to the eastward, near the edge of the alluvium.

Country between Laki range and Indus.

In order to avoid frequent references, it is as well to state at once that nearly the whole of this area is very incorrectly represented on the Revenue Survey map. The details in the Laki range are especially inaccurate: for instance, the Mohan river, miscalled the "Runneewaree" on the map, is represented as rising some 8 miles too far to the north; and the main range, instead of lying east of the upper portion of this stream, is apparently that shown to the westward of the valley, this ridge being continuous all the way southward to Ranikot. The country between the Laki range and the Indus is also very incorrectly represented on the map.

Inaccuracy of map.

The description of the area commences, as usual, at the northern extremity at Sehwán, the Manchhar beds extending north from the Bhagothoro spur to the town itself. Close to Sehwán the Manchhars are seen dipping to the westward, but no good section is exposed for the 3 or 4 miles to the southward. From 4 to 6 miles south of Sehwán, however, near the place marked on the map as Wand Hote Khan, a very interesting section is seen, extending from the Khirthar to the Manchhar group. The section is very well exposed near a foot-path leading from Jhángár to Bhagothoro. All the beds dip west by a little north, at an angle of about 45°.

Manchhars near Sehwán.

Going eastward from the road between Sehwán and Jhángár, the

Section near Bhagothoro; Manchhar beds.

highest Manchhar beds seen are yellowish-brown grits, soft and argillaceous as a rule, but occasionally hard and calcareous; sometimes they are mottled buff and white, and they are associated with argillaceous limestones of the same colour, and with conglomerates. Beneath these beds is a great thickness of the characteristic grey sandstone. A few of the beds which are harder are worked into a kind of platter used for baking bread upon. With the sandstone are bands of conglomerate containing fragments of sandstone, shale, and clay, dicotyledonous fossil wood, crocodiles' teeth, and a few bones. Some few mammalian teeth also occur, isolated and single as usual.

Variegated sands and clays.

Beneath the Manchhars there is a very remarkable and brightly coloured group of sands and clays, white, red, and brown in colour. Thin bands of highly ferruginous sandstone, black and dark-brown in colour, and occasionally passing into ironstone, are interstratified; and some small irregular beds of very silicious rock resembling quartzite are met with, but they are rare and of subordinate importance. Some of the clays are mottled white and purple, and gypsum is frequently associated with the softer beds. These richly-coloured and variegated rocks have a very peculiar aspect, and are different from any of the formations known to occur in the Khirthar range, although somewhat similar beds are found in the Upper Nari group in places.

Gáj beds.

As a rule, these variegated beds are unfossiliferous, but in some places the uppermost layer, a slightly calcareous grit, contains numerous *Gasteropoda, Lamellibranchiata*, and *Foraminifera*, some of which are Gáj species, one of them being *Ostrea multicostata*. Valves of *Balanus* are also found. In a bed immediately above are some large oysters belonging to a species elsewhere found in lower Manchhar beds. Farther to the southward, in precisely the same position, at the base of the Manchhar beds, a thin band of typical Gáj beds comes in above the Nari group.

The variegated sandstones of Bhagothoro rest upon typical lower

Nari beds, the characteristic yellow and brown limestones with *Nummulites garansensis, N. sublævigata, Pecten labadyei, &c.* In one place at least, a spot called Seri, about 8 miles south-east of Jhángár, where a very small spring of fresh water breaks out not far from the path to the Dháran pass, there is distinct unconformity between the two groups. The yellow Nari limestone with *Foraminifera,* and the shales intercalated with the limestone, have been denuded, and the variegated beds rest on the denuded surface, the stratification of the two groups not being parallel.[1]

Nari beds.

Unconformity between lower Nari beds and variegated sandstones.

It is thus evident that there is a break in time between the lower Nari beds and the variegated clays and sandstones. The latter may nevertheless belong to the Upper Nari group, or they may be considered a lower portion of the Gáj formation. The former being, perhaps, the more probable view, these beds have been mapped as Nari. The important point is that there is here denudation-unconformity between lower Nari beds and strata elsewhere conformable upon them.

Fossils in Nari beds.

The lower Nari beds of Bhagothoro Hill are highly fossiliferous, and a large collection of well preserved specimens has been made. The following, exclusive of *Foraminifera,* are the principal forms found:—

CORALS.

Trochocyathus burnesi.
Montlivaultia vignei.

ECHINODERMATA.

Cidaris verneuili.
Cœlopleurus forbesi.
Clypeaster, sp.
Eupatagus rostratus.
Schizaster beloutchistanensis.
S. cf. *newboldi.*

LAMELLIBRANCHIATA.

Corbula harpa.
C. cf. *dubia.*
Venus granosa, var.
Cardium cf. *triforme.*
Chama, sp.
Pecten labadyei.
P. cf. *hopkinsi.*
Ostrea cf. *flabellula.*

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[1] These details and the list of fossils, with several other parts of the description, are from Mr. Fedden's notes.

GASTEROPODA.

Trochus cumulans, var.
Phasianella oweni.
Turritella angulata.
T. deshayesi.
T. monilifera.
T. renevieri.
T. cf., *conoidea.*
Siliquaria granti.
Solarium affine.
Natica patula.
N. sigaretina.
N. decipiens.
N. (*Mammilla*), sp.
Cerithium granti.
C. pseudocorrugatum.
C. cf. *rude.*
Cypræa nasuta, var.
C. digona ?
C. cf. *prunum.*
Voluta jugosa.
V. cf. *dentata.*
V. cf. *crenulata.*
Conus, sp.
Harpa. sp.
Semicassis, sp.
Sycotypus, sp.
Cantharus, sp.
Distorsio, sp.
Triton, sp.

Near the spot marked on the (1-inch) map as More Luck pass, the variegated beds rest almost, if not immediately, on the Khirthar limestone, the surface of which, near Bhagothoro, looks worn and irregular, as if it had been exposed and slightly denuded before the deposition of the variegated beds; whilst the lower Nari rocks are cut away so as to form ridges, upon and against which the newer variegated beds have been deposited.

The eastern side of the ridge north of Bhagothoro overhangs the river Indus, and the railway has now been constructed along the face of the cliff not far from the bank of the river. In some places the surface of the limestone is broken up by enormous cracks of great depth; these are said to have been caused by earthquakes in late years.[1] Probably an argillaceous bed underlies the surface limestone at such places.

North-west of the town of Laki a hot-spring (temperature 103° Fahr.)[2]

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[1] Mr. Fedden learned, by enquiry amongst the hillmen, that the great fissures were produced by an earthquake within the recollection of the oldest men, and apparently nearly 60 years ago, and he suggests that the earthquake of 1819 may have caused the dislocations.

[2] The temperature of this spring is stated in the *Gazetteer* to range from 102° to 124° Fahr. This, if correct, is very remarkable. Mr. Fedden and I took the temperature at an interval of more than a year, and found it to be 103° on both occasions.

Hot-spring of Laki.

issues in a ravine within the hills. The spring is moderately copious, and gives off a larger quantity of sulphuretted hydrogen than any other hot-spring in the province, although all are more or less impregnated with the gas. There is, as usual, a deposit of calcareous tufa from the water.

Sections of range.

The ravine in which the spring occurs runs south-17°-west, and is formed by a synclinal, probably somewhat faulted, of Khirthar limestone. The relations of the beds are shown in the figured section (Plate III, fig. 3, p. 87). To the eastward no trace of Nari or Gáj rocks is seen, but in many places the Manchhar beds are faulted against the Khirthar limestone. The section of the range about 2 miles south of the spring, where a foot-path, known as Dháran Lak, crosses the hills, is shown in the sketch (Plate III, fig. 4, p. 87).

Fossils in shales.

In the soft shaly beds of the Khirthar group exposed in this section a large collection of fossils was obtained, comprising several forms of nummulites, at least 40 species of *Mollusca*, and the two crabs figured by MM. D'Archiac and Haime under the names of *Arges murchisoni* and *A. edwardsi.* Amongst the *Mollusca*, besides a *Nautilus* undetermined, were *Crassatella halaensis, Corbula subexarata, Corbis elliptica, Lucina subvicaryi, Venus* cf. *cyrenoides, Cardita depressa, C. mutabilis* var., *Cardium halaense, Nucula margaritacea, Chama* cf. *geslini, Ostrea vesicularis, Nerita schmideliana,* and *Ovulum murchisoni.* A species of *Anomia*, also, is abundant and characteristic. It is probable that a considerable proportion of the Khirthar and Nari species described by MM. D'Archiac and Haime were procured in the neighbourhood of Bhagothoro and Laki.

Beds below Khirthar limestone.

About a mile south of the Dháran Lak the beds below the Khirthar limestone appear in a valley within the range, and these beds extend thence to the southward for a distance of about 35 miles, being brought up along a faulted anticlinal. For the general section, comprising, in descending order, Ranikot beds about 2,000 feet thick, trap 40 to 90 feet, and the infra-trappean series classed as cretaceous, of which about 1,400 feet are exposed, the list of geological groups in Sind should be consulted.[1] In the accompanying map, owing to the very small scale, only the Ranikot beds and the cretaceous rocks are separately coloured, the narrow band of Deccan trap being omitted. The thickness of the Khirthar limestone in the Tiyún range (the ridge running south-east from Dháran), cannot be great, but it has not been precisely determined. A little farther south it is only 450 feet on the scarp west of Barrah Hill, and nearly the whole thickness is here exposed; there cannot be much more than 500 or 600 feet altogether.

Highest Ranikot beds.

Beneath the Khirthar group, on the eastern scarp of Tiyún, there is found a considerable thickness of yellow limestone, which probably represents the brown limestones of Lainyan to be described presently. Farther south, near Barrah, the yellow limestone is wanting, having probably been denuded away; for throughout this range there is unconformity between the Ranikot beds and the Khirthar. A bed abounding in a species of *Rostellaria*, apparently the *R. columbaria*, Lam. of D'Archiac and Haime, but a very different form from the true *R. columbaria* of Lamarck, is found at Barrah as well as farther north, and is met with some distance below the fossiliferous brown limestone of Lainyan.

Section at Jakhmari.

The Ranikot beds and the cretaceous rocks beneath them are well exposed from top to bottom under Jakhmari and Kharguzáni peaks, but all the upper portion is much obscured by talus from the overlying Khirthar limestone, and no complete section can be measured. The following is the series of the bottommost Ranikot beds, in descending order, with the underlying olive shales or *Cardita beaumonti* beds. The section across the range at Jakhmari is shown in the accompanying section (Plate V, fig. 1).

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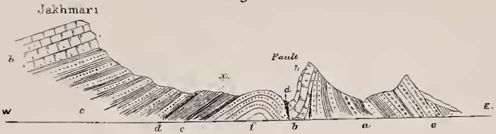
[1] See p. 32.

Fig 1

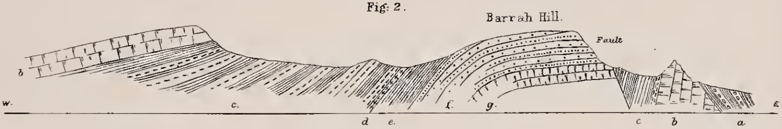


Sketch section at Jakhmari Peak.

a. Manchhar; b. Khirthar limestone; c Ranikot beds; d Trap; e Olive shales, (x. Cardita beaumonti bed);

f. Dark sandstone

Fig: 2.

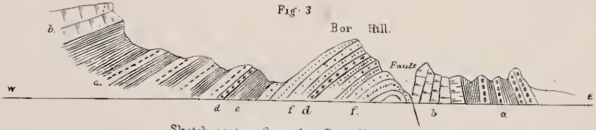


Section through Barrah Hill. Scale—2500 feet = one inch.

a Manchhar beds. b Khirthar limestone c, Ranikot beds. d Deccan trap e. Olive shales with Cardita beaumonti. f. Cretaceous sandstone.

g Limestone with Hippurites.

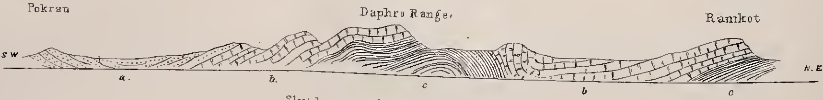
Fig. 3



Sketch section through Bor Hill

References as in section immediately above

Fig: 4.



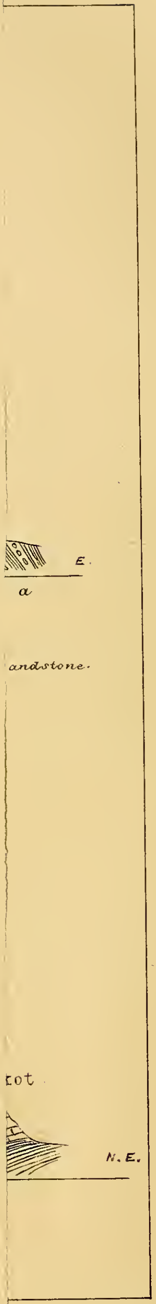
Sketch section from Pokran to Ranikot

a Nari beds. b Khirthar. c. Ranikot

SECTIONS OF LAKI RANGE.

On stone by S K H

XVII. Pl. V



On stone by S.K H?

Section of lower Ranikot and underlying beds at Jakhmari.

		Ft.
RANIKOT BEDS ...	1. Sandstones of various colours, grey, brown, red, yellow, &c., much false-bedded	40
	2. Similar sandstones, but less compact and less false-bedded, sometimes with ferruginous nodules ...	20
	3. Grey and greenish-brown sandstones, with many more or less ferruginous concretionary nodules, some fragments of bones, apparently of tortoises, and of teeth which may be saurian	10
	4. Coarse grey sandstone, with ferruginous nodules and light-coloured variegated sandy shales; also grey and pale brown sandstones, with patches of yellow and red	30 to 40
	5. Pinkish-grey sandy shale, yellow and red in patches	5
	6. Dark-greenish and brown sandstones, rather coarse, soft and shaly	30
	[*N. B.*—In some of the beds, from 2 to 5 inclusive, fragments of wood occur, apparently dicotyledonous.]	
DECCAN TRAP ...	Basalt	70
CRETACEOUS? ...	1. Olive-green sandstones and sandy shales, with gypsum, containing *Cardita beaumonti*, *Natica*, *Turritella*, &c., mostly weathering out as casts. The uppermost sandstones beneath the trap are reddish-brown	200
	2. Olive clays or shales with occasional bands of sandstone and a few thin layers of dull olive or dark-coloured impure limestone. This is the most fossiliferous bed, with *Cardita beaumonti*, *Nautili*, Corals, &c.	100 to 150

The *Cardita beaumonti* shales are well seen along the course of a torrent bed which drains the hills close to the police post at Jakhmari, and the trap bed overlies the shales. Beneath these beds are found the dark sandstones rolling over in an anticlinal, the uppermost layer being full of oysters. At the fault cutting off the lower beds there is again a bed of trap, but owing to the crushing that has taken place, the relations of this band to the sandstones are extremely obscure. Probably the trap is interstratified with the sandstones; and if so, it is at a considerably lower level than the flow in the preceding section at the base of the Ranikot group. Close to the trap, and apparently underlying it, there is a very fossiliferous bed containing *Corbula harpa,* an oyster resembling *O. flemingi,* a *Turritella,* a small coral, and two echinoderms, one of them a *Cidaris.*

East of the fault, the Khirthar beds come in with a reversed dip only a small thickness is exposed, and then Manchhar beds appear dipping at high angles.

Section at Kharguzáni.

The Deccan trap does not extend much farther north than Jakhmari, both it and the underlying beds disappearing beneath higher strata within less than a mile. Under Kharguzáni peak, about 2 miles north-east, only Ranikot beds are seen between the Tiyún range and the fault. The only remarkable point about the section at this spot is that, east of the fault, resting upon the Khirthar limestone, some Nari beds are seen, ferruginous brown limestones with the characteristic *Orbitoides papyracea.* The dip of the Khirthar limestone here also is reversed. The Manchhar beds to the eastward are faulted against the Nari beds, and dip about 60° to east-by-south, and the Khirthar beds underlying the Naris, but with their dip reversed, as if overlying, are faulted against Ranikot beds. The uppermost 200 or 300 feet of the Manchhar group consist of conglomerate overlying soft earthy and sandy beds, yellow, bluish-grey, and red in colour, and these pass down into soft grey sandstones, with conglomerates and argillaceous grits. Bones and teeth of mammalia are not rare, and from this neighbourhood many specimens were procured,[1] especially of the peculiar ungulate types, such as *Hyopotamus, Anthracotherium,* and forms allied to *Merycopotamus.*

Cretaceous beds south of Jakhmari.

To the southward from Jakhmari the outcrop of the cretaceous beds below the trap becomes broader, and the anticlinal ridge of cretaceous sandstone, the lowest strata exposed, becomes higher, but still the infra-trappean (cretaceous?)

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[1] Chiefly by employing Baluch shepherds to collect.

beds occupy all the low ground between the Tiyún range and the hills of Khirthar limestone, east of the fault forming the eastern boundary of the older beds. The lower beds of the cretaceous sandstone group are still concealed. About 2 miles south of Jakhmari the Ranikot beds come in beneath the Khirthar limestone east of the fault, and continue for about 2 miles farther to the southward, being chiefly seen to crop out in the scarp, east of the fault, underneath the Khirthar limestone. The Ranikot beds disappear again beneath the Khirthar limestone close to a place called Khirdhai. West of their exposure, the olive shales only are met with for some distance, the dark cretaceous sandstones being concealed; but the latter crop out again south of Khirdhai, and thence to the southward form a well marked ridge for many miles, culminating in the two hills of Barrah. The higher of these two peaks, that to the southward, rises to a height of 1,200 feet above the eastern base of the hills, and 1,100 feet above the valley through which the fault runs east of the first range.

Cretaceous sandstone hills.

The dark-coloured sandstone ridge here becomes conspicuous from the plain to the eastward, for the rounded hills of sandstone tower above the crags of grey Khirthar limestone to the east of the faulted anticlinal, and are relieved against the pale-coloured scarp, also composed of Khirthar limestone, to the westward of the anticlinal and on the eastern side of the main range. The most conspicuous dark-coloured hills seen are those of Barrah to the north, Bor 3 or 4 miles to the southward of Barrah, and Gadha or Hus, 2 miles farther south, and 9 miles north of Ranikot. Unfortunately all these most interesting sections are difficult of access, there being no roads or villages in the neighbourhood, and the country for many miles from the hills being a waterless desert, except after rain.

Section at Barrah hill.

The section at Barrah hill (Plate V, fig. 2) is the most interesting of all, as the lowest beds known to occur in Sind are seen here alone, and the whole series is well exposed. A very small stream issues from the range, and cuts its way through the eastern ridge of Khirthar limestone: farther up, the same water-course runs between the two sandstone hills. Along the bed of this stream there is a foot-path, practicable with a little climbing.[1]

Section at Barrah Hill.

At the base of the hills Manchhar beds are seen dipping at an angle of about 35° to 45° to east-10°-south. Some of these beds are fossiliferous, containing casts of shells, and rest unconformably upon pale olive clays of Khirthar age, containing *Corbula, Arca, Cardita, &c.*, and passing into a bed abounding in *Nummulites leymerici*. The latter rests upon nummulitic limestone (Khirthar).

The nummulitic limestone continues for some distance, and forms the outer ridge of the hills, the beds having a reversed dip of about 80° to the westward. West of this ridge is some low ground, in which the upper members of the Ranikot group crop out, also with a reversed dip. They comprise the bed with *Rostellaria* already mentioned. They end abruptly against a small cliff of white and grey limestone, the boundary being clearly a great fault. Here, therefore, as to the northward, Ranikot beds occur east of the main fault.

This white and grey limestone of the cliff is compact and hard, and the upper portion is very sandy and gritty, the lower part purer. In the upper part there are thin gritty ferruginous bands. The rock abounds in fossils, but, as a rule, only sections of shells, &c., are seen, and it is very difficult to obtain anything recognizable. No *Foraminifera* could be detected, but sections of Echinoderms and Gasteropods are common, and one fragment of a Hippurite was obtained.

Above the limestone, and, to some extent, passing into the gritty calcareous beds already mentioned, is a great thickness of sandstone forming the dark-coloured hills. The sandstone varies greatly in colour, being brown, pink, and in places white; with beds of conglomerate, dark gritty limestones, and ferruginous bands. The whole weathers of a very dark colour.

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[1] The spot is about 10 miles south-west of Amri. The name of Barrah is only known to the Baluchis, who, when water is available, drive their sheep, goats, and cattle to the hills for pasture. The place may be recognized from a distance by the two dark-coloured hills.

On the top of the hills is a bed containing oysters and fragments of large bones, apparently reptilian. West of the hills the olive shales with *Cardita beaumonti* occur in a marked depression, due to the weathering of these soft beds, which dip westward at a much higher angle than the sandstones, the latter rolling over to the eastward with the usual tendency to an anticlinal. In the olive shales at this spot, besides the usual fossils, two or three fragmentary amphicœlous reptilian vertebræ were obtained, since identified by Mr. Lydekker as belonging to a mesozoic type of crocodiles. Above the olive shales, the trap is found in the usual position, and the Ranikot group, here of great thickness, is exposed on the slopes of the main range and capped by the Khirthar limestone.

Hills south of Barrah.

This, as already stated, is the only place where the white limestone with *Hippurites* appears from beneath the cretaceous sandstone. South of Barrah Hill the main fault appears to divide, and a branch running to the south-west, and having a downthrow to the south-east, causes the disappearance of all the cretaceous rocks below the *Cardita beaumonti* beds, and brings in Ranikot beds west of the main fault. For some distance south of the branch fault, the olive shales with *Cardita beaumonti* form an anticlinal, and their outcrop is scarcely a quarter of a mile broad, the trap bed resting upon them, and the Ranikot group upon the trap, both east and west of the anticlinal. This, however, only continues for about a mile, then the cretaceous strata suddenly roll up to the southward, the Ranikot beds to the east of the anticlinal come to an end, and the cretaceous sandstones re-appear and form the high dark-coloured hill of Bor.[1]

Section at Bor Hill.

Here the section (Plate V, fig. 3) is not unlike that at Barrah, already described, except that the Ranikot beds are wanting to the east of the fault, and that the lowest beds seen are the cretaceous sandstones. The Manchhar beds are highly inclined, and dip at about 75° to east-10°-north; the Khirthars

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[1] The section at Bor Hill was examined by Mr. Fedden only, and I unfortunately misunderstood his account of the section, and, consequently, omitted to search for the lower bed of trap when I made a rather hurried examination of the hills in 1877.

which succeed to the Manchhars are vertical, and near the fault have a reversed dip. Some shales belonging to the Khirthar group occur immediately beneath the Manchhar. The limestones form a ridge, rising into high pinnacles, at least 200 feet above the bed of a stream traversing the range.

The sandstones rise immediately west of the Khirthar limestone ridge. About 600 or 700 feet of them, precisely similar to those of Barrah, are exposed in the scarp. About two-thirds of the distance up the face of the hill is a bed of trap about 40 feet thick, apparently interstratified with the sandstones. On the top of the sandstones is the usual bed with *Ostrea*, *Turritella*, &c.

Lower trap bed.

The trap may be the same as that seen in the fault at Jakhmari. Unfortunately this trap bed was not especially looked for at Barrah, and in many places in these hills the basalt is so thoroughly decomposed, that it can only be distinguished from the associated sandstones by close search. It is, therefore, uncertain whether this lower bed of trap extends to a distance like the upper flow. A similar bed, probably the same, was noticed at one spot a few miles north of Ranikot.

The remaining beds are precisely the same as in the Barrah section.

Bor Hill to Ranikot.

From Bor Hill the cretaceous sandstones and the overlying beds continue south to Gadha (Gahrea) or Hus, where a broad stream bed is cut through the outer range, and the nummulitic limestone only forms a very narrow ridge. Here the whole of the cretaceous beds disappear below the Ranikot group, and for 2¼ miles, the latter abuts against the Khirthar limestone at the main fault. The trap and olive shales re-appear west of the fault, 2 miles farther south, at Kandori, but only for a short distance. Then, after another interval of about 2 miles, the cretaceous beds again crop out at the surface, the sandstones being also exposed, and all continue as far as Ranikot, where they come to an end within the limits of the fortress. They do not extend continuously to the Mohan stream, which traverses Ranikot from west to east, and in which a last appearance of the trap takes place at the axis of the anticlinal of Ranikot beds, the infra-trappean beds not being exposed. South of this the fault appears to die out; the Ranikot beds merely form a flat anticlinal, and are horizontal for a considerable distance, the underlying cretaceous beds not appearing at the surface.

In one place near Kandori, the spot just mentioned, about 6 miles north of Ranikot, a band of carbonaceous shale with some layers of coal occurs in the olive sandstone just below the trap. This coaly bed thins out within a few yards, but serves to show that the olive shales are probably littoral or estuarine.

Trap and infra-trappean beds at Ranikot.

The trap and the underlying olive shales are well seen in a tributary which joins the Mohan stream from the north near the eastern wall of Ranikot. Ranikot is a great fortified enclosure, 3 miles in length from east to west, and about the same from north to south, nearly surrounded by a wall, and having two citadels inside, one of which is the Miri of the map. Some minor fortifications are scattered about. The Mohan river runs through the middle, and a warm spring (temperature 80° Fahr.) rises at the western extremity of the fortress, which was built by the Amirs of Sind about 1812.

The following description of the section on the Mohan stream at Ranikot was given in the notes on this part of Sind published in 1867[1] from the observations made in 1863:—

"At the (eastern) entrance to the gorge the limestones (Khirthar), where they emerge from beneath the alluvial boulder deposits, have a low dip to the east. They are sharply twisted up at one spot, but continue steadily beyond and rise into a hill about 460 feet high. From beneath them, at the west base of this hill, which is part of the outer ridge already mentioned as bordering the plain, the gypsiferous clays and sandstones (Ranikot) crop out, much varied in colour as usual, but with a very high dip of 60° to the eastward. Yet there is no clearly marked unconformity. These beds continue at the same dip for above a quarter of a mile, when they roll over at an anticlinal, and continuing up the stream to the westward lie at much lower angles, frequently horizontal, but generally dipping at 10° or 15° to the west or north-west. At the axis of the anticlinal the lowest bed seen is *trap*, which only appears in the stream for a few yards. It is slightly amygdaloidal,

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[1] Mem. Geol. Surv. Ind., Vol. VI, p. 5.

and contains agates, and it has a slightly stratified appearance. Only a few feet of thickness are seen. The sandstones resting upon it do not appear to be in any measure altered by the contact.

"Below about 20 feet of solid trap there appears on one side of the Mohan stream (in which alone the igneous rock is exposed) a shaly bed, perhaps an ash. It is this which tends to give the trap so markedly stratified an appearance." * * *

"Beyond the anticlinal the variegated sands and clays continue for 1 mile or 1½ miles to the west; then, just beyond the lower part of the Kot, the inner range crosses from north to south, parallel with the outer ridge, and, like that, composed of *Alveolina* limestone resting upon the sands and clays. In neither case does there appear reason to suppose the existence of any fault between the limestone and the underlying beds. Yet it should be noticed that, in neither case, is there any appearance of the rubbly calcareous beds so rich in marine fossils which rest upon the sands and clays of the Lynyan."

* * * * *

The estimate of thickness was not correct, the Khirthars were considered 1,000 feet thick, which is too much, whilst the Ranikot group is thicker than was at first supposed.

The plain outside Ranikot was described as composed of the Lynyan (Lainyan) beds (Ranikot group), and it was supposed that these were concealed and obscured by alluvial deposits of gravel, sand and pebbles. So little is seen of the rocks in the country intervening between Ranikot and Lainyan, that, in a rapid traverse, the mistake is not difficult to account for, and just east of the fortress no section could, at that time, be seen showing the relations of the Khirthar limestone to the beds underlying the plain to the eastward. This section has since been better exposed by the river, and it has been found, from an examination of the neighbouring country, that there is a synclinal east of Ranikot occupied by Manchhar beds; that the Ranikot beds of Lainyan or Leilan dip beneath Khirthar limestone, and this below Manchhar sandstones, and that the limestone rises again from beneath the Manchhar beds east of the fortress.

The section seen in the Sann river (as the Mohan is called outside the hills), about a mile from Ranikot, consists of cliffs of light-brown marl passing down into sandy beds, precisely resembling Manchhar rocks, but perhaps really consisting of reconsolidated detritus derived from the Manchhar beds. On the top of the cliffs is a mass of subrecent conglomerate. Farther west grey and buff sandstones occur, evidently of Manchhar age, with masses of the characteristic Manchhar conglomerate, containing pebbles of clay and sandstone precisely like the associated beds, and some of laterite. At the extreme base of these, resting unconformably on the Khirthar limestone, is some laterite with variegated shales. Similar beds are seen between the Manchhars and Khirthars, both to the north and south, and may probably be of Gáj age, as they are occasionally associated with strata containing Gáj fossils.

Ranikot.

Inside the eastern range a great change has taken place since 1863. At that time the inner scarp of the range exhibited a very fine section of Upper Ranikot beds. Now the scarp has been so covered over by masses of Khirthar limestone fallen from above, that no Ranikot beds can be seen in the cliff. It is said that the talus from above was thrown down by an earthquake in the interim.

The Ranikot beds on the western scarp of the outer range must be east of the fault, if the latter has not died out. Probably, as already noticed, it comes to an end about this, but still there appears to be rather a smaller thickness of Ranikot beds east of the anticlinal in the Mohan stream than west of it, so some may be cut out in the former direction. The only places, to the north of Ranikot, where Ranikot beds are found east of the main fault, are those already mentioned south of Jakhmari and at Barrah hill.

South of Ranikot, on the road to the Girran pass, a path leading across the hills about 5 miles south of the fortress, the Ranikot beds are found dipping at low angles and in places horizontal; they consist mostly of soft sandstones with beds of sandy shale; they are very false-bedded, and variable in composition and colour. There is much soft brownish-yellow sandstone, and an open textured earthy brown sandstone, speckled with white, and having much resemblance to some Damuda rocks. With these are occasionally associated purplish shales and ferruginous beds,

South of Ranikot.

alum shales of a dark colour containing iron-pyrites and decomposing readily on exposure, and also some bright yellow layers of ochrey clay.

Girran pass.

Near the Girran pass these beds dip west at high angles; 45° to 50.° The rocks are much disturbed and contorted, and the Khirthar beds overlying the Ranikot are vertical, or in places have even a reversed dip for a short distance. The inclination, however, soon becomes less.

Hothian pass.

Between 3 and 4 miles south of the Girran pass there is another pathway across the hills called the Hothian pass. The scarp of Khirthar limestone west of the Ranikot anticlinal, it should be mentioned, is continuous throughout the range from Jakhmari to Hothian, except where cut through by the Mohan river at Ranikot. At Hothian, on the face of this scarp, the Khirthar limestone is distinctly seen to be unconformable to the underlying Ranikot beds, the latter dipping at a rather higher angle, and having evidently been denuded before the Khirthar limestone was deposited. The denudation, however, appears of no great amount, only the uppermost Ranikot beds having disappeared. The chief importance of this local unconformity, which appears to be persistent throughout the Laki range, but wanting a few miles away to the south-east, is to show that the boundary between Khirthar and Ranikot beds should be drawn at the base of the white limestone, and that the fossiliferous brown limestones of Lynyan and Jhirak belong to the older subdivision.

The great Ranikot inlier of the Laki range terminates close to Hothian pass; no beds of older date than Khirthar have been discovered to the southward in the range. Before describing the southern portion of these hills, a few remarks are necessary on the western branch, extending along the eastern side of the valley between Chorlo and Pokran, and including the Dáphro range.

Dáphro range.

The head of the Mohan stream is nearly west of Bor Hill, and the ridge west of the stream is one of the usual secondary anticlinals of Khirthar limestone. West of Ranikot, Ranikot beds appear in the axis of this anticlinal, and occupy an area of small breadth, but about 5 miles long from north to south. Between this inlier and Ranikot there is a synclinal occupied by Khirthar limestone. The relations of the rocks are shown in the sketch section (Plate V, fig. 4) from Pokran, near the base of the Khirthar range, to Ranikot. The sketch is approximately on a scale of 2 miles to an inch. The disturbance is in places greater than is represented in the section. Thus, in the ridge of Khirthar limestone between the Dáphro range and that overlooking Ranikot, there is much crushing, and the dip is reversed for some distance.

Near Batri Kurchát.

To the southward the synclinal shown in the above sketch becomes a broad valley into which the Girran and Hothian passes lead, and the drainage from which runs southward to the Báran. In this valley, towards Batri Karchát,[1] Manchhar beds come in with some Gáj and, to the south-west, Nari beds below them. The Dáphro range ends in two spurs called Hatting and Yeting, both of Khirthar limestone.

Laki range south of Hothian.

South of Hothian pass the Laki range, including the ridge or dome-shaped elevation known by the name of Eri, becomes a simple anticlinal of Khirthar limestone between two tracts of Manchhar beds. A thin representative of the Gáj group intervenes between the Manchhar and Khirthar beds to the westward, and the ferruginous beds to be noticed presently are found in places occupying the same position on the eastern side of the ridge. Eri is a higher part of the range, with a slight quaquaversal dip, steeper to the southward, where there is a depression of the anticlinal axis. South of Eri, across this depression, two easy foot-paths, similar to the Girran and Hothian passes, traverse the range, and are known as the Halarke and Hála-lak. This last named insignificant pass is the only spot where the name of Hála, so frequently applied in maps to all the ranges of Western Sind

Hála pass.

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[1] This place is about 9 miles north-west of the spot called Surang Khosa on the accompanying map.

collectively, is found employed for any portion of a range by the people of the country. About the Hála-lak, on the western side, the calcareous rubbly Gáj beds are seen resting on the surface of the Khirthars, the latter being worn and riddled with holes made by boring mollusca. The Khirthar surface, forming the floor on which the Gáj beds have been deposited, is in places of marly limestone, in others of fine calcareous yellowish sandstone with casts of *Nummulites leymeriei.* These upper Khirthar beds are of a light buff colour, and contrast with the more purely white limestones of Eri Hill and the range generally. Amongst them is a bed containing fossil crabs (*Arges*, or *Galenopsis murchisoni*) in abundance. *Cerithium giganteum*, *Ovulum*, and casts of *Lamellibranchiata* also occur.

Some miles farther south, the range is traversed by the Báran river, and a very fair section of Khirthar beds is exposed in the gorge, which is known as Darwáz or Darwát. In the cliffs on each side of the river the massive Khirthar limestones are seen, dipping at a low angle to the westward, except at the east end of the pass, where they are suddenly bent down at a high angle and dip east. Fossils are of frequent occurrence in the limestone, but are chiefly common species; the crab bed is well seen north of the stream on the western side of the pass.

Surjáno range.

The range south of the Báran river and east of Bhule Khán's Thána is known as Surjáno, and here the upper portion of the Khirthar group, composed of rubbly and rather shaly beds, not compact, is much thicker than farther north. The commonest nummulites in these beds are *N. granulosa*, *N. leymeriei*, and *N. spira*, some layers being entirely composed of these species. Some of the beds are yellowish in colour. A band of greenish clay, or fuller's earth, is found interstratified with these upper beds, and is occasionally dug out by the natives and used for washing cloth, &c.

The upper shaly portion of the group is from 300 to 500 feet thick near the Darwát; below the shaly beds comes the whitish compact limestone forming the mass of the range. Farther to the southward, in the direction of Jungsháhi, the upper Khirthar beds are wanting, and only the compact white limestone is found.

The southern portion of the range, beyond the Báran river, possesses but few features of interest, and we may therefore pass on to the country east of the Laki range,[1] commencing again to the northward near Jakhmari, south of Laki.

Manchhar beds between Laki and Mánjhand.

The expanse of Manchhar beds occupying the triangle formed by Laki, Mánjhand, and Ranikot, is of very small interest. The beds are poorly seen, being usually covered by large accumulations of gravel, conglomerate, and sand. At intervals, at a considerable elevation above the present plain, which slopes gradually from the hills to the Indus, there are seen remains of an older slope of detritus in the form of flat-topped or nearly flat-topped rises composed of consolidated gravel.

Ferruginous beds at base of Manchhar group.

Along the edge of the Laki range, at the base of the Manchhars, peculiar ferruginous beds, sometimes forming a kind of laterite, and often conglomeratic, are found. These beds farther south are associated with Gáj fossils. They are probably the same as the variegated beds of Bhagothoro. They are seen at Jakhmari, Ranikot, and many other places.

A similar ferruginous band may be traced along the outer border of the Khirthar limestone in the country between the Laki range and the Indus, from the neighbourhood of Mánjhand to Bandh Vera and the Báran river, and sparingly on the Indus side of the anticlinal. The bed is seen well developed a few miles to the east of Hothian Hill, and it fringes the Khirthar inliers in that neighbourhood. At the edge of one of these inliers is a thin bed of Gáj with *Ostrea multicostata, &c.* A greater development is found to the southward near Bandh Vera. To this further reference will be made presently.

Some silicified fossil wood weathered out of the Manchhar beds is

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[1] The greater portion of the following description is from Mr. Fedden's notes, except the details concerning Laiuyan and Jhirak.

met with here and there. In the great Manchhar tract running southward along the eastern side of the Laki range south of Ranikot, and known as the Vera plain, large fragments of this silicified wood are common; some are evidently trunks of trees, being 30 feet and upwards in length and as much as 10 feet in girth. On the surface these trunks are usually broken across, but still the fragments are easily recognized as portions of the same tree. The stems are mostly exogenous, but endogenous wood also occurs.

Fossil wood.

The lower tertiary rocks near the west bank of the Indus in the neighbourhood of Mánjhand, Kotri, and Jhirak, form a low anticlinal with a very gentle inclination, rarely exceeding 5°, on each side. The Khirthar limestone, which is of no great thickness, probably not more than 300 or 400 feet, has been denuded away from the central portion of the anticlinal, so as to expose the underlying Ranikot beds, which are here quite conformable to the Khirthars, and indeed pass into them. The Khirthar limestone here and to the southward often abounds in *Alveolinæ*. In one place, about 10 miles west-north-west of Kotri, flint and chert were found associated with the nummulitic limestone in large masses, as near Rohri and Sukkur. The outlying rises of Khirthar limestone, east of the Indus at Hyderabad, and farther south, will be noticed at the end of the Chapter.

Lower tertiary beds near Indus.

Flint in Khirthar limestone.

The Ranikot beds are tolerably uniform in composition throughout the large inlier occupied by them. A description of them as they appear around the old coal mine at Lainyan (Leilan) will serve for the whole area. Lainyan, Leilan-je-Tar, or Lynyan, is situated in a plain with a limestone scarp to the eastward and hilly ground to the north and south. The plain is composed of typical Ranikot beds; sandy shales and clays, variable in colour, but usually pink or purplish, with a little gypsum, and beds of sandstone, grey or dark, and ferruginous. Above these variegated beds are alternations of clay and ferruginous shales with gypsum and hard brownish-yellow limestone contain-

Ranikot beds.

Lainyan.

ing fossils. These form the scarp to the eastward, which is 200 to 300 feet in height.

Coal or lignite of Lainyan.

The coal or lignite bed of Lainyan (Leilan) was discovered amongst the sandy shales and clays in a well sunk by the Baluch nomads who inhabit the country, and when found was said to be 7 feet thick. This is doubtful, but the seam measured nearly 6 feet in places. A second smaller seam was found beneath the thicker bed. The coal, however, was found to thin out within a short distance, nowhere exceeding 100 yards. The quality too was inferior.

Section of fossiliferous beds at top of Ranikot group.

The best section of the fossiliferous limestones, overlying the shales and sandstones of the Ranikot group, is seen in the scarp to the eastward of Lainyan. These limestones are the beds the absence of which in the sections of the Laki range has already been noticed.[1] The whole of these brown limestones and their associated beds, east of Lainyan, are considered by Mr. Fedden to be not less than 800 feet in thickness; but the highest portion is not seen in the scarp section.

The uppermost bed seen in the scarp is rather hard, massive, and of great thickness. It is a brown limestone containing numerous fossils, amongst which are a large *Nautilus*, *Spondylus rouaulti*, a *Terebratula* closely allied to the cretaceous *T. subrotunda*, a *Conoclypeus*, and several corals, including *Trochocyathus vandenheckei*, *Cyclolites vicaryi*, and *Montlivaultia jacquemonti*. Below this bed are some clays and ferruginous shales. Then follows in descending order another limestone bed, about 30 feet thick. This abounds in *Ostrea vesicularis* and *Turritella*, and contains *Vulsella legumen*, in masses, several individuals cemented together, a flat *Echinolampas*, and *Operculinæ*. Below this bed again is greyish-brown sandstone, with one or more bands of limestone, and then the variegated sands, shales, and clays.

A list of fossils procured from this locality was given in the note

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[1] See pp. 128, 136, &c.

published in 1867.[1] The following are some of the forms collected besides those noticed above: *Ostrea flemingi, Nerita schmideliana, Natica longispira, N. decipiens, N. flemingi, Voluta teelaensis, Terebellum distortum,* and *Rostellaria angistoma.*

West of Lainyan.

West of Lainyan the rocks dip to the westward at low angles. A fossil bed, apparently on the same horizon as the lower of the two principal fossiliferous belts to the eastward, abounds in *Turritellæ,* the *Rostellaria* referred to *R. columbaria* by D'Archiac and Haime, a *Cassis,* and a small muricoid shell with elegant raised reticulated sculpture. The *Rostellaria* is a characteristic species with a prominent tubercle at the upper (posterior) termination of the lip, and the same form, as already mentioned, is found in parts of the Laki range, and appears to be peculiar to this horizon.

In this direction, west of Lainyan, no Khirthar limestone is seen in place, and the Manchhars appear to rest almost directly on the Ranikot beds. But little rock, however, is seen, the plain of Manchhar beds being much covered over by gravels and alluvial deposits.

Section on road to Kotri.

A very good section of the upper Ranikot beds is also seen south-east of Lainyan on the road to Kotri *via* Bháda.

Ferruginous bed at base of Khirthar.

At the top of the Ranikot beds the brown limestone passes up into a yellowish-brown limestone with *Operculinæ,* and this again passes into a dull whitish bed. Upon the latter there is found a highly ferruginous band, consisting in places chiefly of brown hæmatite, and varying in thickness from 5 or 6 to about 20 feet. It is usually more or less argillaceous, the upper part

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[1] Mem. Geol. Surv., India, VI, p. 3. By mistake the footnote, containing the list of these fossils, was printed on the wrong page, and it was made to appear that the species enumerated were derived from a limestone, containing *Foraminifera,* which really belongs to the Khirthar group, instead of from the "rubbly limestone of a yellow colour abounding in fossils," and the other beds noticed on p. 4. The paper was printed during my absence from Calcutta, and I had no opportunity of seeing the proofs.

having a conglomeratic appearance, the lower being a ferruginous clay. Occasionally this bed is distinctly lateritic in character.[1]

This ferruginous layer is conspicuous on the hills east-by-north of Lainyan. It is also well seen east of Bandh Vera,[2] where it consists chiefly of ironstone. An inlier occurs, surrounded by Khirthar limestone, 1½ miles east of the Bandh.

On the road from Bandh Vera to Kotri, 8 miles from the former place, a good section of the same bed is seen in one of the cuttings. The ferruginous portion is here almost absent, being represented only by a thin band near the base; this passes up into a mottled argillaceous rock, pale purple and white, having a brecciated appearance. Beneath the ferruginous layer is some pale blue and mottled shale.

Lateritic Gáj beds near Bandh Vera.

South of Bandh Vera, a low ridge of Khirthar limestone runs for some distance to the southward, with Manchhar beds on both sides of it. It is on the west side of this little ridge that the lateritic bed, mentioned a few pages back as occurring at the base of the Manchhar group, attains its greatest thickness. The laterite is clearly of detrital origin and gritty. The ridge is a broken anticlinal, with a small fault along the east side. On this eastern side the laterite appears to be less developed.

Associated with the laterite, on the eastern side, there is a thin calcareous bed containing *Ostrea multicostata, O. hyotis,* and *Pecten favrei,* all characteristic Gáj fossils. Apparently above the laterite, west of the ridge, is a bed containing a large oyster with a projection in the hinge, a species found elsewhere in the bottom Manchhar beds.

Lower Manchhar beds near Bandh Vera.

East of the nummulitic limestone ridge are grey and greenish-grey sandstones, very irregularly deposited and obliquely laminated; and interstratified with them are argillaceous grit and nodular conglomeratic layers with fragments of clay, laterite pebbles, and rolled pieces of nummulitic limestone. These

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[1] See *ante*, p. 46.

[2] Bandh Vera is a dam, or "band," across a hollow, for the purpose of storing water for irrigation. After rain there is a large reservoir, but in dry seasons there is no water.

beds have all the characters of Manchhars. Laterite is accumulated in irregular masses in the lower part of these beds, which contain *Ostrea multicostata* and an *Anomia*. But for the fossils all these beds might be classed as Manchhar; but they probably are a mixture of the Manchhar river deposits with the marine formations of the Gáj group, an intermixture commonly found to the southward. In many places to the southward of this no trace of Gáj beds, or of any marine deposit, can be detected at the base of the Manchhars.

Absence of Gáj beds to southward.

Some outliers of Manchhar beds occur 10 to 12 miles west of Kotri, near a camping ground called Petiáni, on the road from Kotri to Bhule Khán's Thána. The outliers consist of calcareous conglomerate, containing fragments of white and yellow sandstone, calcareous sandstone, and iron ore (a ferruginous laterite), and the beds are much disturbed, being in one place vertical.

Probable Gáj outliers north-east of Petiáni.

North-east of Petiáni, however, two small outliers have been noticed resting upon Ranikot beds, and although the relations of neither are quite clear, it is probable that one, if not both, are of Gáj age. The most northerly occurs about 9 miles north-west of Kotri, and 7½ miles north-north-east of Petiáni, and is about a quarter of a mile in diameter. This outlier forms a conspicuous dark-coloured craggy hill in the middle of the Ranikot area, and consists of dark harsh siliceous sandstone, coarse in parts, especially towards the base, with bands of conglomerate containing small pebbles. The rock is obliquely laminated, and 50 to 60 feet thick; it is quite unlike any occurring in the neighbouring scarps of Ranikot beds, and it resembles the hard sandstone to be described hereafter as occurring near Jungsháhi, more than any formation in the neighbourhood. The age of the Jungsháhi sandstone, however, as will be seen,[1] is not clearly determined.

The second outlier is rather larger; it lies about 4 miles south-south-west of the last and between 3 and 4 miles from Petiáni, on the

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[1] See Chapter VIII.

border of the Ranikot group, but below the scarp of Khirthar limestone which surrounds the Ranikot area. The rock of which the second outlier is composed is a calcareous grit, with grains of pale blue quartz. It contains broken fragments of *Balanus*, a few *Alveolinæ*, and some other *Foraminifera*, amongst them *Patellina;* one large *Balanus* was also found, and some worn spines of *Echinodermata*.

This grit is rather thick, and rests upon a small amount of ferruginous lateritic rock, beneath which again is soft yellow marl, with *Eurhodia morrisi* and other Ranikot fossils. There is an appearance of unconformity between the grit and the Ranikot beds, and the character of the former is peculiar. One bed of the grit is flaggy, and bears some resemblance to a rock occurring in the Nari group; another is a grey harsh siliceous sandstone, false-bedded, and quite unlike any Khirthar or Ranikot bed. No similar beds are seen in the neighbouring scarp, where upper Ranikot beds underlie Khirthar limestones, and where the beds of the outlier should be continuous if they belong to either of these groups. The outlier has been mapped as Gáj, but its real position is uncertain. Of course if it be of later age than Khirthar, the *Alveolinæ* and other eocene *Foraminifera* found in it may be derived from older beds.

Fossils in Ranikot beds north-east of Petiáni.

The uppermost Ranikot beds in the neighbourhood of the last named outlier are as highly fossiliferous as they are near Lainyan. A very large number of *Echinodermata* and corals were procured in this neighbourhood, and amongst the former, besides the common *Eurhodia morrisi*, were species of *Echinolampas*, *Conoclypeus*, *Toxobrissus*, *Prenaster*, *Phymosoma*, and one if not more forms of true *Salenia*, approaching very closely in character to cretaceous species.

Southern extremity of Vera plain.

No Gáj beds are seen east of the large Manchhar area forming the southern extension of the Vera plain, nor along the southern extremity of the plain west of Meting railway station, but there are patches along the western boundary of the Manchhars, near the foot of the Surjáno hills and around the Manchhar outlier to the south-west, around Páni Hasanwára. The plain is similar to that farther north; very little rock being seen, although Manchhar conglomerates crop out in places, especially to the westward. Some scattered patches of laterite may indicate the presence of the beds seen at Bandh Vera, but the lateritic deposits are perhaps, in part at least, reconsolidated beds of late origin formed of detritus derived from the older lateritic layers. Blocks and patches of laterite are conspicuous on the road from Kotri to Bhule Khán's Thána, west of Petiáni.

Ranikot beds near Jhirak and Tatta.

The upper Ranikot beds are again very well exposed in the area occupied by them near Jhirak and Tatta, but the dips are so slight that only the highest portion of the group is seen at the surface. It has already been noticed that the division and unconformity, conspicuously exhibited along the western side of the Laki range, between the Khirthar and Ranikot beds, has been replaced by perfect conformity and a tendency to a passage between the two groups in the country north-west of Kotri around Lainyan (or Lynyan). Farther south this tendency increases, so much so that it is very difficult indeed to draw any distinct boundary between the Khirthar and Ranikot beds near Jhirak and Tatta. The white Khirthar limestones in this direction break up into thin beds alternating with calcareous shales, and, towards the base, with soft marly beds of brown and buff colours. The fossils are only in a few instances useful for distinguishing the two groups, several of the commonest species being found in both.

Ranikot beds north of Jhirak.

Under Aongar Hill, a trigonometrical station on the high Khirthar ground, about 8 miles north of Jhirak, and a mile or 2 south-west of Jhuga Pir, the Ranikot beds, near the road from Kotri to Jhirak, consist of flaggy brown limestones, resting on variously coloured soft silty shales, red, yellow, brown, &c., and capped by buff marl. Some of the shales are ferruginous; others contain gypsum in small layers and reticulated veins. To the westward, towards the hills, fragments of brown limestone with *Alveolinæ*, and a few small indistinct nummulites, are met with; the limestone is apparently lower in the series than the shales just mentioned, but the section is not clear. Farther to the westward are black hillocks, composed of soft disintegrated shale, with large ferruginous concretions, and covered over with fragments of black highly ferruginous sandstone forming a gravel. No good section is seen, nor were any fossils found. These beds are, however, higher than those seen near the road.

Still higher in this section ferruginous black sandstone is found in place, the upper portion passing into richly ferruginous clay, in part red hæmatite, succeeded in ascending order by a few feet of crumbling mottled clay impregnated with salt. Then comes a light-coloured yellowish earthy marl, with *Alveolina, Orbitolites,* and a few nummulites. This passes up into sandy and then into calcareous beds with *Alveolinæ.* The last are considered the base of the Khirthar group.

The Khirthar limestone, along the scarp of Aongar Hill, above the rocks just described, appears to be thinly bedded and weathers into flags. Much flint derived from the limestone is scattered about. There are numerous small outliers of Khirthar limestone on the Ranikot area, but they are of no importance, and the details of the topography on the map are not accurate enough to enable small patches to be correctly laid down without much difficulty and loss of time.

Farther to the westward, below the base of the Khirthar group, a well marked lateritic bed comes in, composed in large measure of red ironstone (apparently a mixture of red and brown hæmatite). The underlying Ranikot beds are of very loose and incoherent materials. The ferruginous band corresponds in position with that near Bandh Vera and Lainyan. Still farther west highly calcareous sandstone comes in between the white Khirthar limestone and the Ranikot group; this sandstone is of a light yellowish-brown colour, and forms a conspicuous band on the slope of the hill. A few fragmentary *Foraminifera* and a small *Brissopsis* occur in this bed. In this ground there are one or two sharp folds of the rocks.

Near Meting Railway Station.

Still farther west, near Meting station on the railway, the brown calcareous sandstone, here so calcareous as to be a sandy limestone, increases in thickness and importance and covers the surface east-by-north of the station. The rock contains numerous *Alveolinæ* in parts, and passes down into the soft brown argillaceous beds of the Ranikot group without any ferruginous bed intervening. Towards Jhirak the brown arenaceous limestone becomes further developed.

South-east of Meting.

About 3 miles south-east of Meting there is a flat-topped hill capped with limestone, apparently belonging to the Khirthar group, although the colour is dull yellowish, not white, and some of the beds are arenaceous. This limestone abounds in *Alveolina*, and contains some nummulites (*N. biaritzensis* and a form resembling *N. variolaria*). On the scarp of the hill a reddish sandy bed is seen, and lower down are soft nodular yellow marls with two kinds of *Alveolina*. At the base of the hill is a bed of rubbly limestone full of *Eurhodia calderi*, *Brissopsis edwardsi*, *Nerita affinis*, and *N. schmideliana*, and below this comes a peculiar ferruginous band containing gypsum.

Rocks at Jhirak.

All round the edge of the low hills near Jhirak, brown and ochrey yellow limestones abounding in fossils occur, interstratified with gypseous shales. There are two principal fossiliferous beds. The lower, which is well seen on the edge of the alluvium near the town of Jhirak, is compact, and its outcrop is marked by a row of quarries, the stone procured from which is largely used for building and for tombstones. This bed contains numerous Echinoderms, chiefly *Eurhodia morrisi*, and an *Echinolampas* allied to *E. subsimilis*, besides some *Gasteropoda*. Beneath this limestone, south of the town, is a thin bed of salt resting on sandstone.

The upper fossiliferous band of limestone is some 50 feet higher; it is less compact, and contains *Foraminifera* (especially *Operculina canalifera*, *Nummulites leymeriei*, *N. irregularis*, *N. ramondi*, and *Alveolina ovoidea*), a few corals and Echinoderms, *Lunulites* and numerous *Gasteropoda*, especially *Turritella*, *Rostellaria*, *Voluta*, and *Terebellum*. The rocks intervening between this and the lower fossiliferous bed are shales and sandstones.

On the rises north of Jhirak, many corals occur in a dark-coloured conglomeratic band above the upper limestone. This band contains fragments of argillaceous limestone bored by *Pholadidæ,* and in places it abounds in mollusca. One highly fossiliferous locality is a small hillock, close to the road, 2¾ miles north of Jhirak, and ¼ mile south of the spot where the road branches off to the Meting Railway Station.

Along the western side of the old road from Hyderabad and Kotri to Karáchi, west of Jhirak, there is a low scarp of nodular *Alveolina* limestone, white and yellow. This closely resembles a Khirthar bed, but above it to the westward there are dark-coloured marly and sandy strata, belonging apparently to the Ranikot group. The road just mentioned runs along the north-western bank of Sunehri Dhandh,[1] a lake of some size, about 9 miles west of Jhirak, and on the road from that town to the Jhimpir Railway Station. North of the Dhandh there is a ridge of nodular reddish and yellow *Alveolina* limestone, which crosses the Karáchi road, and west of the Dhandh is the pale coloured limestone previously noticed as forming a low scarp. The last named rock is associated with marly bands, also containing *Alveolina,* and rests upon a dark-brown earthy bed containing a harder arenaceous layer. Below this are yellow marly impure limestones impregnated with salt, and containing *Nerita,* the small variety of *Nummulites spira,* called *Operculina tattaensis* by Dr. Carter and other nummulites. Next in descending order comes the ferruginous black sandstone, purple shales, and other soft brightly coloured beds, which are seen in several places along the bank of the dhandh, and are doubtless the same as those observed to the northward near Meting and representative of the ferruginous beds of Bandh Vera and Lainyan. At Sunehri Dhandh the iron beds are of considerable thickness; they contain some hæmatite, red and brown, and they rest upon white sandstone.

Sunehri Dhandh.

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[1] "Dhandh," a marsh or lake, jhil in Hindi. An old Musáfir-khána on the north-west bank of the Dhandh is marked on the accompanying map, and the lake itself is indicated, but not its name.

Jhimpir.

From Sunehri Dhandh to Jhimpir Railway Station is a distance of about 6 miles; the rocks traversed are the uppermost strata of the Ranikot group and the lowest Khirthar beds, and consist of alternations of brown and yellow salt marls and *Alveolina* limestone. There is some rolling, but the general dip is westward. Near the station, white and grey Khirthar limestone, and yellow marls, with *Nerita schmideliana, Eurhodia calderi, Orbitolites,* and other *Foraminifera,* make their appearance.

A low scarp north-west of the railway, close to Jhimpir station, consists of limestone in alternating beds, white or pale coloured, and brownish, with an admixture of sand. A part of the rock is flinty and cherty. There is a considerable thickness of these alternating beds, and the soft saline yellow marls with *Nerita, Orbitolites,* &c., crop out from beneath them and south-east of the railway. At the base of the scarp there is a red mottled bed.

Plain west of Jhimpir.

On the plain to the west and north-west of Jhimpir only surface gravels and calcareous tufa are to be seen, but farther north some yellow and mottled argillaceous limestone is exposed. Then several low parallel ridges, caused by small anticlinal folds of the strata, are met with, and on the eastern side of the ridge, on which the Ghatana trigonometrical station stands, there is a patch of brown gritty quartzose sandstone containing imperfect marine fossils, none of them, however, being specifically recognizable. This rock might be Nari, but is more probably Gáj. The patch is too small to be shown on the map.

Brown limestone west of Jhimpir.

About 4 or 5 miles west of Jhimpir, and 1½ miles west-north-west of a water hole called Bhookun on the inch and ¼-inch maps, there is a rather conspicuous scarp of compact limestone about 15 feet thick, yellowish-buff or brown in colour, and having much the appearance of a Nari bed. It rests upon white Khirthar limestone, and contains *Alveolina* and *Patellina,* so that it must be of Khirthar age. To the northward this bed continues for a long distance, forming a nearly horizontal plateau, but dipping north at a low angle, about 1°. The same bed re-appears to the south-west, where also *Alveolina* occurs in it; but no such rock was observed in the sections north of Jungshâhi, where, as will be shown in the next Chapter, the Khirthar and lower Nari beds had probably been denuded before the upper Nari strata were deposited.

Subrecent calcareous grit near Jhimpir.

A subrecent calcareous deposit of some thickness is seen in the neighbourhood of Jhimpir Station, covering much of the high ground, and exposed in the railway cuttings. The same rock occurs near Meting. It is a calcareous grit and conglomerate, so compact in parts as to form a good building stone, and to have been used in bridges and culverts on the railway line. The colour is mottled pale blue, white, and red. In the lower ground this rock is covered over with a thin but extensive layer of calcareous tufa (travertine), and upon the latter are seen small thin patches of a dark gravelly false-bedded conglomerate. At a large spring, about a mile south of Jhimpir Railway Station, it is difficult to distinguish the overlying calcareous deposit from the Khirthar limestone, the only lithological difference being that the former contains quartz grains.

Ranikot bed south of Jhimpir.

In the tract of Ranikot beds south of Jhimpir the rocks are the same as those seen between that station and Jhirak, but they are, as a rule, much less exposed. No observations of any importance have been made on this ground.

Makli Hill near Tatta.

The isolated tract of raised ground surrounded by alluvium and known as Makli Hill, west and south-west of Tatta, consists almost entirely of *Alveolina* limestone, thicker to the southward than at the northern extremity. The beds slope gently to the west and south-west. At Pir Phatta, on the detached patch south of the Baghar river, the dip is about 3,° or rather less to the south-west. On the eastern scarp, below the limestones, yellow sandy beds and some dark mottled clay are seen west of Tatta, and again near Pir Phatta and Kuba Bibi Miriam. In one of these, a soft rubbly marl or argillaceous limestone, the small variety of *Nummulites spira* (*N. tattaensis, Operculina tattaensis* of Carter) characteristic of the Ranikot beds, is found abundantly together with *Alveolina ovoidea, Nummulites biaritzensis, Nerita schmideliana* and species of *Natica, Rostellaria, Cassis, Ovulum,* and *Voluta.* These beds are undoubtedly Ranikot; the overlying *Alveolina* limestone has been classed as Khirthar, but some of the upper Ranikot beds seen west of Jhirak appear to have thinned out; and it is possible that some of the *Alveolina* limestones of Makli hill represent beds that have been classed in the Ranikot group farther north on account of marly and sandy beds being found above them.

To the west of Makli Hill there are several small scattered rises in the alluvium; all, except one, which is Khirthar, composed of Nari beds. Farther west, and again to the south-west, there are some detached rocky rises of peculiar formation, ascribed to the Gáj group. Some of these are beyond the limit of the accompanying map. These outlying patches will be noticed in the next Chapter in connection with the similar rock found near Jungshâhi.

Hyderabad and Ganja hills.

The isolated limestone hills of Hyderabad and Ganja, east of the Indus, have not been noticed in connection with the rocks near Kotri, because the most important beds of the latter are those belonging to the Ranikot group, and it was desirable to describe the beds of this formation, as far as practicable, consecutively. The Hyderabad and Ganja hills, the former the northern, the latter the southern of the two limestone tracts, are flat-topped elevations, escarped in general on every side, and especially to the southward, where they rise about 200 feet above the alluvial plain. The slope of the beds is to the eastward, at a low angle, from 2° to 4°.

The uppermost rock is a rather thick bed of white, more or less chalky, limestone, in which very few fossils are seen. Beneath this limestone is a band of pale buff plastic clay, largely dug and sold in the bazars for washing. Mines are sunk through the limestone in places, in the eastern portion of the Ganja plateau, for the purpose of extracting the clay. At the base of the scarp at the southern end of Ganja Hill, some nodular marls, on which salt effloresces, are exposed. A few fossils were obtained from the limestone, the principal being *Chama bri-*

monti and a *Nautilus*. All the beds of these hills appear to belong to the Khirthar group.

Striæ due to sand carried by the wind.

The upper surface of the limestone on Ganja Hill is worn into conspicuous grooves having a general direction of east-25°-north. These striæ are evidently due to the scouring action of sand transported by the wind. Similar markings are seen on other hills, but they are not often so distinct. On the limestone hills of Jaisalmir, precisely the same grooves are found.

CHAPTER VIII.—THE SOUTH-WESTERN PORTION OF THE KARÁCHI COLLECTORATE, INCLUDING THE UPPER BÁRAN VALLEY, WEST OF THE LAKI RANGE, THE HABB VALLEY, AND THE COUNTRY NORTH-EAST AND EAST OF KARÁCHI AS FAR AS BHULE KHÁN'S THÁNA AND JUNGSHÁHI.[1]

Arrangement of chapter.

The remaining area of south-western Sind is a large tract of country, and some further sub-division is necessary in treating of it. The most convenient plan will be, beginning, as usual, on the north, to commence in the Báran valley, near Karchát, where the accounts of the area described in the fifth Chapter concluded, and to give such details as deserve notice in the eastern part of the tract first; and then, re-commencing at the north, to describe the western portion of the area. The first will comprise the Báran valley from the southern extremity of the Khirthar range near Karchát to Bhule Khán's Thána, the country near the road from the last named place to Karáchi, and that in the neighbourhood of Jungsháhi; the second subdivision will commence at the head of the Báran valley, and include the portion of that valley west of the southern extremity of the Khirthar range, together with the great tract of Gáj beds north-west of Karáchi, the Habb valley, and the neighbourhood of Karáchi and Cape Monze.

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[1] This chapter is chiefly compiled from Mr. Fedden's reports, except the portions relating to the Habb valley and its neighbourhood, and the country immediately north and west of Karáchi.

Physical features of area.

There is a very marked distinction between the physical features of the eastern and western portions of the tract. To the eastward the Khirthar beds are largely exposed at the surface, and the hills are chiefly composed of anticlinal ridges of nummulitic limestone. To the west the newer tertiary beds prevail, and the hills are chiefly formed of flat-topped masses of miocene Gáj rocks. Such anticlinal axes as exist consist of soft Nari beds, and do not rise into hills. As a general rule, there is certainly less disturbance of the rocks in this area than farther north.

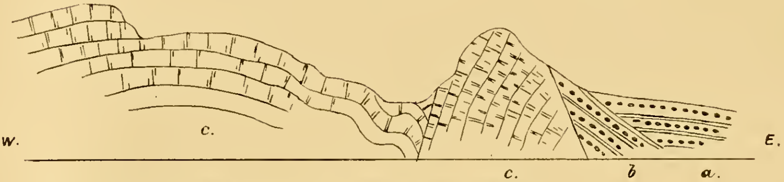
Báran valley near Kajúr and Bacháni.

The Báran valley near Kajúr, the halting place south of Pokran, situated at the spot where the road from Sehwán crosses the Báran river, is thickly covered either with alluvial gravel, in places cemented into a conglomerate, or with a sandy deposit. The valley beneath the alluvial accumulations is composed of Manchhar beds, conglomerate or the typical grey sandstone being the beds most frequently seen at the surface. A considerable quantity of fossil wood is seen, derived from Manchhar beds. The Nari group is wanting on both sides of the valley south of Kajúr, although it is well developed at the end of the Yeting spur just north of the camping ground, and the Gáj group is only represented by a very few feet of beds with marine fossils, at the base of the Manchhar group, the two passing into each other as usual. The Gáj, however, as might be expected, is quite unconformable to the underlying Khirthar beds, the surface of which has been worn and denuded before the newer tertiaries were deposited. Near Kajúr and north-west of it, on the west side of the Batri Karchát valley, the Gáj beds are thicker than elsewhere in the neighbourhood.

Unconformable conglomerates at Bacháni.

At Bacháni, the camping ground south of Kajúr, the subrecent conglomerate is seen resting unconformably on Manchhar conglomerate. The former is horizontal, the latter dips at an angle of about 45° to the north-west, and is associated with grey sandstone. The pebbles of which the two conglomerates consist are very different, the subrecent rock being mainly

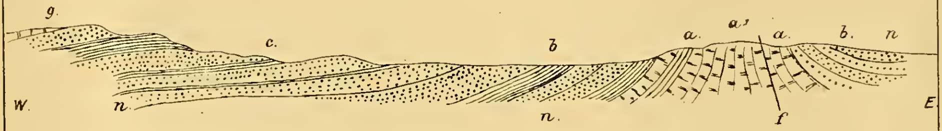
Fig. 1.



Section of hill range west of the Báran valley near Bachám.

a Subrecent beds; Conglomerates &c: b. Manchhar beds. c. Khirthar limestone.

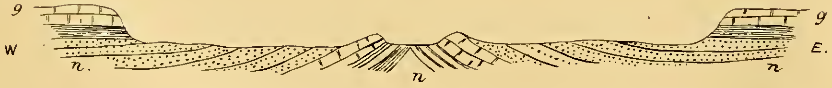
Fig. 2.



Sketch section from the Bil scarp to the Gabbar plain

g. Gáj · n. Nari beds. f. Fault.

Fig. 3.



Sketch section from the Miher to Mol plateau across the Kand Valley

g Gáj n. Nari.

S. K. Hn

composed of rounded fragments of nummulitic limestone, whilst the Manchhar bed contains no nummulitic limestone, but the majority of the pebbles are of fine grained brown limestone. The Gáj beds at the base of Eri Hill, west of Bacháni, are highly fossiliferous, and several of the usual species have been found in them, including *Venus* cf. *nonscripta, V. cancellata, Cardium anomale, Arca kurracheensis, A.* cf. *burnesi, A. peethensis, Ostrea multicostata, Chama* sp., and several *Gasteropoda.*

Section near Arab-jo-Thána.

A very good section of Manchhar beds passing down into Gáj, and the latter resting upon highly inclined shaly and rubbly limestones belonging to the upper portion of the Khirthar group, is seen on the eastern side of the valley near Arab-jo-Thána, about half way between Kajúr and Bacháni. There are about 100 feet of the shaly limestones above the typical massive beds of the group, some of which are arenaceous. These massive beds abound in *Alveolina sphæroidea, A. ovoidea,* and *Orbitolites.* Several hundred feet of limestones are exposed.

In the Kámbú range, to the west of the Báran valley, there is a considerable amount of disturbance, as shown in the accompanying sketch section (Plate VI, fig. 1). From the foot of the hills, there is, as usual, a slope of detrital gravels and conglomerates to the middle of the valley; sections of these detrital beds, 40 feet and upwards in thickness, being exposed in the ravines cut by torrents. Only close to the range are any upper tertiary beds seen, and these consist generally of Manchhars, although in places a very thin band of Gáj, with *Ostrea multicostata, Placuna,* and other fossils, may be detected; and in one or two places beneath the Gáj beds some light grey sandstone was seen, and a thin band with small *Orbitoides,* possibly indicating the presence of a faint representative of the Nari group. The Manchhar conglomerate dips at a considerable angle eastward, and is much coarser, in places at all events, than the subrecent deposit overlying it.

The Manchhar beds rest quite unconformably upon the white massive nummulitic limestone of the Khirthar group, which dips at a high angle, 50° or 60°, to the westward. The limestone appears to belong to the lower portion of the group; it contains *Alveolina, Nummulites spira, N. obtusa*, &c. The beds become nearly or quite vertical, and form a steep ridge, succeeded to the westward by similar limestones dipping at a moderate angle to the eastward. There is doubtless some faulting, but the feature is a synclinal, more or less broken. In one of the limestone beds dipping to the eastward, a little distance north-west of Bacháni, an oligurous crustaeean belonging to the genus *Ranina* was found.

Fault east of Kámbú range.

To the northward near Kajúr, the faulting along the eastern edge of the Kámbú range is greater than at Bacháni, and occurs apparently at the foot of the range between nummulitic limestone (Khirthar) and Manchhar beds. The latter are seen dipping in the low ground towards the former; the actual contact is concealed by detritus, but the Khirthar beds first seen are *Alveolina* limestones, probably far from the top of the group.

Beds to west of Kámbú range.

Along the western side of the Kámbú range the Nari beds are for a long distance cut out by a fault, and Gáj beds appear in contact with Khirthars, but towards the southern extremity of the range, as to the northward between the Kámbú and the termination of the Khirthar mountains, the Nari beds appear in force. Indeed, the Kámbú range appears approximately to represent the eastern limit of the area of deposition in which the Nari beds and all the lower Gáj beds were deposited, the only Gáj beds seen to the eastward, in the valley between the Kámbú and the Laki ranges, and east of the latter, being apparently the uppermost layers of the group. The Nari beds may of course have once existed to the eastward, and have been removed by denudation, but in this case it is probable that remains of them would be found here and there.

Khirthari-Nari boundary near Bhule Khán's Thána.

It is difficult, however, to define the boundary between the Khirthar and Nari beds in the southern portion of the Kámbú range, and in the low anticlinal to the southward known as Gadula Hill, 2 or 3 miles north-west of Bhule Khán's Thána. In the latter hill especially, the uppermost bed, forming the greater part of the surface on the eastern side, is a whitish limestone abounding in the tubes of *Kuphus rectus,* together with a minute *Fibularia* and an *Echinolampas.* In one place there are a large number of dark-coloured calcareous concretions containing casts of a *Cerithium* closely resembling *C. pseudocorrugatum.* It is by no means certain whether this bed should be classed as Nari or Khirthar. On the west side a white limestone, abounding in microscopic *Foraminifera,* is seen cropping out from under whitish limestones with *Nummulites garansensis* and *N. sublævigata.* Above these white limestones are ferruginous sandstones of Nari age. The difficulty of distinguishing between Khirthar and Nari beds in this area is as great as it is 30 or 40 miles further north near Maliri, but the reason is different; to the northward the upper Khirthar beds resemble the lower strata of the Nari group, whereas, near Bhule Khán's Thána, and also in many places to the westward; there are white limestones at the base of the Nari group closely simulating the underlying Khirthar beds.

Valley south of Bhule Khán's Thána.

The valley, through which the hill road runs from Sehwán to Karáchi, continues to the southward after the Báran river has cut its way to the eastward through the Laki range. But south of this the valley becomes less defined, the hills to the westward south of the Kámbú ridge are no longer continuous, but broken up into small north and south ranges, and the Laki range itself only continues along the eastern side of the valley for about 12 to 15 miles south of Bhule Khán's Thána; the country then becomes more open, and the road to Karáchi turns westward, and soon enters the great Gáj area to be described presently.

Gáj beds near Bhule Khán's Thána.

In the plain around Bhule Khán's Thána most of the small rises which appear above the subrecent gravels and sands are composed of Gáj beds, usually fossiliferous, the commonest fossils being *Ostrea multicostata* and *Breynia carinata.* The beds are brown calcareous and ferruginous sandstones. Such are seen just west of the Báran pass (the Durwat) on the road from Bhule Khán's Thána, resting unconformably on Khirthar nummulitic limestones.

Hills near Damach.

About Damach, 6 miles south-west of Bhule Khán's Thána, Nari beds prevail in the low ground. The ridge east of Damach camping ground is an anticlinal of Khirthar beds, with a low angle to the westward, and very high inclination to the eastward, just like the Surjáno ridge, a little farther east.

Hindi or Tangur Hill.

Hindi Hill (Tangur on the inch map) on the west side of the road, about 6 miles west-by-south from Damach, is another Khirthar anticlinal with the lower Nari limestones, containing the characteristic *Nummulites*, well developed around the base, and passing up into calcareous sandstone with *Orbitoides papyracea*. On the top of the hill is an outlier of Nari beds, an arenaceous limestone varying to a calcareous sandstone. In the upper portion a large *Clypeaster* is found, together with *Orbitoides* and the two species of *Nummulites*, and below this is another bed, also containing *Nummulites garansensis* and *N. sublævigata*, together with a large *Echinolampas*. On the surface of the Khirthar limestone, as at some other places, is a bed of corals, and a *Pecten* is common.

Watwáro Hill.

At Watwáro Hill, south-south-west of Damach and close to Trak, the section is similar to that seen on Hindi Hill. Here again Nari limestone with *N. sublævigata* and *N. garansensis* appears to pass down into Khirthar limestone with *N. spira*, a coral bed again appearing at the junction. Above the Nari limestones are sandy beds with *Orbitoides*. In the Nari beds, at the base of Watwáro Hill, a small oyster, undistinguishable from *Ostrea multicostata*, the common Gáj species, occurs in small numbers, with *Orbitoides papyracea*. The tubes of *Kuphus* also occur in the Nari group together with *Nummulites garansensis*.

Trak.

The Nari limestones are well seen about Trak and on the western side of the Kara range, the northern extremity of which is just west of the Trak camping ground.[1] Brownish calcareous sandstone with *Orbitoides* is common, and is seen close to the small dharmshála at Trak. This sandstone dips west, and

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[1] Trak is not marked on the small map issued herewith; its position is on the stream nearly due east of the north-western Alah Yar, that close to the road.

close by, to the eastward, a small strip of Gáj beds is seen, containing *Echinodiscns* and other fossils, dipping towards the Nari beds to the westward, and probably faulted against them. Beneath the Gáj beds, which occupy an insignificant area, are Nari rocks with *Nummulites garansensis, Orbitoides papyracea,* the large *Echinolampas, Natica patula, Pecten labadyei,* &c. The upper Nari beds are consequently wanting here, and the group cannot be more than 200 feet thick, as Khirthar beds appear in the Watwáro range a little farther east. This affords evidence that there is a gradual thickening of the Nari beds to the westward, whilst they are wanting to the eastward.

Khirthar limestone area south-east of Trak.

The large plain, with scattered low rises, extending from the southern extremity of the Laki range, near Trak, to the railway between Jhimpir and Jungsháhi, has afforded no features of interest. The nummulitic limestone (Khirthar) of which the area is composed, is nearly horizontal. At one place, between 7 and 8 miles east-by-south of Trak, and about 3 miles from Kalla (Kael), an "Armenian bole quarry" is marked on the 1-inch Revenue Survey map. The rock, at the spot, is nummulitic limestone, interstratified with which is a bed, about 2 feet thick, of clay or fuller's earth, olive or brownish-olive in colour. The interstratification of this clay with the Khirthar limestone is important, because similar clays found underlying the nummulitic limestone south of Rohri were at first ascribed to an older formation. The limestone contains *Nummulites granulosa, N. leymeriei,* and *N. ramondi.* The beds around dip at a low angle, and are probably high in the Khirthar group.

Near Kalla there is a small patch of beds with *Ostrea multicostata,* apparently Gáj. There are probably other small outliers. It was impossible, without giving much more time than could be spared or than the importance of the geology justified, to map all the intricacies of this country in detail.

Kára range.

The Kára range, extending from Trak to near Jungsháhi, is a long low anticlinal ridge of Khirthar beds, with Nari rocks forming a synclinal to the eastward, and coming in again to the westward. At Mal Mohári, the southern extremity of the Kára range, dull muddy limestones, containing *Nummulites garansensis* and *N. sublævigata*, pass downwards apparently into a coral bed, which contains tubes of *Kuphus*, and is inseparable from the Khirthar group; whilst above the *N. garansensis* bed there is a gritty sandstone with large *Orbitoides* (*O. papyracea*). Here again, as near Trak, there appears a greater distinction between the *Orbitoides* bed and that containing the two Nari *Nummulites*, than between the latter and the Khirthar limestone.

Near Jungsháhi.

The great belt of Nari beds which intervenes between the Khirthar area of Kohistán and the Gáj tract north-west of Karáchi, terminates to the southward near Jungsháhi, being there covered over partly by alluvium, but chiefly by later tertiary formations. There are some anomalies here in the sequence. The Nari beds are evidently very much thinner to the eastward than they are to the westward, and not only their upper sandstones disappear, but some of their lower beds; and the *Orbitoides* sandstone rests unconformably, to the north of Jungsháhi, upon the Khirthar group, without the intervention of the limestone with *Nummulites garansensis* and *N. sublævigata*. The surface of the Khirthar limestone appears in places to have been worn and denuded before the sandstone of the Nari group was deposited. There appear therefore here to be stronger reasons than elsewhere for inferring a break in the middle of the Nari beds rather than at their base. The break is doubtless local, and is one additional instance of the irregular deposition of the Indian tertiary rocks, and of the difficulty of classifying them. Precisely similar local breaks have been noted in the Punjab, and there, as in Sind, it has been found that a classification of the beds, which accords with the facts observed in one portion of the province, by no means agrees with the arrangement of strata exposed in another district.

Break in Nari beds.

The Khirthar beds east of Jungsháhi are, as described in the last chapter, much broken up into rubbly and shaly beds, and interstratified with bands of yellow limestone, more or less argillaceous or sandy, forming the passage beds to the Ranikot group. The thickness of the Khirthar group here can scarcely exceed 500 or 600 feet, and may be less in places.

Khirthar group east of Jungsháhi.

Near the base of the Nari group around Jungsháhi is a hard brownish-yellow calcareous sandstone with casts of *Orbitoides*. This bed, which is very conspicuous and easily recognized, has been much quarried in the neighbourhood of the railway to supply building material. The lowest bed of the group, underlying the hard sandstone, is a softer sandstone, calcareous or argillaceous, with numerous *Orbitoides*. These two beds form the '*Orbitoides* sandstone' already referred to. Upon them are other sandstone beds of varying texture and colour, with shales and some clays. The rocks just described occupy the country around Jungsháhi and immediately north of the station. To the westward there is an ascending section, the Nari group becomes much thicker, and higher beds, chiefly sandstones of various kinds, usually shaly, but sometimes calcareous or gritty, make their appearance. Between 4 and 5 miles west of Jungsháhi gritty buff limestone appears with ill marked *Foraminifera*, some of them small, others very possibly *Orbitoides*, but too ill-preserved for identification. This bed rests on whitish sandstone. A somewhat similar bed is found in the middle of the Nari beds of the Habb valley to the westward, but there shells of *Orbitoides* are abundant and well preserved.

Nari beds near Jungsháhi.

The base of the Gáj beds west of Jungsháhi is at a distance of nearly 8 miles along the railway, in the scarp west of the Ranpetiáni stream. The lowest Gáj consist of rubbly calcareous beds with sandstones, and buff and ferruginous sands, abounding in *Breynia carinata*, *Pecten subcorneus*, *Ostrea multicostata*, and numerous casts of *Voluta*, *Natica*, *Turritella*, &c., besides club-shaped spines of *Cidaris*, swollen near the base, attenuate towards the apex and ribbed.

Gáj beds west of Jungsháhi.

Here, then, only a few miles west of Jungsháhi, the normal sequence of beds exists; Nari beds of great thickness, and Gáj, resting conformably upon them. But immediately south of Jungsháhi Railway Station, and scattered over the country around, there are masses of a peculiar sandstone and grit, forming flat-topped hills. The sandstone is white, grey, or brown in colour, and is sometimes so compact and hard as to break with a conchoidal fracture. Where it is less compact, it is often composed of angular grains, the facets on which glisten in the sun. In some places the rock is a coarse grit, containing fragments of white quartz in a fine matrix. Another form is a ferruginous grit containing crystals and half-rolled fragments of quartz; the crystals occasionally occurring in small hollows. At Jungsháhi this ferruginous grit and white and grey sandstone rest on soft yellowish sandstones and sandy clays belonging to the Nari group, but a little farther to the northward the same grits rest on the *Orbitoides* sandstones, and farther still to the eastward on the Khirthar limestone. It is thus palpable that the ferruginous grits and compact sandstones are quite unconformable to the older tertiary rocks, but it is not quite so clear to what group these overlying beds belong. They have been mapped as Gáj, but they may be very late Gáj, or, perhaps, of Manchhar age. To the southward they become conglomeratic and contain fragments of Gáj fossils.

Peculiar sandstones and grits at Jungsháhi.

On the accompanying map, owing to the small scale, the minute patches of this peculiar rock scattered over the country north-east of Jungsháhi are but imperfectly indicated. A few isolated masses also occur, as was noticed in the last chapter, surrounded by the alluvium, beyond the southern limit of the area represented. To these it will be necessary to refer presently. Of the outliers north-east of Jungsháhi, some rest upon Nari beds, some on Khirthar. Of the former, one of the most prominent is a little ridge, about 2 miles north of Jungsháhi station. The most conspicuous, however, is a rise called Sindar Butti, just north of the old high road, between 4 and 5 miles north-east of Jungsháhi. This forms rather a prominent conical hill,

Supposed Gáj outliers.

Sindar Butti.

rising 120 to 130 feet above the surrounding plain, and is composed of harsh quartzose sandstone, varying considerably in texture and hardness, being very fine in places, coarse, gritty, and quartzose in others, parts being so compact as to be almost a quartzite. There are a few bands containing pebbles. No fossils were detected in this rock. The underlying formation is Khirthar limestone; there may be a thin band of the *Orbitoides* sandstone (Nari) intervening, but it was not observed, the base of the hill being covered with talus.

South of the old high road, which runs along the southern base of Sindar Hill, and also to the east of the railway, there are some large spreads of the harsh sandstones occurring as outliers or small caps on the higher beds of the Khirthar limestone.

Isolated hillocks in alluvium south of Tatta.

In the last chapter (page 154) some isolated rises of Gáj rock were said to occur in the alluvium south of the area represented on the map accompanying this memoir, and beyond the Indus. The most important of these rises is 26½ miles south-by-east of Tatta, and 11 miles south-south-east of Bibi Miriam; it is 1½ miles long from north-east to south-west and half a mile broad, and comprises 5 or 6 small hillocks, the loftiest a conical mound known as Aban Sháh, used as a trigonometrical station, 95 feet above the sea. There are also two rocks in the channel of the Indus—one known as Gungani, on the right bank of the river, between 5 and 6 miles north-west of Aban Sháh, the other a mere pile of stones in the middle of the river, rather more than 2 miles farther down. All are of hard grit or coarse gritty sandstone, much like the rocks just described near Jungsháhi, and probably belonging to the same formation. The structure of the beds varies as usual, sometimes being fine, sometimes coarse, and even conglomeratic. A few fragmentary and ill-defined fossils, chiefly casts, were observed at Aban Sháh, and amongst these was a lower valve of *Ostrea multicostata*, which had, however, been rolled before being imbedded. A small *Clypeaster* and a large silicified coral were also noticed in the rock.

It is as well to repeat that it is far from certain that these beds are of

Gáj age. They may be of later date. It must be borne in mind that all the later tertiary beds are very different near the coast from what they are inland, and the opportunities of examining them were comparatively few and inferior in the former direction.

Thus far, in the present chapter, the country described has lain to the eastward of the great Gáj area, and in the northern portion of the tract has been confined to the neighbourhood of the Karáchi and Sehwán Hill road, between Trak and Kajúr. Before returning to the northern end of the area to take up the description of the lower tertiary beds in the Upper Báran valley and in the Habb drainage area, a few notes on the eastern portion of the Gáj area may be given.[1]

Gáj beds near Khadeji.

The character of the Gáj beds is well seen on the Karáchi and Sehwán road, near the camping ground of Khadeji, about 31 miles from Karáchi and 16 miles from Trak. The road from Trak passes across a plain composed of Nari beds, of which, however, but little is seen for 4 or 5 miles, and then enters the Gáj area. The rocks are nearly horizontal in general, one of the most conspicuous being a white rubbly limestone, closely resembling some of the Khirthar nummulitic limestones in character, but easily distinguished by its fossils and by the absence of nummulites. Other limestones of a yellow colour weather with a scoriaceous appearance and somewhat resemble laterite.

On the left bank of the Khadeji stream, near the camping ground at Khadeji, there is a fine cliff of Gáj beds, and the hills in the country to the northward are flat-topped, and surrounded by steep scarps chiefly composed of limestone. The following is the section seen on the cliff:—

	Ft.
1. Gritty calcareous sandstones and calcareous grits, obliquely laminated, with fragments of organic remains	30
2. Similar beds to the last, more or less compact and calcareous, sometimes coarse grained. In some of the beds *Operculina* abounds	
	30

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[1] Almost all of these and of those on the country near Tong are from Mr. Fedden's reports.

		Ft.
	Brought forward	30
	with *Pecten* and *Ostrea*. Some layers are made up of fine fragments of organisms	55
3.	Yellow shelly limestone, open textured, ragged or soft, sandy and gritty in parts, with *Operculina*, *Lunulites*, &c.; the upper part, as above, composed of a mass of organic fragments	62
4.	Irregular ill-defined marly deposits, with much coral, both detached and in mass.	14
5.	Ragged beds made up mostly of organic fragments, oyster shells predominating, with *Bryozoa*, club-shaped spines of Echinoderms, *Clypeaster*, &c.	3
6.	Close-grained marly white limestone, chiefly organic, and other beds similar to those just above	16
	Total	180

The beds dip to the south-east at low angles, varying in different parts of the section from 7° to 10° or 12°. In general, however, the rocks are nearly horizontal, and in the cliffs around the hills to the north and north-west the beds of white, pale-brown, and yellowish limestones, all pale coloured, have a peculiar appearance from unequal weathering, so that overhanging ledges, supported by irregular masses sometimes taking the form of pillars, are not uncommon. The limestone beds are frequently very rubbly, as if made up of irregular fragments. Amongst the fossils found in these beds are *Kuphus rectus*, *Pecten subcorneus*, *Ostrea hyotis*, *O. multicostata*, *Spondylus* sp., *Clypeaster halaensis*, *Breynia carinata*, &c.

Gáj beds near Damb.

Sub-recent beds near Damb.

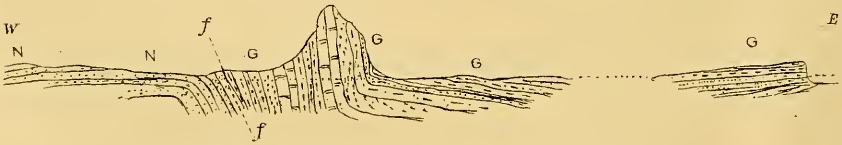
Farther to the south-west along the road higher Gáj beds are seen, the uppermost members of the group being fairly exposed to the east of the next encamping ground at Damb, 16 miles west-south-west of Khadeji. They are sandy and muddy calcareous beds, containing *Balanus*, casts of various *Lamellibranchiata*, as *Arca*, *Venus*, &c., *Ostrea multicostata*, *Pecten bouei*, *P. favrei*, *Turritella*, &c. Near Damb Manchhar beds come in, but very little rock is seen at the surface, and the greater portion of that exposed consists of the sub-recent beds which occupy so large a portion of the plain north-east of Karáchi. There is a great quantity of calcareous conglomerate, passing in places into a gritty limestone: near Damb the latter is the prevailing rock. It is dark grey in colour; very hard and compact, and it separates into cuboidal blocks with exfoliating surfaces. Horizontal beds of this limestone, associated with fine sandstone, form a low scarp extending for some miles down the left or east bank of the Thadi water-course which runs past Damb.

Thickness of Gáj group at Sawáji.

A long inlier of Nari beds, extending some 23 miles from north to south, but only 4 miles from east to west where broadest near Rahúja, lies nearly due north of Khadeji. At Sawáji, or Shahbazjee Takar (the goshawk's hill?), a trigonometrical station about 10 miles north of Khadeji and 1,135 feet above the sea level, the thickness of the Gáj beds was estimated at 800 feet by Mr. Fedden, who considered this the maximum thickness of the group in this neighbourhood.

Rahúji-ka-dát.

Some 12 miles north-by-east from Sawáji and 6 or 7 miles south-east of Thána Sháh Beg (Got Sham Shah Beg of map), the Rahúja stream cuts its way from the Nari outlier to the eastward through the narrow ridge of Gáj beds, and about 500 feet of the latter are exposed, the uppermost beds having been removed by denudation. The Nari beds are nearly horizontal to the westward, but they are suddenly bent over sharply to the east and crushed, and the Gáj beds are almost vertical. The relations of the beds are shown in the accompanying sketch section through the "dát" or gorge. There is a crush and some slipping:—



Sketch section through the Rahúji-ka-dát.
G. Gáj: N. Nari; ff, crush scarcely amounting to a fault.

Line of disturbance.

The line of disturbance here shown is probably that to which the appearance of the long Nari inlier should be attributed. The Nari beds have a double fold in the southern part of this inlier. The same line of disturbance may be traced to the northward in the fault shown on the map near Baili, west of Tong (Rath Náth), and also in the intermediate area near Bill, a locality to be mentioned presently. Although curving to the westward farther north, this line of dislocation has a general north and south direction like most of the axes of disturbance in the province.

Mol plateau.

The Mol and Miher (Mahr) plateaus, two table-lands of Gáj beds, projecting to the northward from the main Gáj area, are each about 1,500 feet above the sea, and 800 to 1,000 feet above the lower plains of Nari beds from which they rise. The Miher plateau will be described in connection with the Habb valley a few pages farther on. The Mol plateau lies immediately west of the Nari inlier just noticed as occurring near Rahúja and Sawáji, and is higher at the edges than in the middle, where it is drained by the Mol Nai (called Andi Nai[1] in the lower part of its course), running southwards to join the Khadeji and other streams that unite to form the Malir. The Gáj beds of this plateau assume the form of a gentle synclinal, in the hollow of which Manchhar beds occur around Thána Sháh Beg, and for some distance to the north. They are much obscured by sub-recent detrital accumulations, conglomerates, gravels, &c., but the latter are easily distinguished by being, as elsewhere, quite unconformable to the true Manchhars.

Manchhar beds of Mol.

The Manchhars not only pass into the Gáj beds, but marine fossils are found associated with the lower members of the Manchhar group, as is not unfrequently the case farther south near Karáchi. Thus the following section was observed at a place called Meán-wári-páni (Neean Waree Panee on 1-inch map), a water-hole in the Drig-jo-doro, about 6 miles north-by-west from Thána Sháh Beg. At the base are fine silty soft sandstones, pale-coloured or white, mottled below with shades of pink and ferruginous. These appear to be Manchhars. Upon them rests (with local unconformity) a marine deposit, a conglomeratic shelly rock varying from an

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[1] The Arde Nie of the accompanying map.

argillaceous grit to a nodular conglomerate (not unlike some of the sub-recent conglomerates in appearance). This contains fragments of shells, mostly of oysters (*Ostrea multicostata* and another species), a few being perfect.

The conglomeratic bed passes up into a purplish-grey thinly flaggy sandstone, with argillaceous nodules; a true Manchhar rock, in which a fragment was obtained of a thick crocodilian scute, like those commonly found in the Manchhar beds farther north. Elsewhere the marine bed passes up into grey soft micaceous sandstone, thinly flaggy, with layers of argillaceous nodules. The last is unmistakably Manchhar, but above it there are again marine bands with fragments of oyster shells (*O. multicostata, &c.*), alternating with Manchhar beds. Bands of conglomerate are intercalated as usual amongst the soft sandstones. These deposits are at times very irregularly bedded, "false bedding" occasionally occurring. Above the bank of the stream, where the section just mentioned was noticed, is a rocky knoll of the sub-recent conglomerate, a compact massive rock composed of a varied assemblage of pebbles.

Valley of Upper Báran stream.

Similar sections occur in the neighbourhood of Karáchi and will be noticed towards the end of the present chapter; but before describing them it is necessary to begin from the extreme northern end of the area at the head of the Báran river, and describe the neighbourhood of Tong (Rath Náth of the map herewith issued) and the country to the southward before passing on to the Habb valley. The Upper Báran valley consists of a synclinal of Nari beds between the great anticlinal of nummulitic limestone to the eastward, forming the southern part of the Khirthar range, and a smaller anticlinal to the westward called Mihé or Myhi (Myhee). A large tract in the middle of the valley is covered with alluvium.

The Nari beds on the Mihé range completely cover over the Khirthar, except to the northward. At a steep pass called To-be-ka-lak, about 3 miles south of the Mihé boundary pillar, some 200 or 300 feet of light buff and whitish limestones are exposed, abounding in *Orbitoides papyracea*. A few *Nummulites garansensis* also occur. These beds pass down imperceptibly into Khirthar limestones, and it is impossible to draw a precise boundary between the two groups. In one place half way between To-be-ka-lak and Tong (about 12 miles north-west of the latter and south of some isolated hillocks of sandstone,) rusty brown sandstone, with partially decomposed *Nummulites garansensis*, and in the upper part a large thin *Orbitoides*, is seen resting unconformably on the worn surface of a yellow limestone. The latter is somewhat arenaceous, and contains large white *Orbitoides*. Apparently this is another instance, besides those previously mentioned, of a break in the Nari group, to which both beds appear to belong.

On the east side of the valley the thick bed of *Orbitoides* limestone was not observed, but it may possibly have been overlooked. There are hillocks of brown arenaceous limestone full of *Nummulites sublævigata* and *N. garansensis* with some *Orbitoides; Pecten bouei* also occurs, and the large *Echinolampas* found at Pokran, Chorlo, &c., abounds in one bed, doubtless the same as that seen on the opposite side of the Khirthar range. A little lower down is the zone of large corals at the top of the Khirthar group. All these beds, except the last named, were also observed in places on the west side of the valley, as at Guráno-jo-kal, 9 or 10 miles above Tong.

Neighbourhood of Tong.

West of Tong (Rath Náth), which is a rather larger village than is commonly found in so thinly populated a district, there is a small ridge formed by the Nari limestone with *Nummulites garansensis, Orbitoides,* &c. This ridge can be traced for a long distance north and south. The dip near Tong is very high, as much as from 50° to 70°, and a great thickness of the limestones and associated beds must exist. Immediately west of the ridge the dip falls to from 5° to 10°, and a considerable distance intervenes before the base of the Nari beds is reached. Some red clays occur, but in general only the hard beds are seen at the surface.

Hot-spring.

Just west of the ridge above mentioned and in the lower Nari beds a hot-spring arises, the flow from which is sufficiently copious to irrigate a considerable tract of wheat-land. As usual with all hot-springs in Sind, there is a considerable evolution of sulphuretted hydrogen. The temperature of this spring is about 93°.[1] Some calcareous tufa occurs in the neighbourhood of the spring, evidently deposited from the water, as is the case in several other thermal springs in Sind.

Gaz and Dumbár range.

The Gaz and Dumbár range west of Tong is an anticlinal fold of the rocks, not rising to any great height. Khirthar beds appear, and, in many parts of the range, form the highest portion; but on the road from Tong to Baili (a police post on the Kelat frontier, 6 or 7 miles west of Tong), only the eastern slope consists of Khirthar limestone, and horizontal Nari beds come in at the crest of the range, whence they continue to the valley of the next stream, a branch of the Baili Nai, where they roll over and dip westward. Just before they roll over, a small fault is seen striking north-10°-west, with a downthrow to the west. On its eastern side it brings up some whitish limestone, which is seen in a low cliff north of the road, and which appears to belong to the Nari group.

Ban Hills.

North-east of Tong, there is a confused mass of hilly ground formed of Khirthar limestone, and known as the Ban (Bunn of inch and quarter inch maps). It forms a kind of irregular spur, projecting to the westward from the Khirthar range, and it consists of *Alveolina* limestone. The beds on the Khirthar range dip steeply towards the Ban, and are faulted for some distance against the latter, the bedding in which is very indistinct.

Gáj beds south-east of Tong.

There is a nearly horizontal outlier of Gáj beds to the south-east of Tong and south of the Ban, separated by an anticlinal roll of Nari strata from the large Gáj tract

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[1] I made it 90°; Mr. Fedden 92·3° on one occasion, 93° on another. The spring issues in an artificial pond about 20 feet in diameter, and 8 or 10 feet deep. It is difficult to get at the actual source, and the temperature of the pond itself may vary somewhat with that of the air. I think the temperature observed by Mr. Fedden is probably correct, as he had a better thermometer; but our two observations of the Laki spring, at which the spot where the water issues is easily accessible, coincide perfectly, though taken in different years. The hot-spring is the place marked on the map as Rath Náth.

extending along the western side of the Kámbú range, already noticed at the commencement of the present chapter. The anticlinal in question appears to be a faint continuation to the southward of the Khirthar axis, and has high dips on both sides, especially on the western. The western border of the larger Gáj area just mentioned is turned up and dips eastward at a considerable angle, being marked by a ridge escarped to the westward, and extending for many miles from north to south. The Gáj beds appear in the bed of the Báran river at Pir Gaibi, south-west of Karchát. They consist largely of argillaceous limestone, as in the area near Karáchi, and are much less shaly than they are to the northward.

East of the Gáj outlier, and opposite the southern extremity of the Khirthar range, the Nari beds, including both the marine beds at the base and the soft sandstones forming the upper part of the group, are well exposed in the Báran river. In the sandstones, impressions of plants were found.

Beynir Hill north-east of Rahúja.

In the Nari belt between the Gáj tract west of the Kámbú range and the main area to the westward, Khirthar rocks appear in one spot, at Beynir Hill, which lies about 7 miles north-east of Rahúja-ka-dát, and 10 miles east-by-north from Thána Sháh Beg. Even here there is some doubt whether the lowest strata seen are the bottom beds of the Nari group or the upper layers of the Khirthar. Calcareous sandstones and arenaceous limestones, with large and small *Orbitoides* (*O. papyracea*) in abundance, cover the greater portion of the rise, but below is a very tough speckled limestone, somewhat arenaceous and containing casts of very small *Nummulites*, the species not determined. This is the lowest bed seen.

Line of dislocation.

Returning northwards towards Tong, along the edge of the Mol plateau of Gáj beds, the north and south line of anticlinal curvature, forming the axis to which the Nari inlier near Rahúja is due, leaves the Gáj plateau nearly south of the Dumbár range, and about 12 miles south-by-west from Tong. Thence the line of dislocation, here becoming a fault, extends northwards towards Baili, where its effect will be noticed presently. About 2 or 3 miles west of the spot where the line of fracture just mentioned enters the Nari beds, there is a peculiar hollow, shaped like an amphitheatre, about 2 miles across in each direction, cut out of the scarp, and having an outlier of Gáj beds to the north-east. This hollow is known as "Bill" (Plate VI, fig. 2). The rocks below the Gáj beds on the top of the scarp consist of horizontal, or nearly horizontal, soft sandstones and sandy shales (*c*), several hundreds of feet thick, having a coral zone at the top (perhaps the same as that found at the base of the Gáj beds near Mugger Peer). In the low broken ground east of the scarp, the beds continue nearly horizontal for some distance, then gradually turn up with a westwardly dip, and coarse sandstones, (*b*) brown and yellowish-brown in colour, false-bedded and partially calcareous, crop out. These pass down into the lower Nari yellow *Orbitoides* limestones and marls (*a*), with sandy beds interstratified. *Clypeaster* is common in some of the *Orbitoides* limestones. The lowest bed seen is a dark-grey limestone (*a'*). Then there is much crushing and some faulting, and then east of the fault the soft sandstones re-appear.

The "Bill."

Amongst the lower Nari beds, the sandstones (*b*) much resemble the fossiliferous beds, with *Nummulites* and *Orbitoides*, seen north of Tong, resting unconformably on yellowish limestones with large white *Orbitoides;* but none of the ordinary Nari fossils were found in these beds in the section east of the Bill.

Farther north the fault, now becoming well pronounced, runs along the eastern side of a ridge called Piro (Piero of the map) crossed on the road between Tong and Baili. East of the ridge are the Nari beds already noticed as dipping westward in the valley west of the Dumbár range, whilst the Piro ridge, towards which these Nari beds are dipping, palpably consists of Khirthar beds, also dipping westward. But the Khirthar beds here differ considerably from those of the Khirthar and even of the Dumbár range. The latter are the usual massive grey and white limestones, but on the Piro range, brown and brownish-yellow limestones in thin beds, with grey and white argillaceous limestone interstratified, are the only beds seen. To the westward, moreover, these limestones pass under thin beds

Piro range near Baili.

of sandstone, precisely similar to the ordinary Nari beds, but above the sandstone again comes limestone with *Alveolina* and a small nummulite, so the sandstone must here be classed as Khirthar. The two groups certainly appear to pass into each other, and neither here, nor to the westward near the Habb, is the massive Khirthar limestone found. The characteristic brown limestone, with *Nummulites garansensis* and *N. sublævigata,* is also wanting at the base of the Nari beds.

In the thin-bedded limestones fossils abound, and many of the typical Khirthar species occur. Amongst the latter are *Nummulites spira,* a variety (apparently) of *N. ramondi, N. lyelli? Orbitoides dispansa,* a gigantic *Operculina, Echinolampas sindensis,* and another species, *Eurhodia calderi, Hemiaster* sp., &c.

Bedúr range.

The rocks continue northward into the high Bedúr range, in which the Khirthar limestones doubtless become more massive. The fault extends for some distance to the north-west. The range here is, however, beyond the British frontier, and has consequently not been examined.

Plain west of Baili.

Baili is on the eastern edge of a broad plain, drained by several streams tributary to the Habb river. The Habb itself runs farther west, on the other side of a rather lofty range, known as Hamlig, which terminates to the southward near Kand.[1] South-west of Baili, between the Piro range and the Mol plateau, the plain exhibits a fair section of Nari beds; the harder limestone and calcareous sandstone bands, at their outcrop, rising into ridges parallel with the Piro range. All these beds have a steady south-west dip towards the Mol plateau, which is about 800 feet above the plain, and surrounded by a scarp. The upper portion of this scarp, like the top of the plateau, consists of Gáj beds. The dip of the Nari beds varies from 15° to 35°, and taking the breadth of the plain, where narrowest, at 3

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[1] The Hamlig range is outside the coloured portion of the accompanying map. The position of Baili has already been indicated; it is north-east of the northern end of the Mol plateau (Gáj) and 3½ miles north of Got Din Muhammad. Kand is a police post 4 miles north of the Myher trigonometrical station, and is named from the stream running past it to join the Habb.

miles, and the average dip at 20° (probably rather too low), the thickness of the Nari group must be over 5,000 feet.

The rocks in the plain west of Mol plateau, between the latter and the Hamlig range, consist also of Nari beds, but with an eastwardly dip, the Mol plateau being in the middle of a synclinal fold. In the northern part of the plain the Nari beds are nearly horizontal, except in the neighbourhood of the Hamlig range, where they turn up and dip sharply to the east. In the southern part of the plain the dip is generally south-east.

Hamlig Hills.

The Hamlig Hills extend for many miles from north to south, along the left or eastern bank of the Habb river, from about 25° 35′ to beyond 25° 55′ north latitude. They are entirely outside the British frontier, and they were only examined very cursorily at their southern extremity near Kand. Here they appear to consist of beds shown to belong to the Khirthar group by their fossils, but differing entirely from the usual type of beds belonging to that formation in Sind, all massive limestones being completely absent. The prevailing beds are fine sandstones of various colours, white, cream-coloured, brown, and olive, and thick olive or grey shales, breaking up when exposed into minute fragments, with thin bands of harder bright rufous brown shale interstratified. Many of the sandstones also are shaly and thinly bedded, with peculiar salient and angular markings on the surface of the beds. These rocks resemble the beds below the massive Khirthar limestone on the Gáj river; and they also closely coincide in character with those attributed to the eocene formation in Makrán (Southern Baluchistan), north of Gwádar.

There is no marked break between the Nari and Khirthar beds. A bed with an *Orbitoides,* apparently undistinguishable from *O. papyracea,* occurs some distance below the top of the shales, so these may be Nari, in part at all events. Some distance lower down a calcareous grit is exposed, containing typical Khirthar nummulites, such as *N. spira, N. granulosa, N. obtusa, N. scabra*?, &c., and with these is a saddle-shaped *Orbitoides,* apparently *O. dispansa.* Beneath this grit thicker bands of limestone, dark and light-coloured, occur, evidently belonging to the Khirthar group.

Scarp of Mol plateau near Kand.

The scarp of the Mol plateau was examined west-south-west of Kand. There all the lower portion of the cliff consists of Nari sandstone and some sandy limestone; the Gáj beds come in about 600 feet above, and a thickness of about 250 feet of them is exposed, consisting entirely of limestone. The lowest bed, 30 to 40 feet thick, is yellowish-white in colour, and abounds in *Foraminifera* and *Echinodermata.* One of the former is an *Orbitoides,* undistinguishable by external characters from the Nari *O. papyracea;* a saddle-shaped variety occurs frequently. Amongst the *Echinodermata* are *Breynia carinata, Echinolampas jacquemonti,* a *Clypeaster,* &c. The upper beds vary in colour, being white, yellow or brown; some of the white limestones are nodular, as at Khadeji. *Echinodermata* occur sparingly, and one layer is almost composed of *Orbitoides,* the same as in the lower beds.

Kand valley.

The Mol plateau and the Myher plateau are precisely similar in height, and in being surrounded by a cliff-like scarp of horizontal, or nearly horizontal, Gáj beds resting on Nari. The valley of the Kand Nai, about 3 miles broad, separates the two plateaus, and consists of nearly flat ground composed for a long distance of Nari beds, although farther south Gáj strata extend across. In the Kand valley the beds are not horizontal, but bend up in the middle to form an anticlinal with high dips, which become lower towards each side of the valley. (Plate VI, fig. 3.)

A few miles farther south, and west of Thána Sháh Beg (Got Tham Sháh Beg), the upper part of the Mol scarp consist of Gáj beds higher in the group than those occurring east of Kand, there being in this part of the Mol plateau a gradual rise of the beds towards the north. The pale-coloured limestones, forming the upper part of the scarp near Kand, are, to the southward, covered by gritty arenaceous limestone with numerous fossils, amongst which some very beautiful and perfect specimens of *Breynia carinata* were found, together with *Clypeaster,* *Cœlopleurus forbesi, Schizaster,* sp., *Echinolampas spheroidalis,* and some mollusca. East of the scarp there is a low ridge having a gentle eastern slope. This ridge consists of still higher Gáj beds, laminated and banded yellowish sandstones, very irregularly bedded. Upon these, Manchhar beds rest near Thána Shah Beg.

Myher plateau.

The Myher plateau extends for about 25 miles to the southward, the scarp running parallel to the river, but at a distance of about 4 or 5 miles from the stream. Farther south the plateau decreases in elevation until it becomes broken up into minor ridges on the borders of the Gadáb plain north of Karáchi.

Nari beds of Habb valley south of Kand.

The Nari beds occupy the Habb valley from the mouth of the Kand stream, where the Habb commences to form the frontier of Sind, to the sea. They sweep round the southern extremity of the Hamlig range east of the river, and of the Lakhan to the west; and apparently extend to the foot of the great Pabb range, a lofty chain to the westward of the lower Habb valley. The Hamlig and Lakhan ranges are apparently anticlinals of Khirthar beds, like so many of the hills farther to the eastward.

At Kand Thána, the Nari beds dip south-east about 20°. Farther south the dip changes to east-south-east or east, and the same general eastwardly dip continues for a long distance, the inclination varying. On the banks of the Kand river, near the Thána, some false-bedded dark-brown calcareous grit is seen, containing *Turritellæ.* Near the Habb a low range of hills extends for a considerable distance along the left bank of the river, south of the spot where it is joined by the Kand stream. Some of the beds near the latter, on the eastern side of the range, consist of fine greenish-grey sandstone, containing round concretionary nodules, some of which are perfect spheres, from 2 inches to upwards of 2 feet in diameter; others are spherical above, but flattened at the base, and when, as frequently happens, the concretion itself has fallen out, a depression is left on the surface of the sandstone, precisely resembling a platter in shape. This bed, with its peculiar concretions, is found in other parts of the Habb valley.

Near the Habb the rocks seen in the range just mentioned are chiefly fine sandstones, resting upon pale olive shales, very sandy, and interstratified with thin bands of hard shale and sandstone, only differing from the Khirthar beds of Hamlig by being more sandy. Similar beds are seen in the banks of the Habb in places, but in general very few rocks are exposed in the river channel.

Near Moidan.

The range of hills, about 2 miles west of the Habb, and north of Moidan (? Maidan) Thána, a police station about 10 miles south of the Kand stream, is composed of limestone and calcareous sandstone dipping south-east at a low angle. The uppermost layers abound in *Orbitoides papyracea,* but no nummulites were observed here, nor elsewhere in the Nari beds of the Habb valley. A peculiar *Cidaris* spine, long and nearly cylindrical, with projecting points, is common. As a rule, the beds are not fossiliferous. These *Orbitoides* sandstones and limestones, however, are far above the base of the Nari beds.

Nari beds of Habb valley.

The Nari group presents similar characters for many miles down the Habb, and requires no detailed notice. It consists of massive sandstones, usually fine-grained, and shales, usually sandy, but sometimes, as near the mouth of the Khar Nai, bluish-grey and hard. Occasional bands of limestone occur, containing *Orbitoides* and a few other fossils; in some hills, south of the Khar Nai, *Ostrea multicostata* occurs with *Orbitoides* in limestone precisely like that of Moidan. The presence of these bands of marine fossils at various horizons in the Nari group shows that the beds must in all probability have been deposited under different conditions from those prevailing during the formation of the unfossiliferous sandstones belonging to the same group in Upper Sind.

Khar Nai.

The Khar Nai is a considerable water-course cutting its way out of the Gáj plateau a few miles south of the Gháti Trigonometrical station. The valley of the Khar, to the north-west, unites with the depression in which the Kand Nai runs northward. The Nari beds, however, only extend a very short distance up the Khar Nai within the line of the scarp, of which the upper 500 feet consist of Gáj beds, and only the lower 150 feet of Nari rocks. The uppermost Nari beds here consist of a rather thick band of very coarse grit, almost a conglomerate; below this are soft brown or grey sandstones, some beds being characteristically variegated with white and purple, and containing ferruginous concretions. In the soft sandstones below, one band contains oysters of a species somewhat resembling *O. flemingi*.

The whole 500 feet of Gáj beds here consist of limestones, chiefly light-coloured. The beds are well exposed at the point north of the Khar ravine; they are not very fossiliferous, but a band of *Orbitoides* occurs.

South of the Khar Nai the Gáj beds have a low southerly dip, the plateau sinks down, the scarp disappears, and the Gâj boundary runs to the south-west and approaches the Habb. On the Shor Wari Nai, about 5 miles south of the Khar, the lowest Gáj beds are thinly bedded calcareous sandstones of a pale colour, sometimes containing valves of *Balani*, and in places Oysters, *Spondylus*, and *Clypeaster*. In another spot in the immediate neighbourhood, a bed just above the base abounds in *Ostrea multicostata*.

Near Lohári Lang.

From Lohári Lang, where the caravan road up the Habb valley crosses the river, the boundary of the Gáj and Nari beds runs nearly due south to Mugger Peer. The beds near the boundary in both groups are fairly seen, the harder bands forming low ridges parallel to the boundary, whilst the softer intervening strata are frequently exposed in the stream beds and ravines between the ridges. This is especially the case on the Hatari stream close to Lohári Lang Thána. Here the general dip of the Nari beds is between 25° and 35° to east by a little south, the direction of dip in the Gáj beds being the same, but the angle diminishing to the eastward.

The Lohári Lang Thána is 3 miles south of the spot where he name is marked on the inch map, and nearly due west of Mio Trigonometrical station. The Hatari stream, a small water-course, runs from the north-east close by. The Nari beds exposed consist chiefly of sandy shales. East of the road to Karáchi (a continuation of the caravan road already mentioned), massive sandstones come in, some of them containing marine fossils, such as *Ostrea, Pecten, Orbitoides,* &c. In the Hatari stream, the typical light-brown sandstones occur with ferruginous shaly bands, which are often brightly coloured. Above these again is limestone containing a small *Orbitoides, Clypeaster, Pecten subcorneus,* and *Ostrea multicostata.* Again, above this is coarse brown sandstone, like that beneath the Gáj limestone of the Miher plateau, together with finer beds of precisely the same characters as the Nari sandstones below. These sandstones are altogether 200 or 300 feet thick above the marine bed just mentioned, and are succeeded in ascending order by the typical Gáj limestone, along the base of which the boundary line between Gáj and Nari is drawn. It is evident that this section shows a complete passage between Nari and Gáj beds, for the marine limestones interstratified with upper Nari sandstones contain none but Gáj fossils.

Passage between Nari and Gáj groups.

Some miles south of Lohári Lang, and near Murád Khán's "band" (dam) across the Habb river, a thin bed composed of corals appears a few feet above the base of the Gáj group. This bed can be traced for many miles to the south. All the species of coral (five or six) are encrusting forms or small branching kinds. A *Pachyseris,* or some closely allied form, and two or three species of *Hydnophora,* are especially common. In the Nari group below, the bed with *Pecten subcorneus* is continuous.

Gáj coral bed.

The outcrop of the Gáj beds here becomes comparatively narrow, owing to a considerable increase in the dip. Opposite the "band" the belt of miocene rocks is rather more than 3 miles broad, but this diminishes to 1¼ miles at Mugger Peer. Nearly east of Murád Khán's "band," and about 16 miles north-by-east from Karáchi, there is seen a good instance of marine beds, undistinguishable from those of the Gáj group, interstratified with the

Marine beds in Manchhars at Hupkáni.

lower Manchhar beds. The place is to the east of a ridge called Hupkáni. The beds dip east at a low angle, and pale buff limestone, full of minute organisms, of open texture and somewhat arenaceous, thinly bedded and flaggy, is seen resting upon a paler bed rather more arenaceous, but otherwise similar; then, after a break, comes in descending order another similar band, 2 feet thick, closer and harder than the others, and below this again impure sandstones, occasionally pebbly, with minute *Foraminifera* and fragments of *Ostrea, Anomia, Balanus,* &c. All the above beds are marine, but beneath them are soft, thick-bedded, grey, buff and dun-coloured sandstones. Of these, 60 feet were exposed in one section, 100 in another. With the sandstones an argillaceous nodular conglomerate is sometimes associated, and both sandstone and conglomerate are characteristically Manchhar.

Faults at Lehra.

At Lehra, 4 miles south-west-by-south from Murád Khán's "band," a small fault, striking west-north-west, crosses the boundary between the Gáj and Nari groups. Other parallel faults occur to the south-west, but some of them are too small to be shown in the accompanying map.

Hot-springs at Mugger Peer.

The hot-springs at Mugger Peer (Magar Pir, or, more correctly, Mangah Pir) rise in the Gáj beds just above the base. The spring near the bungalow, inside the garden, has a temperature of 118°, but that to the westward, outside the garden, is no less than 127° Fahr., and is probably the hottest spring in Sind.

Gáj beds near Mugger Peer.

The boundary between the Gáj and Nari beds curves greatly near Mugger Peer, owing to a small anticlinal, followed to the westward by a synclinal roll of the beds. After a deep S-shaped curve, the base of the Gáj beds runs south-west to Cape Monze. The coral bed can be traced at the base of the Gáj rocks for some distance round the curve south-west of Mugger Peer, but then dies out, and is not met with again to the south-west. Before dying out it forms a low semi-circular ridge, not shown on the inch map, being doubtless too small to be marked. In the much higher semi-circular ridge, which is represented on the map, and which is composed of rocks some distance above the base of the Gáj beds, there is a second coral bed resting upon grey sandstones precisely like those of the Nari group.

The Gáj beds are fairly seen in the ridges traversed by the road from Karáchi to Mugger Peer, and several of the usual fossils occur.

West of Mugger Peer the boundary of the Nari and Gáj beds is difficult to determine exactly, the rocks being much covered by alluvium.

South-west of Mugger Peer.

The marine bed, with *Orbitoides, Clypeaster,* and *Pesten subcorneus,* can be traced here and there just below the top of the Nari group; and a hard band of *Orbitoides* limestone, perhaps the same as that seen in so many places higher up the Habb valley, crops out at a low horizon, and forms a well marked ridge, extending for many miles; but the actual boundary is ill seen until close to the telegraph line from Karáchi to the Mekrán Coast. Here the lowest Gáj beds begin to form a well marked ridge, which continues to Cape Monze, the highest portions being known as Lál Bakkar and Háji Zárá. In this range there are three breaks, caused by faults, all having a general west-north-west and east-south-east direction, two with a downthrow to the south and one to the north. All these breaks are shown on the Revenue Survey Map, which is here and throughout the neighbourhood of Karáchi excellent. North-west of the Gáj ridge, the Nari beds are fairly seen for a short distance, but the Habb valley is a broad sandy plain, with only a few isolated outcrops of the harder Nari beds forming long low ranges.

Orbitoides bed at Háji Zárá.

About Háji Zárá a hard band of *Orbitoides* limestone occurs close to the top of the Nari group. Besides *Orbitoides,* it contains other *Foraminifera,* some looking very like small nummulites. They are, however, not very well preserved, and the identification is doubtful; but if they are really nummulites, the horizon is the highest at which the genus has been observed in Sind.

Cape Monze.

Near Cape Monze (Răs Muári) there is an anticlinal roll of the strata, and the Gáj ridge, after running down the east side of the promontory, turns round at the Cape and runs up the west side as far as the mouth of the Habb river. The rocks are much broken and somewhat irregular. Near the mouth of the Habb there is a synclinal, and Nari beds re-appear on the coast. East of the synclinal the Nari sandstones are seen with a reversed dip in a low range of hills running from north-north-east to south-south-west.

Raised oyster beds and marine shells.

At the jutting rocky point on the eastern side of the Habb, opposite the sand spit which forms a bar at the mouth of the river, there is a raised oyster bed about 50 feet above high water mark. There are also oyster shells attached to the rocks, about 10 to 15 feet above high-water mark, east of Cape Monze. On the flat or undulating ground of the Nari rocks between the two Gáj ridges that unite at Cape Monze, recent marine shells are scattered in considerable numbers, the most common being two forms of *Turbo* (a *Senectus* and a *Lunella*), both species living on the coast. Nearer to the shore many kinds of shells are scattered about. The oyster beds clearly prove that elevation of the land has taken place at no distant period, and the remaining shells may have been left behind by the sea when it overflowed the plain. The circumstance that forms of *Turbo* are so much more common than other genera may perhaps be due to pearly shells resisting the influence of exposure longer than other kinds. At the same time the *Turbo* shells may have been brought by men, and the animals used for food, but nothing was noticed like the shell heaps (Kjökkenmoddings) usually produced under such circumstances.

Manchhar beds east of Cape Monze.

Turning eastward from Cape Monze, Gáj beds occur for a few miles, then Manchhar beds appear resting upon the Gáj. The Manchhar rocks are fairly seen between 6 and 7 miles from the Cape in some ravines; farther to the eastward the plain between the Gáj hills of Háji Zárá and the sea is covered by alluvium for the most part. The Manchhar beds at the place just noticed present in part a very peculiar character; a portion of them consists of grey sandstones as usual, but other beds are whitish sandy clays with interstratifications of very thin laminated papery sandstones. These closely resemble a very characteristic form of the Makrán beds,[1] so largely

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[1] Rec. Geol. Surv. of India, Vol. V, page 43.

developed on the Baluchistan coast farther to the westward, and very probably the marine equivalents of the Manchhar and Siwalik formations. In the Manchhar beds, south-east of this, also, and at a rather higher horizon, a marine bed was found. Light-grey, thick, soft sandstones, obliquely laminated, rest with slight unconformity on a yellow limestone containing fossils in abundance. Amongst the latter were two species of *Pecten* (one of them *P. subcorneus*), *Spondylus*, *Cardita*, *Cerithium*, a small *Clypeaster*, and corals. The bed is only a few feet thick, and rests unconformably on laminated dun-coloured clays, succeeded in descending order by soft sandstones, silty shales, &c.

Neighbourhood of Karáchi.

Of course, these beds may all belong to the Makrán group, and not to the Manchhar; but as the relationship to Gáj beds is the same as in the case of the latter group, this view is in favour of considering the two identical. The unconformity noticed is probably only local. The beds seen near Karáchi are of small interest or importance, and the exposures, as a rule, are poor. There are some masses of conglomerate, apparently of subrecent age, in the plain to the west of the town, and oyster shells are occasionally found associated with them. Manchhar beds appear north-east of Karáchi, about 2½ miles from the town, at a place called Guru Goraknáth. Just south of the Makrán telegraph line, horizontal post-tertiary conglomerates are seen resting unconformably on Manchhar beds; the latter dip at a considerable angle and rest upon the Gáj group. The Manchhar beds consist of the usual grey sandstones and conglomerates with clay nodules. North of the telegraph line a conglomerate, apparently identical with that forming everywhere, where it is seen, the uppermost bed of the Manchhar group, and chiefly composed of oblately spheroidal nummulitic limestone pebbles, overlaps the lower beds and rests upon the Gáj group. All the Manchhar beds seen at this spot, a considerable thickness, are overlapped in the space of less than a quarter of a mile. Here, therefore, the Manchhar beds must be unconformable to the Gáj group. A little farther to the north-east, the Manchhar sandstones re-appear and are associated with marine beds.

Relations of Manchhar to Gáj beds north-west of town.

Manora.

The headland of Manora, on which stands the light-house at the entrance to Karáchi harbour, consists of pale-brown, bluish, and purplish clay, sandy in parts, with conglomerate bands. These beds appear to be Manchhar; they are capped by a thick mass of conglomerate, composed of oblately spheroidal pebbles, chiefly of nummulitic limestone. The conglomerate is unconformable to the underlying clays, and may perhaps be a post-tertiary formation.

Oyster rocks.

The "oyster rocks," or Ram Jharocha, or Andrai, small rocky islets in the sea, rather more than a mile north-east of Manora point, consist of brown sandstone with sandy shale (Manchhar apparently) capped by the same conglomerate as that of Manora, but not so coarse nor quite so thick. Some oysters and fragments of bone were here found in the conglomerate.

Clifton.

The same beds—conglomerate of post-tertiary origin resting unconformably on Manchhar sandstones—are seen at Clifton, on the coast east of the harbour, and south or south-east of Karáchi, the ground between Clifton and Karáchi being alluvial. East of the town Gáj beds come in and extend nearly to the coast at Ghizri (Gisri) east of Clifton.

Layári valley.

Up the Layári water-course north of Karáchi, beneath the surface accumulations of gravels and rain-wash, the post-tertiary conglomerate occurs as a strong compact bed. From below this, Manchhar beds crop out in places, and generally consist of fine and soft light-grey or pale-brown sandstone, with an efflorescence of salt on damp surfaces. Farther to the north are mounds or hillocks, 30 to 40 feet high, of the same soft sandstone, with a thick capping of the coarse post-tertiary conglomerate, which, however, is here not compact, but loosely cemented. Between the conglomerate and the Manchhar beds is a powdery deposit, having some resemblance to dry pipe clay in appearance, and containing small concretionary nodules.

Manchhar beds north and north-east of Karáchi.

The Manchhar beds north and north-east of Karáchi occupy a considerable area; they are much obscured by surface gravels and post-tertiary conglomerates, and they are peculiar in appearance, there being a great admixture of silty and marly beds; and marine layers with oysters, &c., being of common occurrence. In all probability these silty and marly beds are the same as those already noticed as occurring east of Karáchi, and as resembling certain rocks of the Makrán group. Amongst these Manchhar beds, north of Karáchi, there are great irregularities of stratification; beds of soft sandstone, for instance, resting upon silty shale or marl, irregularly-shaped masses of which project from the surface of the lower bed into the material of the upper. These peculiarities may be due to deposition in a variable area, at one time subjected to river action, at another to marine.

Hills about Matráni H. S. and Saphura.

A part of the Native Infantry lines in the Karáchi cantonment stands upon post-tertiary conglomerate, and the low hills east of the lines are capped with the same. Along the road, east of the town of Karáchi, grits resembling those of the Manchhar group are intercalated with high Gáj beds. The latter crop out to the east of the town; they are seen in the neighbourhood of the hill road to Sehwán, and they form the hills of Matráni and Saphura. They consist of yellow, brown, or buff-coloured limestones, very largely composed of organic fragments, and contain many of the usual fossils, such as *Operculina,* spines and fragments of Echinoderms, *Balanus, Venus granosa,* &c. Some of the beds are sandy, and the proportion of arenaceous ingredients increases in the lower beds. In the latter, which are seen in some of the ravines, are dark-coloured ferruginous beds, and beneath these again are soft brown sandstones impregnated with salt. The limestones and calcareous sandstones furnish the building stone used in Karáchi, and of this rock the church and other public edifices are constructed.

Plain near Saphura.

Near Saphura Lándi, the first camping ground from Karáchi on the Sehwán hill road, the Manchhar beds come in, but they are, as usual, much concealed by the immense spread of post-tertiary conglomerate. The surface of the ground is generally sandy. Near Saphura, the pebbles in this conglomerate are mostly derived from the Gáj limestones. Below the conglomerate, the same calcareous and arenaceous rubbly earth is found as was noticed north of Karáchi.

Malir.

The Malir valley, like that of the Lyári, is covered with subrecent gravels and rain-wash. To the eastward the Manchhar beds re-appear, and thence to Darbeji railway station, it is very difficult to draw any line of division between this group and the underlying Gáj, the two formations passing into each other, and bands of Gáj character, and containing Gáj fossils, being interstratified with the Manchhar beds. The rocks east of Malir station are clearly Manchhar, although marine beds occur amongst them. Two or three miles farther east, fine soft silty sandstone, greenish-grey and light-brown in colour, is seen, occasionally with harder calcareous bands intercalated, and sometimes obliquely laminated. In the hilly ground to the north-east, near Sáj Takkar, lower beds occur; they are rather coarser sandstones, grey or brownish-grey in colour, and calcareous, containing imperfect casts and fragments of shells, chiefly *Gasteropoda,* amongst which a *Cerithium* like *C. telescopium* (*Telescopium fuscum*) and an imperfect specimen of *C. subtrochleare,* a fragment of *Ostrea multicostata* (the closely ribbed variety), a portion of a long narrow oyster, a globose *Anomia,* a minute *Pecten,* and fragments of *Balanus,* were found.

Gáj and Manchhar beds east of Malir.

Soft silty sandstones (Manchhar) occur both below and above the fossil bed; those below are highly micaceous. The dip near Malir is westward, but at Sáj Takkar it becomes south. Farther to the north-east undoubted Gáj beds crop out, containing tubes of *Kuphus,* &c., and the Kattiani hills in the same direction are of rubbly limestones, more or less sandy, with quantities of coral. These rocks are in fact a continuation to the southward of the Khadeji beds already described.

APPENDIX.

NOTE ON THE ROCKS SEEN NEAR THE COAST BETWEEN KARÁCHI AND SONMIÁNI.

From the neighbourhood of Karáchi an excursion was made to Sonmiáni for the purpose of seeing whether any connection could be traced between the Manchhar beds of Sind and the Makrán group. It was found, however, that no representative of either group existed between Cape Monze and Sonmiáni. The Makrán group only appears at a considerable distance west of the place last named. The following are some notes made on the geology :—

Churna Island.

Churna Island, an uninhabited rock in the sea, about 4 miles west of Cape Monze, appears to consist entirely of Gáj beds. It is possible that the lowest strata seen on the east side of the island may be older, but they do not resemble Nari rocks. The beds generally dip west at an angle of about 30°, except at the north-west end of the island, where the dip turns southward, and becomes rather higher, about 40°. The upper beds, seen on the west side, are whitish and buff limestones, most of them gritty; they rest upon calcareous sandstones and some shales. In the limestones *Breynia carinata, Echinolampas jacquemonti, Clypeaster, Echinodiscus,* a large *Echinus* or allied genus, *Pecten subcorneus* and *Kuphus rectus,* occur.

Coast west of the Habb.

On the sandy plain west of the Habb, close to the mouth of the river, is a small hill of hardened sandstone, probably Nari. Thence for a long distance no rocks are seen. About 10 miles from the Habb there is a little isolated hill forming a headland, and connected with the main land by a broad spit of sand. The rock of this hill is dark grey limestone resting on buff shales, and probably belonging to the Khirthar group. No fossils were detected.

Gadáni Hill.

The most conspicuous hill on the coast is at Gadáni, about 18 miles from the mouth of the Habb. This hill is peculiarly white in colour, and consists of very fine calcareous sandstone and compact calcareous shale, greenish-white and pale dull purple in colour, some beds being almost white. These beds, which are cut up in almost every direction by veins of calcite, are vertical, striking north 30° east, and they closely resemble in mineral character the peculiar limestones of the Parh range,[1] west of the Khirthar, on the upper Gáj. The latter rocks have already been shown to be, very possibly, cretaceous. The Gadáni beds have a very ancient look, but this is commonly the case with even eocene beds in Makrán.

Basalt and black limestones near Gadáni.

Just south of Gadáni Hill is some dark-grey and blackish limestone, containing fossils, amongst which, however, nothing recognizable could be detected, and only sections of bivalves could be distinguished. The rock resembles some of the Makrán nummulitic beds. A small head-land to the eastward is formed of basalt, which continues for half a mile along the coast. It is not amygdaloidal, and it may be intrusive.

Pabb range on road to Sonmiáni.

The above were the only rocks examined on the coast itself. The road along the telegraph line, after crossing the Habb at Muách Thána, traverses about 5 miles of alluvial plain before reaching the Pabb range, which is crossed by a gap, just north of a considerable hill called Ganta. The rocks seen near the road consist of a dark-coloured limestone made up of angular fragments (a common character amongst Khirthar beds), dark-grey limestone abounding in nummulites (*N. granulosa, N. obtusa, &c.*), dark-brown granular limestone, also containing nummulites, and white and buff, compact, homogeneous and very fine-grained limestones and shales. The brecciated limestone is seen to the eastward and is nearly vertical; the main hill is of almost horizontal beds, and farther west there are other ridges dipping westward, but with their strata much contorted. All the rocks seen are characteristically Khirthar, and similar to those of Hamlig and of the upper Gáj river.

After passing these hills, the road for 5 or 6 miles traverses a sandy

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[1] See p. 98, No. 11 of the section on Plate IV.

plain cut up by ravines, in which no rock is seen; then a stream is crossed, in which olive and light-brown thin-bedded sandstones and shales are exposed, much hardened and cut up by small quartz veins, and closely resembling some of the Makrán eocene strata and the lower Khirthar beds of the upper Gáj section. The spot is nearly north of Gadáni.

West of Pabb range.

Four or five miles farther, the road descends to a flat sandy plain near the sea shore. The descent is over a cliff of hard sand beds, horizontal, unfossiliferous, and very false-bedded. The sand is rather coarse, and much resembles that forming sand-hills near the shore. It is difficult to tell how this deposit has accumulated; it may be simply blown sand consolidated, or it may be fresh water and alluvial. The cliff itself is probably due to marine denudation, and its distance from the sea may indicate a rise of land.

The cliff continues for about 12 miles to the westward from the spot where the road descends to the coast plain; then the higher ground recedes from the sea, and there is nothing but a low sandy plain, apparently alluvial, all the way to Sonmiáni. Far to the westward, the hills of Hingláj are seen running out to Rás Malán; they appear to be in great part composed of Makrán beds, but time did not permit of their being visited.

Near Sonmiáni.

PART III.

CHAPTER IX.—ECONOMIC GEOLOGY.

This will be a very short Chapter, for the valuable minerals of Sind, so far as is hitherto known, are very few in number, and, with the exception of building stones and limestone, none are abundant.

Lignite.

Small quantities of coal or lignite have been found in various places amongst the shales and sandstone beds of the Ranikot group, but in only one instance has anything more than a mere layer, a few inches in thickness, been detected. This exceptional case was at Lainyan (Lynyan, or Leilan), about 27 miles north-north-west of Kotri, and 15 miles from the right (west) bank of the Indus. The geology of the neighbourhood has been described in Chapter VII, and the details concerning the coal mine have already been published in a previous volume[1] of these "Memoirs." It is said that two seams were met with, the upper being in one place nearly 6 feet thick; the lower was very thin, not more than a foot.

A shaft was put down by Mr. Inman, who was in charge of the exploration, in 1857, and the coal, which was first discovered in a well, was found to be 5 feet 9 inches thick. This thickness, however, diminished rapidly to the east, north, and west, and when galleries had been driven into the seam to a short distance, it was found useless to continue working, as the coal thinned out. In a deeper shaft sunk to the south-east, at a distance of 100 yards, for the purpose of intersecting the seam, the latter had dwindled away to a thin layer, so insignificant that it was passed through in the shaft without being recognized. At the outcrop of the beds associated with the coal-seam, 250 to 300 yards south-west of the shaft, the seam is only represented by a bed of slightly carbonaceous shale. In short, as was shown by a discussion of all the

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[1] Vol. VI, p. 13. These details are taken from a report to the Government of Bombay, by whom I had been deputed to examine the locality.

data, there is nothing which could properly be called a coal-seam, but merely a mass of lignite not extending much more than 50 yards in any direction.

The quality is inferior. The mineral is a lignite, brittle, and abounding in iron-pyrites, so that rapid decomposition sets in on exposure, and there is much liability to spontaneous combustion. Still if a large quantity could be obtained, some use might be made of this substance as fuel.

Numerous sections of Ranikot beds have been examined in the Laki range without any mass of lignite similar to that of Lainyan having been found. Some highly carbonaceous shale was seen in the lower Khirthar group of the Upper Gáj valley, but the thickness of the bed was only a foot.

Iron.

Owing to the want of fuel, it is not probable that the iron ores of Sind will ever be largely worked, and their rarity is consequently of small importance. Almost the only occurrence noted of the metal, in sufficient quantities to be available for the manufacture of iron, is in the passage beds between the Khirthar and Ranikot groups north-west of Kotri, and especially in the neighbourhood of Lainyan (Lynyan) and east of Bandh Vera. The beds are in many places 15 to 20 feet thick, but only a portion of this is sufficiently ferruginous to deserve the name of an ore of iron. Masses of magnetite and bands of red and brown hæmatite, more or less pure, occur, however, in considerable quantity, in many places. The same bed exists west and south-west of Jhirak, but it does not appear to be so rich in iron as near Bandh Vera.

Some ferruginous rock also occurs in the beds at the base of the Manchhar group, where the latter rests upon the Khirthar limestone near Bandh Vera and along the base of the Laki range; but it is doubtful whether the deposit is ever sufficiently rich in iron to be of value, especially in the neighbourhood of the locality where a much richer mineral occurs amongst the Upper Ranikot beds.

Building stones.

Stone of good quality for building occurs throughout the greater part of the rock area. The principal building stones are procured from the Ranikot, Khirthar, and Gáj beds; but some of the Nari sandstones would be well adapted for many purposes, and the yellow and brown limestones and calcareous sandstones near the base of the Nari beds are excellent material. Some stone from these beds has been employed on the railway near Jungsháhi. Limestone from the Khirthar group is employed for building at Sukkur, Rohri, Kotri, and Hyderabad, whilst at Karáchi a whitish or brownish-yellow rather porous limestone derived from Gáj beds is used, and greatly resembles in appearance the well known "Calcaire grossier" of which Paris is built. At Jhirak, perhaps the best building-stone of all known to be found in Sind is employed; it is a light yellowish-brown fine-grained limestone derived from the Ranikot beds. This rock is largely employed, both in the neighbourhood of Jhirak and in other parts of lower Sind, for the manufacture of Mahammadan tombstones and memorials over graves. Many of these are elaborately carved and engraved with inscriptions in the Persian character.

Numerous varieties of limestone occur in the Khirthar group; some of them so fine grained, that they might very possibly be employed as lithographic stones. The stone from the Ranikot beds just mentioned closely resembles the very beautiful jurassic limestone procured at Jaisalmir. The latter was formerly brought to Calcutta for lithographic purposes.

The rocks of the Manchhar beds are usually too soft for building-stones, though the more calcareous sandstones might be employed, especially for works not requiring resistance to great pressure, and selected blocks have been used in the railway works. The conglomerates would doubtless be available for ordinary building purposes. The more fissile grey sandstone beds are sometimes, as near Sehwán and north of Bhule Khán, dug and chipped into a kind of rough platters on which bread is baked.

Some of the post-tartiary calcareous beds also furnish good building material, and a gritty limestone of subrecent origin has been employed for bridges, &c., on the railway at Jhimpir station.

Lime.

As the bulk of the Khirthar group, numerous beds in the Gáj (and sometimes nearly the whole formation), several bands at the base of the Nari beds, and extensive deposits on the upper Ranikot beds, consist of limestone, the supply of lime is abundant almost wherever rocks occur, or the detritus of the lower beds is washed by streams. An abundance of limestone pebbles is found in the pliocene and post-tertiary conglomerates.

Gypsum.

In the Gáj beds of the Khirthar range, near the top of the group, gypsum of tolerable purity is abundant, and is not unfrequently found in beds 3 to 4 feet thick. Two such beds, one of them much purer than the other, occur in the section exposed on the banks of the Gáj river, and thence to the northward similar beds are of not unfrequent occurrence. Some gypsum is found in the Ranikot group, but the quantity is small.

Alum shales.

Some of the pyritous shales found in the Gáj beds are employed in a rough manufacture of alum. Places where the salt had been made were seen on the Maki Nai north of the Gáj, and in one or two other places in the hills. Some has also been made at Ranikot from shales in the Ranikot group, and some from Nari shales, as at Bill, 12 miles north of Thána Sháh Beg, in Kohistán. The manufacture is evidently rude, and has not been observed in progress by the members of the Survey. It is said by the natives to consist in merely burning the shales and lixiviating the burnt shale in water. Probably, however, the potash necessary for the production of alum is added, being procured from ashes of plants or some such source.

Fuller's earth.

In some places, as in the southern portion of the Laki range, and near Hyderabad, a pale greenish clay is found, which is dug and used for washing cloth, and also, it is stated, eaten by women during pregnancy, a common practice in parts of India. That obtained near Hyderabad is also largely employed by the natives for washing their hair.

Celestine.

Celestine (sulphate of strontia) was found by Mr. Fedden scattered sparingly over the surface of the Khirthar limestone hills of Kohistan, especially east of the range to the eastward of Bhule Khán's Thána. The mineral occurs in crystalline lumps about the size of walnuts.

In concluding this memoir, I have to express my obligations to Mr. Fedden for assistance in seeing it through the press, and also to Mr. Wynne for having very kindly prepared the sections used in illustration.

On the Distribution of the Fossils described by Messrs. d'Archiac and Haime in the different Tertiary and Infra-Tertiary Groups of Sind, *by* F. Fedden, A.R.S.M., F.G.S., *Geological Survey of India.*

In the process of examining the several collections made during the progress of the Survey in Sind, I have been able to identify a large proportion of the fossils figured by Messrs. d'Archiac and Haime in their "*Description des Animaux fossiles du groupe Nummulitique de l'Inde,*" and so to determine their position in the series.

It had hitherto been impossible, as has been shown in the preceding paper on the Geology of Sind, to tell from which particular horizon the fossils described by d'Archiac and Haime were obtained. It now appears that, instead of these fossils being exclusively Eocene, some are older and many newer, a large proportion being Miocene. A list giving the distribution would evidently be a necessary sequel to the great French work, indeed this was pointed out by the authors themselves. The following table will serve provisionally toward that end, until the whole collection can be taken in hand by an experienced palæontologist.

The identifications of the Nummulites and some of the other Foraminifera have been confirmed by Professor Rupert Jones: Mr. Blanford has examined and verified many of the Echinodermata and Mollusca; it was intended that we should go through the whole together, but want of time has prevented his doing so.

In the following table both Corals and Bryozoa are omitted; the former are now being examined by Professor Martin Duncan for publication in the "*Palæontologia Indica;*" the Bryozoa have not yet received specific attention. Those fossils in d'Archiac and Haime's list that came from other parts of India and have not been met with in Sind, are also omitted in the list below; neither have I entered any genera or species not mentioned in d'Archiac and Haime's work, deeming it undesirable to complicate the present table. It should be borne in mind, therefore, that this is by no means a complete list of the fossils already determined; and that there are many new species yet to be described and named.

Table showing the distribution (so far as determined,) amongst the different groups of rocks, of the Sind fossils enumerated in Messrs. d'Archiac and Haime's "Tableau de la faune Nummulitique de l'Inde,"—Description des Animaux Fossiles de l'Inde, pp. 363—372.

NOTE.—*The sign ? indicates that the identification of the fossil found is doubtful.*

CLASSES AND ORDERS.		GROUPS.						REMARKS.
Genera.	Species.	Manchhar.	Gáj.	Nari.	Khirthar.	Ranikot.	Cretaceous?	
RHIZOPODA.								
FORAMINIFERA.								
MILIOLA	sp. indet.	...	×	...	...	...	...	
ROTALIA	*newboldi*, d'A. & H.	...	...	...	...	...	...	
ALVEOLINA	*melo*, d'Orb.	...	...	...	?	...	...	
„	*sphæroidea*, H. J. Cart.	...	...	...	×	...	...	
„	*ovoidea*, vel *oblonga*, vel *elliptica*	...	...	...	×	×	...	
CYCLOLINA	*pedunculata*, Cart.	...	...	...	×	...	...	
OPERCULINA	*canalifera*, d'Arch.	...	?	...	...	×	...	
„ ?	*tattaensis*, d'A. & H.	...	...	...	...	×	...	This is really a variety of *Nummulites spira.*
„	*hardiei*, d'A. & H.	...	...	×	...	...	...	
NUMMULITES	*lyelli*, d'A. & H.	...	...	...	×	...	...	
„	*sublævigata*, d'A. & H.	...	...	×	...	...	...	Very abundant and characteristic of lower Nari beds.
„	*garansensis*, Jol. et Leym.	...	...	×	...	...	...	
„	*carteri*, d'A. & H.	...	...	...	×	...	...	
„	*scabra*, Lam.	...	...	...	×	...	...	
„	*obtusa*, C. Sow.	...	...	...	×	...	...	
„	*lucasana*, Defr.	...	...	...	×	...	...	
„	*ramondi*, Defr.	...	...	...	×	×	...	
„	*geuttardi*, d'A. & H.	...	...	...	...	...	...	

Classes and Orders.		Groups.						Remarks.
Genera.	Species.	Manchhar.	Gáj.	Nari.	Khirthar.	Ranikot.	Cretaceous?	
Nummulites .	*biaritzensis*, d'Arch. .	...	...	...	×	...	...	
" .	*beaumonti*, d'A. & H.	...	...	...	×	...	...	
" .	*vicaryi*, d'A. & H. .	...	...	...	×	...	...	
" .	*exponens*, C. Sow. .	...	...	...	...	...	...	
" .	*granulosa*, d'Arch. .	...	...	...	×	...	...	
" .	*leymeriei*, d'A. & H. .	...	...	...	×	×	...	
" .	*spira*, Roissy. .	...	...	...	×	×	...	
" .	*miscella*, d'A. & H. .	...	...	...	...	...	...	
Orbitoides .	*dispansa*, Cart. .	...	...	...	×	...	...	
" .	*ephippium*, Cart. .	...	...	...	...	...	...	
" .	*fortisi*, d'Arch. .	...	×	×	...	...	...	This is *O. papyracea* of Boubée, an older name, and should have priority: very abundant in Nari beds.
Orbitolites .	*complanata*, Lam. .	...	...	...	×	...	...	This is *Cyclolites pedunculata* of Carter.
" .	*mantelli*, d'Orb. (Cart.)	...	...	...	...	...	...	Not really Indian, Carter mistook *Orbitoides fortisi* for this species.
Rhabdella .	*malcolmi*, d'A. & H. .	...	...	...	...	...	...	
ECHINODERMATA.								
ECHINOIDEA.								
Cidaris . .	*verneuili*, d'Arch. .	...	...	×	×	...	...	
" . .	*halaensis*, d'A. & H. .	...	×	...	...	...	...	
" . .	*serrata*, d'Arch. .	...	...	...	...	...	...	
Phymosoma .	*nummuliticum*, d'A. & H. . . .	...	...	...	...	...	...	
Cœlopleurus .	*coronalis*, Klein. .	...	...	...	...	...	...	
" .	*pratti*, d'A. & H. .	...	...	...	...	...	...	
" .	*forbesi*, d'A. & H. .	...	×	×	...	...	...	
Echinus . .	*stracheyi*, d'A. & H. .	...	?	...	...	...	...	
Temnopleurus .	*valenciennesi*, d'Arch.	...	...	...	...	×	...	

CLASSES AND ORDERS.		GROUPS.						REMARKS.
Genera.	Species.	Manchhar.	Gáj.	Nari.	Khirthar.	Ranikot.	Cretaceous?	
TEMNOPLEURUS .	*hookeri*, d'A. & H. .	...	×	...	...	...	...	
,, .	*costatus*, d'A. & H. .	...	×	...	...	...	...	
,, .	*rousseaui*, d'Arch. .	...	×	...	...	...	...	
,, .	*tuberculosus*, d'A.&H.	...	...	...	...	...	...	
ECHINOMETRA .	*thomsoni*, d'A. & H. .	...	...	...	×	...	...	
ECHINANTHUS .	*profundus*, d'A. & H.	...	×	×	...	...	...	
,, .	*halaensis*, d'A. & H. .	...	×	...	...	...	...	
,, .	*depressus*, C. Sow. .	...	×	...	...	...	...	
,, .	*oblongus*, C. Sow. .	...	×	...	...	...	...	
ECHINOLAMPAS .	*discoideus*, d'Arch. .	...	...	...	×	...	...	A species near *discoideus* occurs in Ranikot beds.
,, .	*sindensis*, d'Arch. .	...	...	×	×	...	...	
,, .	*sphæroidalis*, d'Arch.	...	×	...	...	...	...	
,, .	*jacquemonti*, d'A.&H.	...	×	...	...	...	...	
,, .	*subsimilis*, d'Arch. .	...	...	...	...	?	...	It is doubtful if this be the European species, but it is probably that noticed by d'A. & H.
,, .	*vicaryi*, d'Arch. .	...	×	...	...	...	...	
EURHODIA . .	*morrisi*, d'A. & H. .	...	...	...	...	×	...	Peculiar to the Ranikot group, upper part.
,, .	*calderi*, d'A. & H. .	...	...	...	×	...	...	Peculiar to the Khirthar group, near the base.
CONOCLYPEUS .	*flemingi*, d'A. & H. .	...	...	...	×	...	...	
,, .	*pulvinatus*, d'Arch. .	...	...		×	...	...	
BREYNIA .	*carinata*, d'A. & H. .	...	×	...	...	...	...	The fascioles in d'A. & H.'s figure are incorrectly drawn. See Manual Geol. Ind., Pl. XVI, fig. 9.
EUPATAGUS .	*patellaris*, d'Arch. .	...	...	...	...	...	...	
,, .	*rostratus*, d'Arch. .	...	...	×	×	...	...	
,, .	*avellana*, d'A. & H. .	...	...	...	×	...	...	
BRISSOPSIS? .	*scutiformis*, d'Arch. .	...	...	...	×	...	...	

Classes and Orders.		Groups.						Remarks.
Genera.	Species.	Manchhar.	Gáj.	Nari.	Khirthar.	Ranikot.	Cretaceous?	
Brissopsis?	*sowerbyi*, d'Arch.	...	...	...	×	...	...	The fasciole differs from that in d'A. & H.'s figure.
Hemiaster	*digonus*, d'Arch.	...	...	...	×	×	...	
Schizaster	*beloutchistanensis*, d'A. & H.	...	...	×	×	...	...	
"	*newboldi*, d'A. & H.	...	...	...	...	×	...	
MOLLUSCA.								
PELECYPODA.								
Pholadomya	*puschi*, Gold.	...	...	...	...	...	...	
"	*halaensis*, d'Arch.	...	...	...	×	...	...	
Mactra	*dubia*, d'Arch.	...	...	...	...	...	...	
Crassatella	*sindensis*, d'A. & H.	...	...	...	×	...	...	
"	*halaensis*, d'A. & H.	...	...	...	×	...	...	
"	*salsensis*, d'A. & H.	...	...	...	...	...	...	
Corbula	*trigonalis*, C. Sow.	...	×	...	...	...	...	
"	*subexarata*, d'Arch.	...	...	...	×	...	...	
"	*harpa*, d'A. & H.	...	...	...	...	×	×	On re-examining the Nari fossil, I am persuaded that it is not *C. harpa*, but a small *Crassatella*.
Tellina	*exarata*, C. Sow.	...	...	...	...	...	...	
"	*subdonacialis*, d'A. & H.	...	×	...	...	...	...	
Corbis?	*elliptica*, d'A. & H.	...	...	...	×	...	...	
"	*subelliptica*, d'A. & H.	...	...	...	?	...	...	
Lucina*	*mutabilis*, Lam.	...	...	...	...	...	...	
"	*gigantea*, Desh.	...	...	...	×	...	...	
"	*bellardii*, d'Arch.	...	...	...	...	...	...	
" (?)	*pseudoargus*, d'A. & H. (see below under *Venus*).	...	×	...	...	...	...	This shell is re-named *Venus pseudoargus* in the Appendix to d'A. & H.'s work. It is really a *Dosinia.*

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* Several of the species of this genus are described and figured by d'Archiac and Haime from casts, and the specific characters are insufficient for determination.

Classes and Orders.		Groups.						Remarks.
Genera.	Species.	Manchhar.	Gáj.	Nari.	Khirthar.	Ranikot.	Cretaceous?	
Lucina*	*incerta*, d'A. & H.	...	×	...	...	...	...	
„	*vicaryi*, d'A. & H.	...	...	...	...	...	...	
„	*subvicaryi*, d'A. & H.	...	...	...	?	...	...	
„	*pharaonis*, Bell.	...	...	...	...	...	...	
„	*pendjabensis*, d'A. &H.	...	...	...	×	...	...	
Astarte	*hyderabadensis*, d'A. & H.	...	×	...	×	...	...	
Venus*	*granosa*, C. Sow.	...	×	×	...	...	...	The form of this shell varies considerably.
„	*cancellata*, C. Sow.	...	×	×	...	...	...	It is doubtful whether this is distinct from the last.
„	*non-scripta*, C. Sow.	...	×	...	...	...	...	
„	*subvirgata*, d'Orb.	...	×	...	...	...	...	This is a *Tapes*.
„	*subaglauræ*, d'A. & H.	...	?	...	...	...	...	
„	*hyderabadensis*, d'A. & H.	...	×	...	...	...	...	
„	*astarteoides*, d'A. & H.	...	...	...	×	...	...	
„	*filifera*, d'A. & H.	...	...	...	...	...	...	
„	*pratti*, d' A. & H.	...	...	...	...	...	...	
„	*subovalis*, d'Arch.	...	...	...	×	...	...	
„	*cyrenoides*, d'A. & H.	...	...	...	?	...	...	
„ ?	*pseudoargus*, d'A. & H.	...	×	...	...	...	...	This shell, as mentioned above, is a *Dosinia*.
Cardita	*obliqua*, d'Arch.	...	...	...	×	...	...	
„	*subcomplanata*, d'Arch.	...	...	...	×	...	...	
„	*dufrenoyi*, d'Arch.	...	...	...	...	...	...	
„	*beaumonti*, d'Arch.	...	...	...	...	...	×	Abundant and characteristic of the olive shales of this group.
„	*ovoides*, d'A. & H.	...	...	...	...	...	...	
„	*keyserlingi*, d'A. & H.	...	...	...	...	...	...	
„ ?	*funiculosa*, d'A. & H.	...	...	...	...	...	...	

* Several of the species of these genera are described and figured by d'Archiac and Haime from casts, and the specific characters are insufficient for determination.

Classes and Orders.		Groups.						Remarks.
Genera.	Species.	Manchhar.	Gáj.	Nari.	Khirthar.	Ranikot.	Cretaceous?	
Cardita . .	*sowerbyi*, d'Orb. .	...	?	...	...	...	...	This fossil Sowerby mistook for *C. intermedia*, Lam.
,, . .	*depressa*, d'A. & H. .	...	...	...	×	...	...	
,, . .	*mutabilis*, d'A. & H. .	...	...	...	×	...	...	
Cardium . .	*ambiguum ?* C. Sow. .	...	...	...	...	...	...	
,, . .	*brongniarti*, d'Arch. .	...	..	...	...	...	...	
,, . .	*halaense*, d'A. & H. .	...	...	...	...	...	...	
,, . .	*austeni*, d'A. & H. .	...	...	...	...	...	...	
,, . .	*greenoughi*, d'A. & H.	...	...	...	...	...	...	
,, . .	*sharpei*, d'A. & H. .	...	...	...	...	...	...	
,, . .	*picteti*, d'A. & H. .	...	...	...	×	...	...	
,, . .	*salteri*, d' A. & H. .	...	...	...	...	...	...	
,, . .	*anomale* (?) . .	...	?	...	×	...	...	Apud d' A. & H. sed non Mathéron. The fossil requires renaming and figuring.
,, . .	*limæforme*, d' A. & H.	...	...	...	×	...	...	
,, . .	*bunburyi*, d' A. & H. .	...	...	...	...	...	...	
,, . .	*horneri*, d' A. & H. .	...	...	...	...	...	...	
,, . .	*triforme*, C. Sow. .	...	×	×	...	...	...	
Cypricardia .	*carteri*, d' A. & H. .	...	...	...	×	...	...	
Arca . .	*hybrida*, C. Sow. .	...	×	...	...	...	...	From the transition beds at the top of the Gáj group, in Gáj river section.
,, . . .	*peethensis*, d' Arch. .	...	×	...	...	...	...	
,, . . .	*kurracheensis*, d' Arch.	...	×	...	...	...	...	
,, . . .	*subfiligrana*, d'A. & H.	...	...	...	...	...	...	
,, . . .	*burnesi*, d' Arch. .	...	...	...	?	...	...	
,, . . .	*larkhanaensis*, d'Arch.	...	×	...	...	...	...	
Pectunculus .	*pecten*, C. Sow. .	...	×	...	...	...	...	
,, .	*lima*, d' A. & H. .	...	...	...	...	...	...	
Nucula . .	*margaritacea*, Lam. .	...	...	...	×	...	...	

CLASSES AND ORDERS.		GROUPS.						REMARKS.
Genera.	Species.	Manchhar.	Gáj.	Nari.	Khirthar.	Ranikot.	Cretaceous?	
NUCULA . .	*studeri,* d' Arch. .	...	×	...	...	...	...	From the transition beds, Gáj river section.
CHAMA . .	*brimonti,* d' A. & H. .	...	...	...	×	...	...	
,, . .	*geslini,* d' A. & H. .	...	...	...	×	...	...	
MYTILUS . .	*lithophagus,* Linn.? .	...	...	...	...	...	...	
,, . .	*subobtusus,* d' Arch. .	...	...	...	...	...	...	
,, . .	*nummuliticus,*d'A.&H.	...	...	...	×	...	...	
PECTEN . .	*corneus,* C. Sow.? .	...	×	...	...	...	...	It seems desirable to adopt d' A. & H.'s suggestion, and call the Sind shell *sub-corneus.*
,, . .	*bouei,* d' Arch. .	...	×	...	...	...	...	
,, . .	*favrei,* d' Arch. .	...	×	...	...	...	...	
,, . .	*labadyei,* d' A. & H. .	...	...	×	...	...	...	
,, . .	*hopkinsi,* d' A. & H. .	...	...	×	...	...	...	
SPONDYLUS .	*rouaulti,* d' Arch. .	...	...	...	×	×	...	
,, . .	*tallavignesi,* d' Arch.	...	×	...	...	...	...	
,, . .	*geniculatus,* d' A. & H.	...	...	...	...	...	...	
OSTREA . .	*multicostata,* Desh., var. . . .	...	×	×	...	...	...	A variable shell common in the Gáj group; a dwarfed variety occurring in Nari beds.
,, (GRYPHÆA)	*vesicularis,* Lam. .	...	...	...	×	×	...	The Khirthar variety Sowerby named *Gryphœa globosa.*
,, . .	*lingua,* C. Sow. .	...	?	...	...	...	..	
,, . .	*subdeltoidea,* d' A. & H.	...	...	...	...	...	...	Not figured in d' A. and H.'s work. It is probably a Gáj fossil.
,, . .	*angulata,* C. Sow. .	...	...	...	...	...	...	Apparently a variety of *O. multicostata.*
,, . .	*flemingi,* d' A. & H. .	...	...	...	...	...	×	The typical *flemingi,* and also a strong variety, occur in Ranikot beds.
VULSELLA .	*legumen,* d' A. & H. .	...	...	...	×	×	...	

Classes and Orders.		Groups.						Remarks.
Genera.	Species.	Manchhar.	Gáj.	Nari.	Khirthar.	Ranikot.	Cretaceous ?	
BRACHIOPODA.								
Terebratula	indet.	...	...	...	...	×	...	There are two species from the Ranikot beds.
GASTEROPODA.								
Melania	*stygii*, Brong.	...	...	...	...	...	...	The figure is a very doubtful cast.
Nerita	*schmideliana*, Chemn.	...	...	...	×	×	...	Abundant in the Khirthar group. The shell properly belongs to *Velates*, a sub-genus of *Neritina*.
,,	*affinis*, d'A. & H.	...	...	...	...	×	...	
,,	*haliotis*, d'A. & H.	...	...	...	...	?	...	Very near, if not identical.
Natica	*glaucinoides*, Desh. ? var.	...	...	...	...	...	...	
,,	*cepacæa*, Lam.?	...	...	...	...	...	...	
,,	*patula*, Desh.?	...	...	×	×	×	...	
,,	*sigaretina*, Desh.?	...	...	×	×	×	...	
,,	*dolium*, d'A. & H.	...	...	...	...	...	...	
,,	*mutabilis*, Desh.?	...	...	...	...	...	...	d'A. and H. refer to this species J. Sowerby's *N. depressa*. A specimen from Ranikot beds more closely resembles the latter species.
,,	*decipiens*, d'A. & H.	...	...	×	...	×	...	
,,	*rouaulti*, d'A. & H.	...	...	...	..	?	...	
,,	*longispira*, Leym.	...	...	...	...	×	...	
,,	*angulifera*, d'Orb.	...	...	...	×	×	×	
,, ?	*subacutella*, d'A. & H.	...	...	...	...	...	...	
,,	*obscura*, C. Sow.	...	?	...	...	...	...	
,,	*flemingi*, d'A. & H.	...	...	...	...	×	...	
,,	*epiglottina*, Lam.?	...	...	...	...	×	...	
Ringicula ?	indet.	...	...	...	...	...	..	

CLASSES AND ORDERS.		GROUPS.						REMARKS.
Genera.	Species.	Manchhar.	Gáj.	Nari.	Khirthar.	Ranikot.	Cretaceous ?	
SILIQUARIA .	*granti*, C. Sow. .	...	...	×	...	...	...	
SCALARIA .	*subtenuilamella*, d'A. & H. . . .	...	×	...	...	...	...	
,, . .	*sedgwicki*, d'A. & H. .	...	...	...	...	...	...	
DELPHINULA .	*cordieri*, d' Arch. .	...	...	...	...	×	...	
,, . .	*coulthardi*, d' A.&H. .	...	...	...	...	...	...	
SOLARIUM . .	*affine*, C. Sow. . .	...	...	×	...	...	...	
,, . .	*euomphaloides*, d' A. & H. . . .	...	...	×	...	...	...	
TROCHUS . .	*cognatus*, C. Sow. .	...	×	...	...	...	...	
,, ? . .	*subcognatus*, d' A.&H.	...	?	...	...	...	...	
,, ? . .	*loryi*, d' A. & H. .	...	...	...	...	...	...	
,, ? . .	*desmoulinsi*, d' A.&H.	...	...	...	...	...	...	
,, . .	*agglutinans*, Lam. .	...	...	...	...	...	...	
,, . .	*cumulans*, Brong.? var. *a* . . .	...	...	×	...	...	...	
PLEUROTOMARIA?	*bianconii*, d' A. & H.	...	×	...	...	...	...	
TURBO . .	*martinsi*, d' Arch. .	...	...	...	...	?	...	A fragment only.
PHASIANELLA .	*oweni*, d'A. & H. .	...	...	×	?	...	...	
,, ? .	*scalaroides*, d' A.&H.	...	...	...	...	...	...	
TURRITELLA .	*angulata*, C. Sow. et var. . . .	...	×	×	...	×	...	
,, . .	*deshayesi*, d' Arch. .	...	...	×	...	...	...	
,, . .	*affinis*, d' A. & H. .	...	...	×	...	...	...	
,, . .	*renevieri* d' A. & H. .	...	...	...	...	×	...	
,, . .	*heberti*, d' A. & H. .	...	...	...	...	...	...	
,, . .	*collombi*, d' A. & H. .	...	...	...	...	...	...	
,, . .	*subfasciata*, d' A.&H.	...	×	...	...	...	...	
VICARYA . .	*verneuili*, d' Arch. .	...	×	...	...	...	...	
CERITHIUM .	*rude*, C. Sow. . .	...	×	×	...	...	...	

CLASSES AND ORDERS.		GROUPS.						REMARKS.
Genera.	Species.	Manchhar.	Gáj.	Nari.	Khirthar.	Ranikot.	Cretaceous?	
CERITHIUM	*pseudocorrugatum*, d' Orb.	...	...	×	...	...	...	
,,	*subsemicostatum*, d'A. & H.	...	...	...	...	...	...	
,,	*helli*, d'Arch.	...	...	...	...	?	...	
,,	*subnudum*, d'A. & H.	...	...	...	...	...	...	This and the four next species are said to be very rare, and do not appear to be in the Survey collections.
,,	*kayei*, d'A. & H.	...	...	...	...	...	...	
,,	*subbacillum*, d'A. & H.	...	...	...	...	...	...	
,,	*subfiliferum*, d'A. & H.	...	...	...	...	...	...	
,,	*subtrochleare*, d'A. & H.	...	...	...	...	...	...	
,, ?	*delbosi*, d'A. & H.	...	...	...	×	...	...	
PLEUROTOMA	*voyseyi*, d'A. & H.	...	...	...	...	...	...	
TURBINELLA	*affinis*, C. Sow.	...	×	...	...	...	...	Our shell does not quite agree with Sowerby's figure, but is probably the same species.
FASCIOLARIA	*hexagona*, d'A. & H.	...	...	...	...	×	...	
FUSUS	*nodulosus*, C. Sow.	...	...	...	...	×	...	
,,	*subregularis*, d'A. & H.	...	...	...	...	...	...	
,, ?	*mixtus*, d'A. & H.	...	...	...	×	?	...	The Ranikot fossil is a cast only.
,, ?	*bucklandi*, d'Arch.	...	...	...	...	...	...	
,, ?	*granosus*, C. Sow.	...	...	...	...	...	...	The small figure given by Sowerby much resembles our "buccinoid shell" from the Ranikot beds, but his description does not tally and is insufficient.
RANELLA	*morrisi*, d'A. & H.	...	...	...	...	...	...	
,,	*viperina*, d'A. & H.	...	...	...	...	...	...	
MUREX	*lyelli*, d'A. & H.	...	...	...	...	...	...	
,,	*tchihatcheffi*, d'A. & H.	...	...	...	...	...	...	

CLASSES AND ORDERS.		GROUPS.						REMARKS.
Genera.	Species.	Manchhar.	Gáj.	Nari.	Khirthar.	Ranikot.	Cretaceous?	
MUREX	*rœmeri*, d'A. & H.	...	×	...	...	...	...	
"	*halli*, d'A. & H.	...	×	...	...	...	...	
TRITON	*davidsoni*, d'A. & H.	...	×	×	...	...	...	
ROSTELLARIA	*prestwichi*, d'A. & H.	...	...	...	×	×	...	
"	*fusoides*, d'Arch.	...	...	...	×	×	...	
"	*columbaria*	...	...	...	×	×	...	(Apud d'A. & H., but not the true *columbaria* of Lam.); this fossil requires renaming and figuring.
"	*angistoma*, d'A. & H. et var.	...	...	...	...	×	...	
"	*jamesoni*, d'A. & H.	...	...	...	...	×	...	
STROMBUS	*deperditus*, C. Sow.	...	...	...	...	...	...	
"	*nodosus*, C. Sow.	...	×	...	...	...	...	
"	*fortisi*, Brong.?	...	...	...	...	...	...	
CASSIDARIA	*carinata*, Lam.?	...	...	...	...	×	...	
"	*desori*, d'A. & H.	...	...	...	...	×	...	
CASSIS	*subharpæformis*, d'A. & H.	...	...	...	...	...	...	
"	*sublævigaster*, d'A. & H.	...	...	...	...	...	...	
"	*philipsi*, d'A. & H.	...	...	...	...	×	...	
BUCCINUM	*vicaryi*, d'A. & H.	...	×	...	...	...	...	
"	*falconeri*, d'A. & H.	...	×	...	...	...	...	
"	*cautleyi*, d'A. & H.	...	×	...	...	...	...	
"	*fittoni*, d'A. & H.	...	...	...	...	...	...	
"	*jelalpoorense*, d'A. & H.	...	...	...	?	...	...	
TEREBRA	*contorta*, d'A. & H.	...	...	...	?	×	...	
VOLUTA	*jugosa*, C. Sow., et var.	...	...	×	×	×	...	

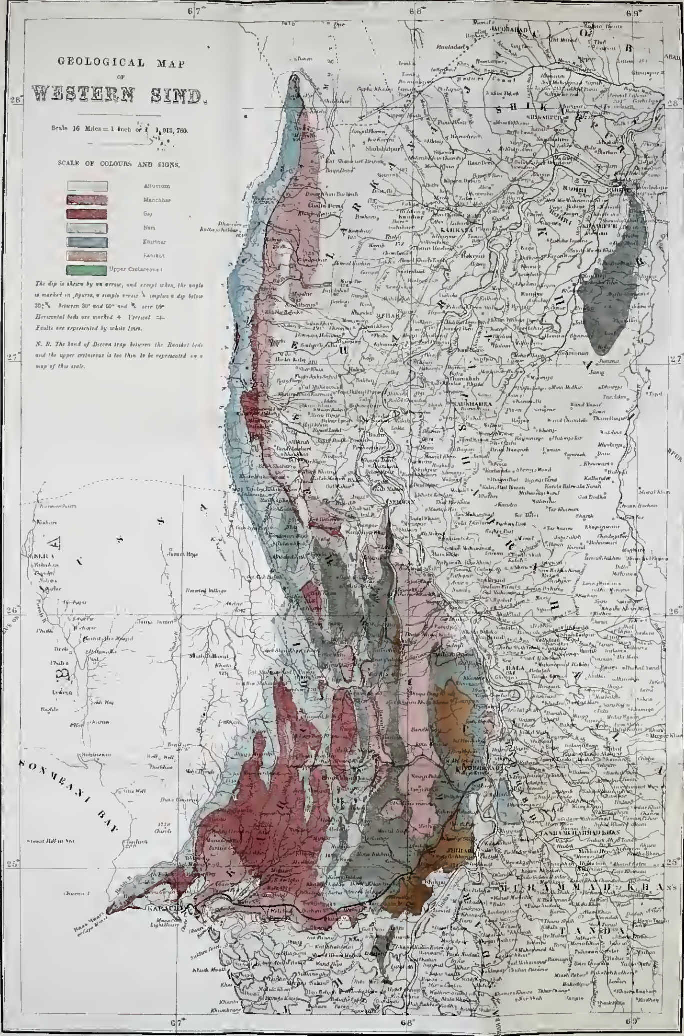
Classes and Orders.		Groups.						Remarks.
Genera.	Species.	Manchhar.	Gáj.	Nari.	Khirthar.	Ranikot.	Cretaceous?	
VOLUTA	*edwardsi*, d' Arch., et var.	...	×	...	...	...	...	
,,	*dentata*, C. Sow., var.	...	...	×	...	...	...	
,,	*sykesi*, d' A. & H.	...	...	...	...	?	...	
,,	*cythara*, Lam.	...	...	...	...	...	...	
,,	*haimei*, d' Arch.	...	...	...	...	×	..	
,,	*sismondai*, d' Arch.	...	...	...	...	...	...	
,,	*multidentata*, d' A. & H.	...	...	...	×	...	...	
,,	*humberti*, d' A. & H.	...	...	...	...	?	...	
,,	indet.	...	...	...	...	×	...	d'A. & H. pl. XXXII, fig.6.
,,	*teelaensis*, d' A. & H.	...	...	...	...	×	...	
,,	*salsensis*, d' A. & H.	...	...	...	...	×	...	
OVULA	*depressa*, d' Arch.	...	...	...	...	...	...	
,,	*murchisoni*, d' Arch.	...	...	...	×	...	...	
,,	*ellipsoides*, d' Arch.	...	...	...	×	×	...	
,,	*cylindroides*, d'A. & H.	...	...	...	...	...	...	
,,	*expansa*, d' A. & H.	..	...	...	...	?	?	
,,	*elongata*, d' A. & H.	...	...	...	...	...	...	
CYPRÆA	*humerosa*, C. Sow.	...	×	...	...	...	...	
,,	*prunum*, C. Sow.	...	×	×	...	...	...	
,,	*digona*, C. Sow.	...	...	×	.	...	...	
,,	*granti*, d' Arch.	...	...	×	...	...	...	
,,	*jenkinsi*, d' A. & H.	...	...	...	...	...	...	
,,	*nasuta*, C. Sow.	...	...	×	...	...	...	
TEREBELLUM	*obtusum*, C. Sow.	...	...	×	...	...	...	
,,	*subbelemnitoideum*, d' A. & H.	...	...	...	...	×	...	
,,	*distortum*, d'A. & H.	...	...	?	×	×	...	
,,	*plicatum*, d'A. & H.	...	...	...	...	×	...	

Classes and Orders.		Groups.						Remarks.
Genera.	Species.	Manchhar.	Gáj.	Nari.	Khirthar.	Ranikot.	Cretaceous?	
Oliva	*pupa*, C. Sow.	...	×	...	...	×	...	Apud Sow., from Gáj beds; apud d'Arch., from the Ranikots.
"	*virginiæ*, d'A. & H.	...	...	...	...	...	...	
Conus	*militaris*, C. Sow.	...	?	...	...	...	...	
"	*brevis*, C. Sow.	...	...	...	...	...	...	
"	*subbrevis*, d'A. & H.	...	×	...	...	...	...	
CEPHALOPODA.								
Nautilus	*subfleuriausianus*, d'Arch.	...	...	...	...	×	?	
"	*deluci*, d'Arch.	...	...	...	...	×	...	
"	*labechei*, d'A. & H.	...	...	...	×	×	×	
"	*forbesi*, d'A. & H.	...	...	...	...	×	?	A species near *forbesi* occurs in Nari beds.
ANNULOSA.								
ANNELIDA.								
Serpula	*recta*, C. Sow.	...	×	×	×	...	...	This is a *Kuphus* tube, not a *Serpula*.
"	*spirulæa*, Lam.	...	...	...	...	...	...	
"	*keertarensis*, d'A. & H.	...	...	...	...	...	...	
"	*gundavaensis*, d'A. & H.	...	...	...	...	...	...	
CRUSTACEA.								
Arges	*murchisoni*, Miln.-Edw.	...	...	...	×	...	...	Milne-Edwards considers these two the male and female of one species which he has formed into a new genus *Galenopsis*, retaining *murchisoni* as specific name.
"	*edwardsi*, d'A. & H.	...	...	...	×	...	...	
Balanus	*sublævis*, C. Sow.	...	×	...	...	...	...	


MAP OF INDIA
SCALE.
100 80 60 40 20 0 100 200 Miles
LEGEND.
1 Bari Doab Canals.
2. Sirhind "
3. Western Jumna "
4. Eastern "
5. Gangas "
6. Agra "
7. Lower Ganges "
8. Dun "
9. Betwa Canals.
10. Soane "
11. Midnapore "
12. Orissa "
13. Mutha System
14. Nira "
15. Ekruk Tank.
16. Ashti "
Irrigation Canals
66° 70° 74° 78° 82° 86° 90° 94° 98°
32° 28° 24° 20° 16°
AFGHANISTAN
BELUCHISTAN
GREAT TIBET
HIMALAYA MTS.
PUNJAB
N. W. PROVINCES
OUDH
RAJPUTANA
SIND
BOMBAY
AGENCY
CENTRAL INDIA AGENCY
BUNDELKUND
GUZERAT
CENTRAL PROVINCES
CHOTA NAGPORE
BENGAL
ASSAM
LOWER BURMA
UPPER BURMA
NIZAM'S DOMINIONS
HYDERABAD
MADRAS PRESIDENCY
ARABIAN SEA
BAY OF BENGAL
Mouths of the Ganges
Vindhia Hills
Western Ghats
Eastern Ghats
Indus River
Jhelam River
Chenab River
Ravi River
Sutlej River
Jumna River
Ganges
Soane River
Brahmaputra River
Mahanadi River
Godavery River
Irrawadi River
PESHAWUR
SRINAGAR
JAMOO
KANDAHAR
QUETTA
LAHORE
AMRITSAR
SIMLA
MOOLTON
ROORKEE
DELHI
ALLYGURH
AGRA
LUCKNOW
JEYPORE
JEYSULMERE
AJMERE
JHANSI
ALLAHABAD
PATNA
DARJEELING
KURRACHEE
Mt. Abu
BARODA
INDORE
CALCUTTA
NAGPUR
CUTTACK
BOMBAY
POONA
HYDERABAD
MANDALAY
RANGOON

Memoirs Vol. XVII.

Blanford. *GEOLOGICAL SURVEY OF INDIA.* Memoirs Vol. XVII



Taken from the Engraved Map [illegible] Scale 16 Miles = 1 Inch.

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Calcutta April 1879.

MEMOIRS

OF THE

GEOLOGICAL SURVEY

OF

INDIA.

MEMOIRS

OF THE

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OF

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NOTICE.

Some passages of the present Memoir were marked for omission or complete revision. As now modified by the author (pp. 4 to 7), they are allowed to stand, by his desire; but even in their present form some elucidation is called for. As remarks to the same effect have already been made public elsewhere, under the title "Recent Publications of the Geological Survey of India," it would be independently desirable to notice those statements, although any one who would take the trouble to sift the publications referred to could hardly fail to take a correct view of the case.

2. His study of the Salt-range fossils finally determined Dr. Waagen (Pal. Ind., Ser. XIII—1) to adopt for certain deposits a grouping essentially different from that given in Mr. Wynne's recently published memoir on that ground, an examination of the stratigraphical conditions having satisfied him that such a step would be justifiable, as is clearly explained (*l. c.*, pp. 7, 8). The step is a very bold one—to treat as one series beds hitherto accepted as carboniferous with others that had been announced as silurian. The risk and responsibility of the attempt might have warned against captious objections, as they certainly removed it from any suspicion of frivolous change for the sake of novelty. It was quite essential that Dr. Waagen should exhibit the full significance of the change he had to propose; but Mr. Wynne complains that in this process *his* representation of the former classification has been misstated and his irresponsibility for it ignored. As editor of Dr. Waagen's text

in the Palæontologia Indica, I should hold myself responsible for any such errors; but I am quite satisfied that they do not occur.

3. As regards the question of responsibility: there was no chance that Mr. Wynne would be held accountable for the identification of the *Obolus* as a silurian fossil; but as a geologist he *is* responsible for forming or for adopting the opinion that certain beds are of silurian age, on the evidence of a single Brachiopod; and it would have been quite uncalled for in Dr. Waagen to have disputed such an opinion in a geologist of Mr. Wynne's standing; an opinion in which he did not stand alone, Dr. Oldham having announced the same conclusion (Records, VII, p. 64), which was not an unreasonable one in a provisional way, and apart from the consideration of collateral evidence. It was, however, especially incumbent on Mr. Wynne to examine, exhibit, and be guided by the stratigraphical features for or against such a correlation of the groups; and it is presumable that he is satisfied in both respects, for in the present memoir the silurian age of the lower deposits is still affirmed (p. 90); the point is, indeed, as yet not finally disposed of. But this question of responsibility is a secondary point in the argument as now presented by Mr. Wynne.

4. It is upon the point of misrepresentation that most stress is laid, and Mr. Wynne puts himself in an unaccountable dilemma: from a position that is quite plausible and logical, if not sound, he assumes one that is illogical and unintelligible. Both in his table of the Salt-range series, which for the part under discussion Dr. Waagen reproduces exactly, and in his text, Mr. Wynne in the fullest sense declares the silurian age of the *Obolus* bed: at page 68 (Memoirs, Vol. XIV), he mentions the *Obolus* as "determined by

Dr. Stoliczka, thus indicating an age not newer than silurian"; and at page 280 he speaks of his tabular series as "comprising thirteen main divisions, of which nine are distinctly referable, each to one of the thirteen principal formations known to geology; and the ages of four are less accurately ascertained." Let this be compared with the statement on page 5 of the present memoir—"In chapter III of my report, when describing the stratigraphical series of the Salt-range, I avoided using the word '*formations*' lest it should convey too much of identity with the geological scale elsewhere, calling the sub-divisions instead 'rock-groups.'" It is true the passage quoted from p. 280 of the Salt-range memoir does not occur in chapter III; but Mr. Wynne would hardly claim this evasion; and he refers to this page himself as supporting his contradiction of Dr. Waagen's statement that the local divisions were treated in the Salt-range memoir as "real formations equal in importance to silurian, devonian, etc.," and the older division "as equivalent to the whole palæozoic series, as it has been defined in Europe and elsewhere." It seems to me impossible to take Mr. Wynne's account in any other way than that he objects to. The auxiliary use he makes of the term 'rock-group' does not affect the main position. It is quite clear that the indeterminate 'rock-groups' were not called after standard formations, simply because direct evidence was wanting, not from any doubt as to their comparative position in his local palæozoic series, between a true silurian and a true carboniferous horizon; and Dr. Waagen's words can mean no more than this.

5. Mr. Wynne's complaint of the treatment his work has received in the Manual of the Geology of India is quite on a par with the preceding: the impression regarding the distinct

assemblage of cretaceous rocks at Chicháli was taken from his own most distinct expression of it in the tabular list at p. 276 of the Salt-range memoir. The statement regarding the unconformity at the Indus was taken from his admirable illustration of it in his ideal section at p. 69, such sections being always understood to represent the original conditions of the deposits, unaffected by dislocations. The word 'unconformity' is used in the manual, as it is defined in the glossary appended thereto, to include marked overlap—the absence of deposits that are largely developed in adjoining ground. Mr. Wynne uses it in a restricted sense only; and from his own type sections he appeals to obscure passages in his text that might mean something different. But even granting the facts he would make of such importance—the few inches or feet of conglomerate between the limestone and the salt-marl at the Indus, and the absence of denudation at the top of the nummulitic group in the east Salt-range—unconformity, as required in the manual, would hold good.

6. As this notice has to appear, one specific caution may be added, as to the use Mr. Wynne makes of the term *Subathu* at p. 56 and elsewhere. The Subathu group was instituted for the nummulitic rocks at Subathu, brought to notice by Vicary. They there rest directly upon the slates of the lower Himalaya, and pass up transitionally into the red clays of the Dagshai group. The calcareous element is very subordinate, at the base of the group, in this its original area. From Subathu it has been traced interruptedly to the north-west, having the same composition and relations, into the Jamu sub-Himalayan region, and its basal beds here have been specifically identified (Records, IX, p. 57) with the lowest nummulitic beds at the

east end of the Salt-range. In this range these nummulitic deposits are, at least locally, in transitional relation with upper mesozoic rocks (Mem., XIV, p. 103), and Mr. Wynne sometimes (Rec. X, p. 113) classes them as lower nummulitic. There is thus a strong presumption that the older nummulitic deposits are represented at Subathu, and it was to those bottom beds that the name Subathu was especially applied, including any overlying deposits with marine nummulitic fossils. Mr. Wynne's first acquaintance with recognised Subathu beds was near Murree, where the upper beds, transitional with the Murree (or Dagshai ?) group, are well exposed, the bottom limestones being at the same time greatly expanded; and he has ever since endeavoured to restrict the term Subathu to the upper beds: a conspicuous instance of this occurs in the present Memoir, p. 56, where he speaks of "the nummulitic limestone and Subathu beds," the bottom bed of the latter being a coarse conglomerate of nummulitic debris, shown (pp. 19, 20) to be at least in part post-eocene. It is apparently the same rock as at the disputed unconformity in the Salt-range; and it might be confounded with the conglomerate placed as "Siwalik ?" resting unconformably upon triassic rocks (pp. 60—62). If there were a distinct proposal made to sub-divide the original nummulitic group of Subathu, in the west if not in the east, the position would be intelligible; but as it is, there is manifest confusion, against which Mr. Wynne should have forewarned the reader.

H. B. MEDLICOTT,
Superintendent, Geological Survey of India.

CALCUTTA,
January 1880.

PREFACE.

The Survey Memoir upon the geology of the Salt-range having been published, after long delay, almost simultaneously with the conclusion of the examination of the extension of this range from the river Indus to the British frontier, through the Bannu and Dera Ismail Khan hills, may enable the present memoir with its accompanying map to appear so soon after that relating to the cis-Indus portion of the range as to form a supplement not greatly removed in the consecutive order of the Survey publications.

In view of the connexion between the Salt-range proper and its prolongation, I have sought to keep the supplementary character of the present memoir in view, and thus to avoid unnecessary recapitulation as much as possible.

It is to be regretted that I am unable to furnish fuller observations upon the fossils of the district, regarding which palæontological details may be expected when the fossils of the whole Salt-range region have undergone examination, already commenced and in competent hands. For any specific determinations given in the following pages, I am under obligation to Dr. Feistmantel, Palæontologist to the Survey.

Some of the views advanced upon the geology of the Punjab in the Survey Manual lately published, and which relate to this district, will be found less confidently stated or differently regarded. So far as they admit of doubt, it is well to have more opinions than one.

A. B. WYNNE.

Murree,
May 1879.

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CHAPTER II.—RELATIONS BETWEEN STRUCTURAL GEOLOGY AND FORM OF GROUND.

CHAPTER III.—GEOLOGY.

PART II.—DETAILED DESCRIPTIONS.

LIST OF ILLUSTRATIONS.

A. B. Wynne fecit

J. Schaumburg, Lith.

SHEKH BUDÍN HILLS, FROM THE SOUTH.

MEMOIRS

OF THE

GEOLOGICAL SURVEY OF INDIA.

ON THE TRANS-INDUS EXTENSION OF THE PUNJAB SALT RANGE,

by A. B. WYNNE, F.G.S., &C., *Geological Survey of India.*

[In continuation of the Salt Range Memoir by the same (Mem. Geol. Surv., Vol. XIV).]

PART I.

CHAPTER I.—INTRODUCTORY.

It is customary in these memoirs to mention the writings of previous observers; in the present case they have been few, so far as I am aware, and none have treated of the local geology, either comprehensively or exhaustively. Dr. Fleming, in his valuable papers on the Salt Range (Journal, Asiatic Society, Bengal, Vols. xvii, xviii, and xxii), makes many allusions to the geology of the trans-Indus extension of this range; and Dr. Verchere, in his long paper upon the Western Himalaya and Afghan mountains, and another, in the Journal of the same Society, Vols. xxxiv, xxxv, and xxxvi, pages 42, 89, 90, &c., describes a section across the Maidán range, Shekh Budín hill, and parts of the adjacent ranges. Dr. Oldham[1] and Dr. Warth[2] have written upon the neighbourhood of Kálabágh, and Dr. Costello has given a paper, in the Journal of the

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[1] Memorandum: Results of a cursory examination of Salt Range.—Report to Government of India, 1864.

[2] Report, administration, Inland Customs, Appendix, 1870-71.

Asiatic Society of Bengal,[1] upon Shekh Budín, with some allusions to other parts of the region.

Dr. Fleming.

Dr. Fleming's references to this district extend to the northern part of the Khasor range, where he records the contact of the tertiary sandstones and clays with the carboniferous limestone,[2] and notices saliferous sandstones appearing from beneath the latter. These he took to represent his Devonian rocks (the saline series) east of the Indus. He mentions with more detail the rocks of the Chicháli pass and range, and those near Kálabágh, giving sections of parts of both localities; but his most detailed records will be found in passages treating of the coal and alum of the hills near Kálabágh and Kotli. His accounts exhibit a general accuracy of observation, but he seems to have been led, by a desire to assimilate the ground he studied with the geological systems of other countries, to conclusions that have somewhat reduced the completeness of his work, which nevertheless retains a marked superiority over all the early records of Northern Indian geology with which I am acquainted.

Dr. Verchere.

In his first paper (Journal, Asiatic Society, Bengal, Vol. xxxiv, page 42) above mentioned, Dr. Verchere describes a section across the Maidán range, of which he gives a map. In neither of these are the jurassic beds present recognized as such; and the detrital covering of the uppermost conglomeratic portion of the Siwalik rocks concealing, as usual, much of the relations of the beds themselves, are described as moraines. The conglomerate band at the top of the eocene limestone is noticed, and several analyses are given of the lignites which occur associated with the lower eocene and jurassic alum shales.

In his later and larger paper his description of the ranges beyond the Indus, towards and including Shekh Budín hill, can be fairly followed by one who knows the ground; but the discrepancies of his details are nearly

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[1] Journal, Asiatic Society of Bengal, Vol. XXXIII, p. 378.

[2] In which he included the Ceratite beds.

as marked as the similarities when compared with obvious facts. He relates that the carboniferous limestone along the Khasor (or Ratta Roh) range rests on a peculiar bed, a certain micaceous quartzite which he never found *in situ,* but still identifies with a sub-carboniferous rock stated to occur in Kashmir. As I have also entirely failed to find such a rock in the series, though I have seen the junction of the carboniferous and next lower beds, if he does not refer to erratic (*i. e.,* travelled) fragments perhaps derived from the sub-carboniferous boulder-beds, I am at a loss to reconcile his reading with the facts of the case.

Again, the variegated rocks of the jurassic formation towards the southern part of the Khasor range are erroneously referred by Dr. Verchere to his supposed triassic Salt Range saline series. Further on he gives a somewhat imaginative description of the rocks supposed by Fleming to represent this saline series at the northern end of the same range, and by himself to form an intrusion of 'felspathic paste.' He appears to have missed detecting the palpable stratification of these sandstones, &c.

In describing the Shekh Budín hill, Dr. Verchere correctly refers the mass of the strata to the jurassic formation, whether "Oxfordian" or not still remains to be decided from a proper examination of the fossils. Here again he sees in the variegated portion of the jurassic group the saline series of the Salt Range,[1] but omits to record the presence of the highly fossiliferous triassic and carboniferous beds beneath, till a subsequent paper in January 1869, in which the latter are referred to. It is, however, uncertain if this paper has been published.[2]

In a section which he gives of Shekh Budín, the anticlinal and complementary synclinal curves of the locality are exaggerated into eight folds separated by suppositious faults.

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[1] The erroneous identification of the Salt Range saline series, here and above at both ends of the Khasor range, is quoted on Dr. Verchere's authority in the Geological Survey Manual at p. 487.

[2] This record would appear to have escaped notice in the Geological Survey Manual (*see* p. 491). I have only had a MS. extract from it.

Dr. Oldham.

The late lamented chief of our survey, Dr. Oldham, was deputed in 1864 to inspect the coal of the Salt Range, and in his report to Government he described the coal localities of Kálabágh, Kotli, Chushmea, and Mulla Khel, pointing out that the coaly beds occur on two distinct horizons, one in the jurassic, the other at the base of the eocene rocks, and specially noticing the inferiority of these coal sources in an economic point of view. He also added some valuable observations upon the management of the rock-salt mining operations of the Salt Range generally.

Dr. Warth.

Dr. Warth, formerly in charge of the Salt Range Salt Department, in an appendix published with the administration report of the Inland Customs Department, 1870-71, describes the salt quarries of Kálabágh as open workings in a thick group of salt beds ranging from 4 to 10 or even 20 feet in maximum thickness. These salt beds run along the western side of the Lún nala for 2 miles, extending up the side of the gorge as high as 200 feet, and dipping to the west at 70°. There are fourteen working places in this group of rock-salt beds. Dr. Warth's notes, though short, are correct, and therefore valuable.

Dr. W. Waagen.[1]

In the Palæontologia Indica, Series ix, page 245, Dr. Waagen records the occurrence of *Perisphinctes asterianus*, a lower neocomian form of Ammonite, in the Chicháli pass, deducing thence that this lower cretaceous horizon is represented here. My observations with regard to the indication of a cretaceous or neocomian horizon among the uppermost few feet of the jurassic rocks at Chicháli Pass are given at page 277 of the Salt Range Memoir.

At the time Dr. Waagen and myself visited this section, the identification of the *Ammonite* above mentioned appeared sufficient to show that an overlying mass of unfossiliferous sandstone intervening between the jurassic and eocene groups was probably cretaceous. Since then I have

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[1] For elucidation of Mr. Wynne's remarks in this and the following section the reader is referred to the Notice prefixed to this Memoir.

seen reason to doubt its being entirely so, if not there, at least elsewhere trans-Indus.

Another number of the Palæontologia Indica, Ser. xiii, fasc. 1, has been recently issued, in which Dr. Waagen introduces his descriptions and figures of the Salt Range fossils, with several observations upon the geology of the Salt Range and upon my classification of its rocks as well as other matters. The intimate connection between the Salt Range series and its continuation in the trans-Indus hills is sufficient ground for noticing here the manner in which misrepresentations and errors are attributed to me and to the language of my report.

It is repeatedly endeavoured to be shown that I have illogically represented the Salt Range series to be the full equivalent of the formations composing the geological scale elsewhere. This is simply not the case. I have referred the various fossiliferous formations of the series to different geological horizons upon the evidence afforded by the palæontological officers of the survey (of whom Dr. Waagen was one), and by other palæontologists also, as to the fossil fauna of each group. My general classification was made known to Dr. Waagen; and to none of the separations as to age or position did he then offer the least objection.

In chapter iii of my Report, when describing the stratigraphic series of the Salt Range, I avoided using the word "*formations*" lest it should convey too much of identity with the geological scale elsewhere, calling the sub-divisions instead "rock groups." I mentioned (pages 280, 281, of Report) merely the periods to which the divisions may be referred, and distinctly stated that " there is no reason why either of the two groups beneath the carboniferous should be called devonian or old-red-sandstone." From this alone it will be seen how impossible is the statement that I considered the whole palæozoic series represented.

Dr. Waagen now proposes a triple classification, in which nothing more definite as to age is indicated than that the uppermost division, including groups 9 and 10 of my list, is composed of newer mesozoic formations, while the silurian group, determined by Drs. Oldham and

Stoliczka and confirmed by himself from my discovery therein of *Obolus* (see Salt Range Memoir, page 68), is bracketed together with the "productus limestone," as well as the two unfossiliferous groups beneath this limestone.

In the footnote on page 3 of the paper under notice, it is said that I considered *Terebratula (Waldhemia) flemingi* to be carboniferous. This is an error: the settlement of such a point I left of course to the palæontologists of the survey, whose proper business it was, but I have pointed out the higher horizon at which the fossil was obtained on page 104 of my Report.

Geological Survey Manual.

In the recently published Manual of the Geological Survey, in the Introduction as well as in chapters xx and xxi, there are numerous scattered allusions, both directly and indirectly bearing upon the geology of this district, chiefly taken from pre-existing papers, but from want of correct observations on this trans-Indus region the references to its physical geography are more reliable than those to its geology. Regarding the latter, the reader will not be able to gather much information, most of the points noticed as taken from the accounts given by earlier observers sharing their inaccuracy or inadequacy.

The impression might be conveyed[1] that a distinct assemblage of cretaceous rocks ranging from lower neocomian to the upper (?) horizon of the olive group of the Salt Range, is present at Chichâli pass. At this place (see Salt Range Memoir, pages 105, 276, 277) one thick dark-coloured bed forms the top of the jurassic series, and in its upper part an *Ammonite* occurs, which has been determined by Dr. Waagen to be of neocomian age, while other *Ammonites* and *Belemnites* in the lower part of the *same bed* are on the same authority said to be jurassic. This dark zone is overlaid by a thick light-coloured sandstone previously referred to the cretaceous period, but it has furnished no fossils, and has been since found to occupy the same relative position

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[1] In the introduction at page xlix, and at pages 496 and 497.

as a similar rock further westward enclosing pebbles of nummulitic alveolina limestone.

At pages 487 and 488 the erroneous observations of others as to the distribution of the salt marl in the present district are quoted, and there is said to be no reasonable doubt as to this rock being sedimentary; with this latter statement I cannot entirely coincide.

In the introduction to the Manual at page xxiv, the salt marl is said to be immediately overlaid by the carboniferous limestone in the west Salt Range, and this relation is described as an unconformity between these groups. However much this may seem to be a local interpretation of the case at Kálabágh (trans-Indus), I have never found it to be so in the Salt Range (cis-Indus), and if such a relation existed, its importance would have claimed full notice. On the contrary, conformity is stated to mark the succession throughout; and in every Salt Range region to the westward where the normal relations of the rocks are described, other beds are shown to intervene between the salt marl and the carboniferous groups, while the conditions of contact near the Indus are stated to be those of dislocation. If the misconception arose from the appearance shown in the greatly contracted ideal diagram at page 69 of my Report, intended only to exhibit the distribution of the Salt Range groups,[1] it might have been corrected by the text at pages 53, 56, 58, 66, 86, 90, 93, and 258, particularly the third paragraph on page 90, where one of the intervening groups is said only to be lost amid complicated dislocations near Mári on the Indus.

Slighter inaccuracies, as to the existence of the carboniferous group at Shekh Budín and the trias in the Chicháli range, are to be found in the work at pages 491 and 493, the authority quoted being erroneous.[2]

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[1] In colouring this diagram to render it more distinct, I discovered an error, whether my own or the draughtsman's who copied it I am unable to say. The carboniferous group No. 6 should have been shown to thin out just beneath the dotted line under the Níla-wán in the profile above. It is, however, stated to commence there in the text, Salt Range Memoir, p. 95.

[2] In p. 493, line 11 from foot, there is a misprint of "west" for "east."

But at page 506 the reference to the newer part of the series is somewhat different from that observed. Over most of the district as well as in the Chicháli hills, I have been unable to discover any break amounting to definite unconformity above the nummulitic limestone, nor any denudation of its surface during tertiary times; parallel conformity, with indications here and there of a break in some adjacent area, on the contrary, seems to prevail, and this break may have existed even before the nummulitic period.

Some of these and other points regarding references in the Manual to the geology of this district will be found mentioned where necessary in the present paper.

A. B. Wynne.

In a short appendix to my Salt Range Report previously mentioned, I drew up a slight sketch of the structure of the ground beyond (west of) the Indus in the vicinity of the Salt Range; partly from what I had learned from Dr. Waagen of his investigations in that ground when I was not with him, partly from observations made while we were in company. The sketch, however, is imperfect, as it does not mention all the rocks since found to occur at the locality, the only reference to the carboniferous group being to an isolated mass of some 20 feet thick of this limestone which projects from the fault running up the middle of the Lún nala, while a considerable portion of the group also occurs in the hills near Kálabágh. A mass of nummulitic limestone likewise occurs in the Lún nala, faulted into its present position.

Other formations or groups are referred to in this appendix, and the section seen in Chichâli pass is described. In the latter a set of sandstone beds, apparently intermediate between jurassic and eocene, have been grouped as cretaceous.[1] It would have been better to have qualified this grouping with the statement that most of the zone so separated is unfossiliferous. The only cretaceous fossil as yet identified is that already referred to as occurring in the top of the same layer which contains jurassic

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[1] At the suggestion of Dr. Waagen.

fossils. The absence of organisms, so far as yet discovered, in the sandstone which here forms the principal member of the group, of course leaves its age an open question, and some part, if not the whole, might as well be cretaceous, as of any other immediately older or newer period.

Earlier observers.

Early allusions to the Kálabágh portion of the district will be found in the writings of Elphinstone, Burnes, Munshi Mohun Lal, and Dr. Jameson.[1] These refer chiefly to the salt, coal, alum, and gold of the district. The last-named writer has arrived at a correct conclusion as to the value of the coal; although his classification of the rocks upon which his opinion is based has been found inapplicable.[2]

PHYSICAL FEATURES.

Different opinions have been recorded as to where the true westerly extension of the Salt Range proper lies; most of the early writers having supposed that the occurrence of rock-salt in the hills of the Kohát district indicated the continuation of the range towards the Safed Koh mountains in Afghanistan. In the Geological Survey Memoir upon the Salt Range I have adopted the natural view that this escarpment, both orographically and geologically, has its continuation more to the southward, in the ranges bordering the Indus plains from Kálabágh on that river to the British frontier (previous to 1879) beyond the Baín-darra pass[3] northward from Tánk.

This portion of the northern wall of the Indian desert forms a sigmoid curve lying between the points just named, for the most

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[1] Elphinstone's Caubul, visited in 1808, Lond. 1815. Burnes, Sir A.: A Memoir: Geol. Soc., Lond., Proc. Vol. II, and Jl. As. Soc., Bengal Vol. XII, p. 564. Mohun Lal: Jl. As. Soc., Bengal, Vol. VII, p. 25. Jameson, Jl. As. Soc., Bengal, Vol. IX and XII.

[2] See introductory chapter, Salt Range Memoir, Mem. Geol. Surv. India, Vol. XIV.

In which travelling is unsafe without an armed escort, though daily patrolled, and protected by a fort at its south exit and a chain of towers along the line of road"—*Thorburn's Banu, or, Our Afghan Frontier.* During my inspection of this region in January 1879 the country was unusually disturbed, the town of Tánk was raided and burned, and other frontier posts were attacked by the hill tribes.

Form of mountains.

part strongly scarped towards the plains of the Indus, rising into broad lofty mountain summits northward of Kálabágh, and to the westward presenting a triple, double, or single range. Starting from Kálabágh the highest crests run north-by-west for 12 miles on each side of the Lún nala, a small tributary of the Indus; these crests, at first with considerable undulation, turn to the west-by-south for 22 miles, forming the Súrgarh[1] or Chicháli range, and the Shíngarh[2] and Lakargarh mountains to the north. Again, bending sharply south, the double chain of the Shíngarh and Chicháli ranges unites, continuing for more than 20 miles as the Maidán range to where the Kuram river issues from the Bannu basin at Tangdarra (literally, confined valley). Four miles south of the Kuram this chain bends again to the south-west, forming for about 26 miles the Níla Roh[3] part of the Marwat[4] range, as far as Shekh Budín, flanked by a confluent range 6 to 8 miles distant to the south-east, called the Ratta Roh[5] or Kíri-Khasor[6] ridge, which rises in part directly from the right bank of the river Indus. At Shekh Budín hill station the Níla Roh turns to the north-west at a right angle, and passing off through the low Bhattani ridge unites with the trans-frontier border hills of the Bannu and Dera Ismail Khan districts.

Súrgarh.

Their heights.

The northern ranges in the Kálabágh region have elevations up to 3,900 and 4,700 feet above the sea, according to Government maps; the cliffs of Dangot rise sheer 2,070 feet from the Indus, and there are many other lofty precipices among the Lakargarh and Shíngarh mountains, as well as along the southern escarpment of the Chicháli range. The highest summit of the Maidán scarp is over 4,200 feet, while the Indus, east of the inter-

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[1] Súrgarh, from *sur*, red, and *garh*, mountain.

[2] The Shíngarh is also called the Lowágarh range; "*shín*" in Pashtu means green.

[3] *Níla*, blue; *roh*, mountain.

[4] Mowrut of the inhabitants; name of a tribe.

[5] *Ratta*, red, *roh*, mountain; a misnomer for these hills.

[6] *Kíri*, a tent or hut encampment of the wandering tribes, who live chiefly on milk, which is called *kír*.

A B Wynne fecit.

J Schaumburg, Lith.

THE TAKHT-I-SULEMÁN, FROM PANIÁLA.

vening Isa Khel plain, has a level of 700 feet at Kálabágh, declining to 650 opposite the Khasor range. This last-named range is about 3,000 feet above the sea at its northern end, rising nearly a thousand feet higher to the southward before it terminates. The Níla Roh maintains a very regular height of nearly 3,000 feet, for most of its length, until it reaches Shekh Budín, where the massive clump of Makdúm Gúnd,[1] with two conspicuous parallel east and west lobes, rises suddenly to 4,516 feet,[2] far overtopping all the local elevations, though of less height than the Prangzai Sír (4,797 feet) of the Lakargarh Khatak mountains, north-westward from Kálabágh.

Surrounding regions.

To the north and north-west of this crooked and broken system of ranges lie the Kohát salt field and the open plain of the Bannu valley; to the east or south-east are the plain of Isa Khel and the river Indus, and to the south the sandy plains of the Deraját. Away to the west rise range after range forming, in the country of the *Yákí* (independent) tribes or of Afghanistan, the northern continuations of the Sulemán mountains, and including a conspicuous unevenly table-topped summit called the Takt-i-Sulemán, or throne of Solomon (Plate II).

Drainage.

In the Salt Range Memoir I have already noticed the peculiarity in the physical geography of the Upper Punjab, that the general southerly tendency of the drainage of the country is but slightly interfered with by the existence of that range. This observation may be repeated for the country under notice. The Indus itself intersects the whole range, after receiving the Kabul river, its largest affluent from the west; and the Kuram cuts right across the chain continuous with the Salt Range. A far smaller stream from the northward, making, however, a much deeper and narrower gorge, does the same at Chicháli pass, where the cañon called the *Darwáza* (or doorway) is eroded between limestone cliffs, at one spot

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[1] Gúnd, a peak or excrescence.

[2] In the latest maps this is given as 4,551 feet, so that probably 35 feet should be added to the rest of these elevations.

but 14 feet apart and from 300 to 500 feet in height immediately on either side (see Plate IV). A chasm of very similar character at the Barochi pass near Mulla Khel leads some local drainage across the run of the hardest rocks for a short distance, and indeed, generally speaking, it is only local drainage that can be regarded as deflected by these trans-Indus ranges.

Chicháli chasm.

One of the most remarkable points connected with the meteoric agencies of the region is the joint evidence of torrential action and atmospheric erosion, afforded both by the depth of the gorges or height of the cliffs and the amount of coarse rock detritus spread out fan-wise along the southern and eastern base of the mountains. The whole area is a dry one, capriciously visited by rain enough to produce vegetation on the lower ground (about one year in four according to Thorburn, *l. c.*), so that the long-continued natural conditions of desert climates, *i. e.*, great extremes of heat and cold, drought, frost, wind, and exceptional storms of rain, are sufficient to explain the signs of energetic meteoric aqueous action accompanying the arid, stony and barren, appearance of the ground.

Torrential action.

Climate.

Along most of these hills, particularly on the desert side, drinking water is scarce and bad, being largely impregnated with the soda salts of the *reh* or *kallar* so prevalent in the rocks and soil, a solution the use of which by those unaccustomed is productive of illness. Streams, mainly flowing upon limestone, are in some instances good, but very often so mingled with the discharge from sulphurous springs as to become nauseous; while the ravines in which these springs occur are so charged with sulphuretted hydrogen that the atmosphere is more than perceptibly tainted with the noxious gas.

Water.

ASPECT OF THE COUNTRY.

The mountains of this country are, in the cold season at least, all bare and rocky on their southern face and frequently upon other sides also, but many of the higher and northern declivities are thickly clothed with spear grass

The mountains.

and *Sunhetta* (*Dodonœa*) jungle. Scattered *fullai* (*Acacia modesta*) bushes are commonly dotted over most of the ranges at intervals, except the Níla Roh and Bhattani hills, which may be called absolutely bare. The bluish-green colour of the bare rocks gives to the Níla Roh, as well as to the Shíngarh chain, their descriptive names, the former being the blue, the latter the green mountains;—names more applicable than that of the Ratta Roh, or red mountain, by which the Khasor range is also known, though the local colouring partakes more of an orange than a red tint. Vegetation is generally or largely absent upon most of the mountains formed of the tertiary sandstones; indeed, many of these are too precipitous to admit of its growth, and their surfaces are being constantly removed. So much is this the case that the freshly stripped pale gray or whitish sandy peaks of the Shíngarh range, seen from a distance, have all the appearance of mountains streaked and flecked with snow.

This Shíngarh range is finely serrated and peaked, but, as a rule, the sandstone mountains, though rugged and eaten by ravines into the very core, present long even outlines, the exception to this being where the inclinations of the beds are unusually steep. Those parts of the mountains formed of limestones are even more uniform in outline, this uniformity being, however, always associated with the sudden contrast of high cliffs and abruptly broken ground, immediately overlooking the plains, except in the case of the Khasor range, where the rugged talus of the diminished escarpment occupies most of the eastern slopes.

The plains.

The plains of the Deraját bordering these hills are of the sandy desert pasture land called Thal,[1] the localities of distant villages being marked by scattered lines and clumps of foliage. Higher up the Indus its many flat island patches

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[1] From its application I am uncertain whether this name always means "desert." *Tharr*, in South Sind and the Punjab, is applied to sandy water "*flashes*" or *jhíls*. *Thalla, Tarla*, or *Tallœri* in Panjabi means *below, lower*, the bottom of a box or sole of a shoe, the lowest of two villages, &c., and this may be alike applicable to the low plains of the Indus and the low site of the frontier camp at Thal (Tul) on the Kuram.

are covered by a dense jungle of high feathery *jaow*, with cultivated openings here and there. For some miles along the bank of the river at foot of the Khasor hills a strip of the alluvium is wooded, in parts thickly, with plantations of fertile date palms, but the Isa Khel plains sloping gently to the river are sandy, covered with tufts of coarse herbage or grass, and only cultivated where their elevation permits them to be irrigated from the Kuram.

The Indus.

The Indus channels in this country are inconstant; the river may once have traversed the valley between the Níla Roh and Khasor ranges, and even now the main stream changes its place to more easterly or westerly parts of the large space forming its recent bed, so that after the annual flood it may run 8 to 13 miles away from its former course. For several years past the principal stream has been deflected to 8 miles eastward of Isa Khel, once upon its bank, the change destroying 17 villages;[1] and this season (1878-79) another set brings it obliquely back, so as to impinge upon parts of the Khasor range, where last year one could have walked dry shod from end to end of those hills in the old Indus channel.

The current is strong, making the upward passage for boats very tedious; where shoals occur the water runs over them often in noisy rapids, and even where gliding still and unbroken there is constantly heard the loud plash of undermined masses of the banks falling in.

As in the Salt Range, here also a boulder zone, 3 or 4 miles in width, borders the Indus plains along the base of the mountains, forming a very marked feature of the country. In this the dry stony *wáns* or water-courses from the hills unite, distributing their rounded boulder debris in the form of blending fans, most distinct where the ranges above supply the harder varieties of rock. This zone is sparsely dotted with *bheker* (*Adhatoda*) bushes, &c., never affords a drop of water, and from its ruggedness is always difficult to traverse.

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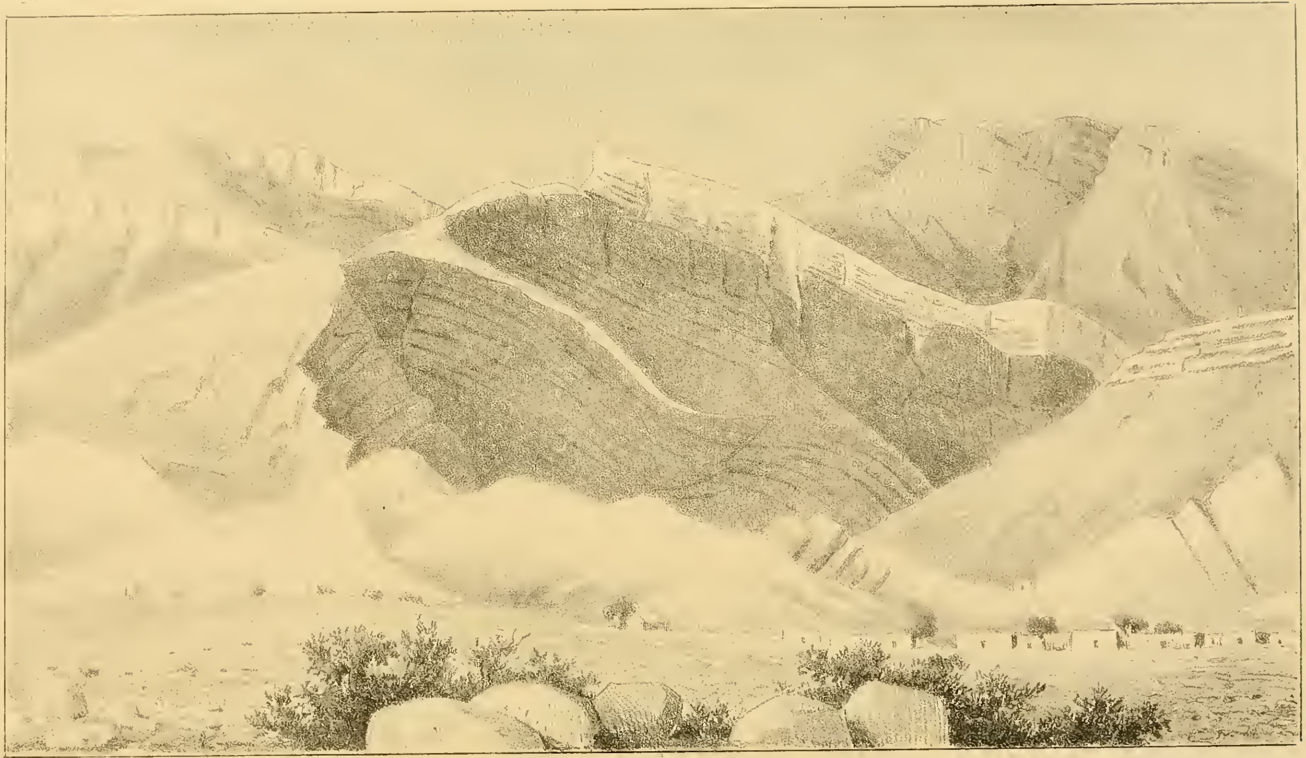
[1] Thorburn's 'Banu.'

GEOLOGICAL SURVEY OF INDIA

Wynne

Memoirs Vol·XVII Pt. 2. Pl III



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THE ANTICLINAL AT MULLAKHEL.

Bannu plain.

The Bannu plain, 1,000 to 1,150 feet above the sea, on the further side of the mountains, and traversed by the Kuram, which here receives the Gambela and other rivers, is sandy or even stony round its margin: at some places to the west presenting karewah-like terraces so characteristic of the Kashmir valley, but here covered with stones, many of them coated by a black film of oxides of iron or manganese, apparently weathering from the rock (these are supposed to be the "*dozak ki kanre,* hell stones" mentioned in Thorburn's 'Banu,' page 7). In such situations, except where slightly cultivated in favourable seasons, the ground is bare, with thinly scattered trees. In more central and lower parts the plain is extensively irrigated, well wooded, and richly cultivated. Its aspect in the cold weather, the wintery look of the trees, the familiar birds, ravens, rooks, flocks of starlings, and the flights of wild fowl, recall November scenes in Britain, a resemblance heightened by distant treeless hills in all directions closing the view.

CHAPTER II.—RELATIONS BETWEEN THE STRUCTURAL GEOLOGY AND THE FORM OF THE GROUND.

Coincidence.

As may be elsewhere observed in the Punjab, and indeed as is generally the case in most countries, the coincidence between the physical features and the geological structure of the ground is intimate. The axial lines of the mountains carrying on the Salt Range feature are also axes of anticlinals lying for the most part along the scarped acclivities presented towards the Indus plains. A single anticlinal runs (or ran, for much of it has been removed) from Kálabágh to the Kuram; greatly dislocated in the former neighbourhood by disturbances connected with the chaotic disarrangement of the geological series where the Indus finally leaves the mountain regions of Upper India. A double fold traverses the country from the Kuram to Shekh Budín, one forming the outer or Khasor range, the other the

Anticlinal structure.

Níla Roh and Battani hills. This last is complicated by minor convolations in the Makdúm Gúnd or mass of Shekh Budín itself.

Parallel fractures.

Along the escarpments denudation has reached the axis of curvature from the side towards the plains and removed much of that half of the anticlinial fold, or else so completely obscured it as to raise a doubt whether the atmospheric erosion has not been assisted in developing the escarpment, by extensive parallel fractures lying in the vicinity of the outer base of all these border ranges of the Indus plains,—fractures to the existence of which, as much as to the elevation of the arches, is due perhaps the striking contrast between the dead flat of the level ground and the abrupt harshly-pronounced features of the boldly scarped façade of the mountains.

In other (outer Himalayan) regions such long parallel fractures are closely associated with the scarps of the lesser ranges, and here where outer Himalayan orographical features blend with those of the outer Sulemáni area, the existence of similar fractures just within the hills is ascertained, while better evidence to show the original anticlinal structure of now uniclinal scarps than the Salt Range escarpment affords, is here found in the partial occurrence of the missing side of the once continuous arch. The former existence of arches where there are now escarpments is even more conclusively shown by the way the cliff line of the Chicháli and Maidán ranges passes into the long anticlinal ridge of the Marwat hills (Níla Roh and Battani Roh), confluent for a long distance with a feature of the same scarped-anticlinal nature forming the Khasor range.

A Salt-range feature.

Another Salt Range feature, most prominent near Kálabágh, where the salt marl is present, is the extremely disordered, slipped, faulted and displaced arrangement of the undercliff and talus portions of the escarpment. This is also present along all the border of the Isa Khel plain, but even more noticeable on the Indus face of the Khasor range. The cause of this confusion is traceable to the superposition of the hard carboniferous or other limestones upon such soft or destructible rocks as the more sandy groups, the salt marl and gypsum, or the hardly less easily reduced gypseous and boulder clay groups, or, in some cases, to the soft variegated jurassic sandstones and alum shale underlying and cropping out from beneath harder limestones of the same and of eocene age. The more tender and saline rocks being reached by percolating water have yielded to the wasting influences, and thus the harder masses above have been dislodged.

Older rocks in scarps.

The outer escarpments are thus always occupied by the older and harder rocks. Behind them is an enormous mass of the newer (Siwalik) tertiary soft sandstones, forming the whole of the Dangot, Lakargarh, and Shíngarh mountains, the west side of the Maidán range, the north-west foot of the Khasor ridge, and all the Marwat hills except Shekh Budín gúnd.[1]

Bannu plain, tertiary basin.

The Bannu plain occupies a basin formed by these newer tertiary beds extending under the flat ground on all sides, except the north, where its boundary coincides nearly with a fault, edged by a repetition of the scarped-anticlinal ridges elsewhere so pronounced.

Derajât.

The plains of the Derajât and Indus[2] are a part of the great flat, mostly desert, which reaches hence to the Aravali range and the sea in Lower Sind, doubtless wandered over in times past as they are now less extensively here, by the capricious movements of the Indus, the Aba-sín, or "Father of waters" as the great river is called in some maps.

Marine plains.

Whether these plains are in any degree due to marine erosion is a point so uncertain as to be beyond discussion here. It cannot even be known whether the later mesozoic and tertiary deposits are spread horizontally beneath them in this region, or if the rocks which they conceal are disturbed. The original anticlinal structure of the different ranges adjacent, and the fact that the upper tertiary beds crossed the anticlinals towards the southward, afford grounds

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[1] 'Gúnd' means a distinct *dheri*, or hill.

[2] For further information relating to the plains of North-Western India, Mr. Medlicott's chapter on the Geology of the Punjab and its dependencies in the *Government Gazetteer* of the province may be consulted.

for presuming that these rocks exist for some distance beneath the alluvium of the plains, and if undisturbed the production of a flat surface would be probable, particularly when lying relatively low enough to receive the washings from higher ground.

Forty miles southward of the Salt Range a group of very old rocks appears from beneath these plains in the Karána hills and the Chenab river (described in Dr. Fleming's second paper quoted). If the tertiary beds extend beneath the plains, even half that distance from these hills, they would pass beyond the limits of the ground now, properly speaking, under consideration.

That the sea may once have covered this low ground and washed the base of the ranges, even in comparatively recent times or more than once, would, of course, be no proof that these extensive flats are really parts of a plain of marine denudation, or that the cliffs of the ranges were once sea-formed cliffs.

Ancient shore line.

In the ancient infra-carboniferous period, the accumulation of rounded metamorphic boulders, as I have elsewhere noticed, testifies to the existence of the shore of an early land. The indications are vague, but extend for a distance of 64 miles north-east to south-west, and as the boulders are not the common Himalayan detritus of the country, the inference is that this old land lay within the region now occupied by the plains of the Indus and the Indian desert. To follow the changes which have taken place since these early times would involve the consideration of a much larger area than is now referred to, and it is very doubtful if the evidence available is sufficient for the purpose.[1]

DISTURBANCE.

Regarding the period at which the physical features of this country were produced, there is evidence of disturbance having occurred more than once, but the ridges themselves, as they at present exist, doubtless

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[1] A highly speculative view of the subject is given in Dr. Waagen's paper upon the ancient physical distribution of land and water over the Indian area. (See Records Geological Survey India, Vol. XI, p. 267, 1878.)

mark the same great later or post-tertiary period of mountain-forming activity, in which originated not only the remainder of the Salt Range chain, but also the Western Himalaya and the Sulemán and Afghan ranges. This is evident from the tilting of the higher tertiary beds on both sides of these trans-Indus escarpments, hence the last disturbance must date from a period later than that of the newest inclined beds.[1]

Last disturbance.

Whether the dislocations of the strata which possibly contributed largely to the formation of the escarpments are strictly synchronous with the elevation of the mountains, or were formed towards the close of the display of force that has left its mark so strongly upon the country, it is not easy to decide; but the probability seems to be that while inseparably connected with the general disturbance, the fractures, particularly if caused by strain and accompanied by partial subsidence, took place after the formation of the curves.

Connection with parallel fractures.

Of earlier disturbances of the region, one which dates from post-eocene times may be connected with the absence of the great group of lower tertiary Murree sandstones and clays so largely developed in other parts of the Punjab. To account for this, mere local cessation of deposition at this Murree period might have been sufficient, but that with the missing beds in some localities the eocene limestones have also disappeared entirely. These, it is true, are by no means universally found in the sections of the Upper Punjab, but the absence of both together is very suggestive of a physical reason, such as local elevation of the sea bottom. And further, where these limestones and the Murree beds are wanting, there is

Early disturbances.

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[1] The high angle at which part of the Kálabágh mountain post-tertiary beds are inclined (45° to 50°) would be a reason for supposing the general elevation of the region of later than post-tertiary date; but elsewhere in the district conglomerates and sands, evidently of recent accumulation, are found inclined at the same high angle (see p. 65); hence if it be possible that detrital beds in the latter case were *deposited* at this angle, so might they have also been in the post-tertiary instance specified. In this Kálabágh instance subsidence might also have influenced the position of the beds.

found in their place a layer of conglomerate formed almost entirely of limestone pebbles, but of such upper eocene alveolina-limestone as occurs to the north, and not of the local nummulitic kind, showing that the eocene beds in some parts of the country had been undergoing denudation in consequence of disturbance which took place previous to upper tertiary Siwalik or pliocene times.

This conglomerate of foreign eocene limestone debris is also found resting conformably upon nummulitic limestone of the Salt Range type in the Maidán range, and associated with such fossiliferous nummulitic sandstones as are often found near the base of the Murree beds or upper eocene group; from this it may be argued that the disturbance which perhaps limited the depositing area of the mass of the Murree beds took place about the close of the period of the upper eocene limestones.

Pre-Siwalik or upper eocene disturbance?

Another case of disturbance and elevation may be traced in the relations of the rocks at the northern and north-west side of the Khasor range; but whether this also may be referred to the same period as that just mentioned is not quite clear. The Siwalik beds here rest on some magnesian limestones and thick soft sandstones, both unfossiliferous, and if not of jurassic, at least of triassic age. The junction bed at the base of the Siwaliks is a conglomerate formed chiefly of palæozoic limestones and older rocks derived from the local sub-carboniferous beds. In a southerly direction near the other end of the range, jurassic rocks come in between the carboniferous and Siwalik horizons, but all the intervening eocene and cretaceous beds are wanting, while the lowest parts of these newer tertiary rocks progressively extend beyond the jurassic ones, till they rest upon the older formations, thus establishing a clear case of overlap.

Pre-jurassic disturbance.

If the elevation of the carboniferous and triassic ground took place in pre-jurassic times, all the overlapping beds as well as the Siwaliks would probably be conglomeratic at their junction with the older rocks of the then-existing shore line: this development of shore beds has, however, been only found at the Siwalik junction, and for no great distance from the northern end of the ridge. On the other hand, if the elevation here is referable to the upper eocene period, as in the case above alluded to, denudation and removal of all the older tertiary sandstones, and the eocene, cretaceous, jurassic, and a portion of the triassic beds over a slightly raised area, may be supposed to have locally taken place; this area being then again depressed and covered up by Siwalik deposits, subsequently denuded in their turn, would account for present appearances.

This extensive denudation of all the mesozoic and much of the tertiary rocks would, however, involve the formation of thick local conglomerates of pre-Siwalik age which have not been discovered; and should this be a fatal objection to the above interpretation of the case, it can only be supposed that the northern Khasor elevation is the oldest yet recorded in the Salt Range region, and took place before the deposition of the jurassic rocks; or else that the jurassic deposition was here suppressed, and the elevation took place at a later pre-Siwalik period.

Pre-carboniferous disturbance.

Still earlier disturbance of unknown regions largely formed of metamorphic rocks must have enabled these to be fashioned into the smoothly-rounded boulders which fill the boulder beds below the carboniferous group of the Khasor range.

There would thus be three or four separate periods of elevatory disturbance traceable in this district, two palæozoic, one mesozoic or pre-jurassic (?) and two cainozoic: of these one being post-eocene and the other probably dating from later tertiary to post-tertiary times.

How far subsidence may have affected the ranges, or even produced some amount of local elevation, I refrain from discussing for want of sufficient evidence to justify conclusions.

DENUDATION.

Denudation.

It need scarcely be observed that denudation has taken an important part in the sculpture of this region, removing enormous masses of the mountains by processes which there is no evidence to show were other than those due entirely to atmospheric agency and which are still in action.

The coincidence between the continuous cliff lines of the mountains and the disturbance of the beds in the area that they immediately overlook points to relations of cause and effect, the displaced and variously inclined fractured rocks having given way readily to erosion; this must have acted during an enormous space of time, not only to remove so many hundreds of feet of the newer formations, but also to have enabled the drainage of a comparatively small area (roughly 48 square miles) to eat through hard limestones and cut through the very core of such a massive range as that of Chicháli. The present remnant of this still rises some 3,400 feet higher than the nearest part of the Indus channel.

Of the Chicháli range.

Extreme results of this agency are also exhibited in the vicinity of the Indus itself, where disturbance has likewise been intense, and where some of the ancient valley beds, belonging to a period when the river apparently ran 2,000 feet above its present level, are probably represented in the post-tertiary conglomerate which caps the hills of Kálabágh.

Of the Indus gap.

Denudation of three older periods is also traceable in the detrital beds connected with the discordance already pointed out, and is indeed the chief evidence on which the detection of the older earth movements has been based.

Of older periods.

CHAPTER III.—GEOLOGY.

The geological structure of the trans-Indus extension of the Salt Range repeats in a great measure that of the western portion of the Salt Range proper, but with some considerable differences. The palæozoic rocks, so far as represented by the red marl, rock-salt and gypsum, are quite the same, and so are the carboniferous and triassic groups, but others of the sub-carboniferous beds present themselves with a different association from those cis-Indus. The purple sandstone group of the Salt

Compared with Salt Range.

Range and all the formations above it up to the carboniferous are absent at Kálabágh, and there is but one place far away in the Khasor range, near Saiduwáli, where a group answering in position and appearance to this purple sandstone has been observed. This group had begun to assume a capricious distribution for a long distance from the Indus eastward; its disappearance at Kálabágh is involved in the mysterious absence of so many groups of the Salt Range series at that singular place, and its re-appearance so far to the southward at Saidúwáli may indicate the main direction of its development.

Subcarboniferous.

In several places along the Khasor escarpment coming out from beneath the carboniferous limestones, &c., are certain red, earthy, boulder beds containing a variety of red granitic and other well-rounded crystalline blocks, some of them polished and scored as if by the agency of ice. Exactly similar beds to these, in the western Salt Range sections northward of Músa Khel, take the place of the purple sandstone, but whether most connected with the superior or inferior palæozoic groups it is hardly possible to say. In this trans-Indus district the red boulder group is accompanied by gypsum layers, some of them containing small bipyramidal quartz prisms, the same as those found in the gypsum of the saline series at Mári, opposite to Kálabágh; and near Saiduwáli a great thickness of gypsum and dolomite underlies the boulder beds, being itself underlaid by the purple sandstone above mentioned.

Mesozoic formations.

The mesozoic formations seen in the western Salt Range are all represented trans-Indus, and one new formation appears. The triassic group has the same characteristic aspect and about the same general thickness, but the jurassic formation becomes largely increased, forming as to bulk the most important member, perhaps, of the trans-Indus series. The new group of sandstones which at Chicháli overlies a blackish bed containing *Ammonites* and *Belemnites* of cretaceous species (Waagen) also increases in thickness to the west and south-westward.

Cretaceous.

The eocene limestone.

The eocene limestone, absent just at Kálabágh, soon re-appears to the north, and becoming disentangled from the local displacements, increases rapidly in bulk as it stretches along the escarpment bordering the Isa Khel plain. It assumes a thickness of about 1,500 feet in the Maidán range, and disappears, buried beneath the newer tertiary rocks, as the anticlinal axis of that range stoops downwards near Mitha, being only seen again in one small exposure west of Isa Khel, and entirely absent in the Khasor and Marwat sections.

The lower tertiary sandstones.

The lower tertiary sandstones, inseparably transitional with the uppermost eocene limestones, which may or may not be on nearly the same horizon as much of the trans-Indus and Salt Range nummulitic limestone, are but feebly represented in this country. The same red band, chiefly of clays, which borders the northern flanks of the Salt Range, seems to recur in the Lún nala, and further west, north of the Chichάli pass, also on the west side of the Maidán range, but here it dwindles away to a mere streak of a few red clay beds in the base of the next succeeding mass of thick gray sandstones (Dangot beds). The latter, in this country, are remarkably free from intercalated beds of clay, as compared with sections more to the eastward. The whole of the enormously thick group of upper tertiary beds here assumes a strongly upper Siwalik character; fossil mammalian bones occur, and towards the top of the series zones of crystalline pebble conglomerates or, in their absence, of drab clays, occupy the sections.

Upper tertiary sandstones.

Overlap or unconformity.

In the Khasor range and Marwat hills about Shekh Budín, palpable overlap, which may even amount to unconformity, though occurring here between almost parallel bedded groups, is more evident than I have found it to be anywhere along the Salt Range. The eocene limestones at the eastern end of the latter range disappear from the series entirely, and here they are again wanting, the cretaceous and jurassic formations for a long distance being also absent.

Post-tertiary.

The post-tertiary conglomerate of the Kálabágh mountain, not having been elsewhere met with, may be presumed quite a local deposit analogous to some boulder beds in the Son part of the Salt Range long since recorded by Mr. Theobald (see Mem. Geol. Surv., Vol. XIV, p. 114).

Alluvium.

The alluvium of this region includes coarse boulder deposits,[1] loose sands, and more clayey accumulations, the latter occupying the lower grounds.

In order to show at a glance the relations of the formations of this district with those of the Western Salt Range, as well as the groups absent from the series in these neighbouring regions, the following table has been constructed to include both series in parallel columns:—

Comparative Table of Formations.

(Natural Order).

Trans-Indus Series.			**West Salt Range representatives.**
		Quaternary.	
Alluvial and Subrecent	13.	Rain-wash and superficial deposits.	The same.
Post-tertiary	12.	Conglomerates and clays. *Unconformity.*	15. The same. *Unconformity.*
		Cainozoic.	
Pliocene	11.	**Upper Siwalik.** Conglomerates, clays.	14. **Upper Siwalik.** Conglomerates and clays to the north.
Miocene	10.	**Lower Siwalik.** Sandstones and clays with fossil bones.	13. **Lower Siwalik.** Sandstones and clay with bones.
		Overlap. **Nahan or Murree Beds.** Slightly represented purple or gray sandstones and red clays.	12. **Nahan or Murree Beds.** Slightly represented: the same as opposite.

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[1] In the Memoir on the Salt Range (*l. c.*, p. 115), I have suggested the subterranean extension of the boulder zone bordering the Salt Range to the southward. Dr. Warth informs me that a well has been sunk (since the country was examined) at the edge of the boulder zone to supply the engines of the wire tramway from Khewra. After passing through this for some 20 feet or so, thick alluvial clays were found for the rest of the whole depth of the well, which was sunk about 100 feet. It would hence appear that these boulder fan deposits are more or less superficial.

Eocene	9. **Upper Nummulitic.** Olive clays, pale sandstones, conglomerate of limestone. **Lower Nummulitic.** Pale limestones.	11. **Upper Nummulitic.** Traces, if any. **Lower Nummulitic.** The same as opposite; pale limestones.

MESOZOIC.

Cretaceous	8. Partly. Whitish sandstones over dark earthy zone containing a few neocomian fossils.	10. **Absent**, or unrecognisable.
Partial unconformity at one place.		
Jurassic	7. Light-coloured thin limestones and shales with a dark earthy zone at top: contains *Ammonites*, *Belemnites*, Bivalves, &c., &c. Variegated soft sandstones and clays, often coaly, or alum shale. Fossils, chiefly obscure plants; limestones subordinate.	**Absent**, or ill developed. 9. **Jurassic.** Variegated sandstones, gray and yellow limestones, marls, &c.
Trias	6. **Ceratite Beds.** Gray thin limestones, thick marls, dolomite, sandstones, &c., *Ceratites*, &c.	7. **Trias.** Gray limestones, gray marls, calcareous sandstones, &c., *Ceratites*, &c.

PALÆOZOIC.

Carboniferous	5. Gray, magnesian, and white limestone, some sandstones and earthy beds, many *Producta*, *Spirifera*, *Bellerophon*, *Corals*, &c., &c.	6. **Carboniferous.** The same beds, rocks, and fossils, as opposite.
	Absent.	5. **Speckled sandstone group.**
Infra-carboniferous.	4. **Boulder Beds.** Dark coloured or red or purple clays, with boulders; sandstone and gypsum.	**Similar beds on this horizon.**
Silurian?	3. **Gypsum and Dolomite group.** 2. **Purple sandstone group.** 1. **Salt-marl, salt and gypsum** at Kálabágh only.	**Absent.** 2. **Purple sandstone group.** The same. 1. **Salt-marl, salt and gypsum** of Salt Range.

The series.

On comparing both sides of this list, it will be seen that the continuation of the Salt Range presents no exception to the changeable character of the sections which affects the whole chain from its eastern to its western regions. The newer formations are most alike throughout, the older palæozoic series most dissimilar, to those of this region. The mesozoic rocks are likewise differently developed; but the stratigraphically united zone comprising the carboniferous and triassic formations is common to the country on both sides of the Indus. Eastward of the Indus the speckled sandstone group just beneath the carboniferous has reached its greatest development, becoming fugitively present towards this river, but beyond it to the westward the group is unknown to occur anywhere.

Changes in the series.

In localities where it does occur east of the Indus, there intervenes between it and the salt-marl the set of dark purple boulder beds already stated to exist in the Khasor range, and (in the absence of the speckled sandstone) to underlie directly the carboniferous group. But the sections are unlike: cis-Indus the boulder beds rest immediately on the salt-marl and gypsum: in this country they contain gypsum bands in one place, and in another they overlie a group of chemically formed magnesian and gypseous rocks, entirely unlike the Salt Range saline series, and moreover resting on purple sandstones similar to those which are well known to overlie that series.

Relations. Boulder beds.

Hence it would appear that the boulder beds are really much newer than the purple sandstone, and are separated from it by a gypseous and dolomitic group unknown in the Salt Range.

This additional information afforded by the trans-Indus sections would thus give the following arrangement for the oldest portion of the whole Salt Range and trans-Indus Series:—

4. Purple boulder beds containing trap, red granitic and other crystalline well-rounded blocks, some of which are polished and show slight striation (glacial?). Red and white gypsum layers occur in the group trans-Indus.

3. Thick formation of gypsum, dolomite and shales, some of the gypsum being black and bituminous: only known trans-Indus.
2. Purple sandstones, cis-Indus and trans-Indus.
1. Cis-Indus, gypsum beds with lenticular patches of volcanic rock: great beds of rock-salt and *kallar* (impure salt), red gypseous marl, and thin layers of dolomitic rock, also beyond the river at Kálabágh and in the Lún nala adjacent.

Age of the boulder beds.

An important point, however, depends upon the identification of this purple sandstone group (No. 2) trans-Indus. In the Salt Range the next group overlying it to the eastward contains some shells of an *Obolus* or nearly allied form, referred by Drs. Stoliczka, Oldham, and Waagen as a silurian fossil, though the determination of this age for the beds has since been impugned as premature by the latter authority.[1] The determination of the age of these fossils being thus still somewhat unsettled, if the *Obolus* shells should ultimately prove silurian, it is possible the group No. 3 above, if not also No. 4, may belong to that period, no devonian rocks being known in this part of India.

The boulder group No. 4, from the evidence it gives of disturbance and denudation, and its shore-like character, may none the less have a claim to be considered to belong to an entirely newer group than 1, 2, and 3; such signs of a break as the boulders afford are usually associated with a lapse of time, which may in this instance have a chronological value of its own.

Before proceeding to notice with some attention to detail the various localities of the district, I shall conclude this chapter by a condensed sketch of the different groups in their stratigraphical order, with the view of conveying a clearer impression of each than could be comprised within the space of the preceding general table.

1. *The Salt Marl and Gypsum.*—Limited to the hills of Kálabágh and the Lun-nála, it is quite similar in character to that of the Salt Range, largely displayed at Mári on the opposite bank of the river Indus. It includes the bright crimson or deep purple gypseous marl as unstratified

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[1] Rec. Geol. Surv., Vol. XI, p. 276, 1878. Translation of a paper by Dr. Waagen: Imp. Acad. Sciences, Nat. Science Section, Vienna, 1877.

as usual, with strongly contrasting alternations of gray clay and thin bedded dolomitic layers or reddish and white gypsum masses. The rock salt is also of the usual Salt Range kinds, varying from earthy layers to bands which afford particularly fine, large transparent crystals, some measuring a foot or more on the side. The pure salt beds range up to 20 feet in thickness, and none of them that I have seen bear the characteristic appearance of the gray Kohát salt.

2. *The Purple Sandstone.*—This group has not been found in its place overlying the salt marl at Kálabágh nor elsewhere except near Saiduwali. Being simply a thick set of purple sandstones it does not admit of much further description.

3. *The upper gypsum and dolomite group.*—This is a thick gray band of very distinct aspect; it comprises numerous alternations of thickly bedded whitish and gray-spotted, granular, or amorphous gypsum, with massive bands of gray dolomite and sometimes with layers of soft white or yellow incoherent sandstone, and gray shale or clay. Some of the gypsum is black and strongly impregnated with bituminous matter smelling of petroleum.

4. *The Boulder group.*—This varies somewhat in places; its lower part includes dark gray tough shales or clays containing little fragments of broken grass-like plants or leaflets; above these are dark purple clays and sandy beds, sometimes with alternations of red and white gypsum, one or more layers containing bipyramidal crystals of quartz. At various horizons, chiefly in the upper part of the group, are the boulder beds, full of well-rounded metamorphic and crystalline blocks, amongst which varieties of granitic rocks with red felspar are common. Some of these blocks are highly polished, and on a few I observed superficial striation. The blocks are occasionally of considerable size.

5. *The carboniferous group*—Has all the main characteristics of its Salt Range portion. It is of dark colour and sandy calcareous nature below. Magnesian limestones and sandstones may occur at any horizon, and the main mass is of limestone of dark gray or black colour, sometimes of a clear pale gray, and sometimes in the upper part occurs

a beautifully compact or crinoidal white limestone, which rings like a bell when struck. At the top of the group, sandstones are frequent and dark shales may be found on various horizons. Fossils are numerous throughout, though zones in which no organism can be detected are also met with; but unless these are magnesian or unusually massive, a few paces will generally lead to fossiliferous rocks containing many of the common organisms of the formation, such as *Producta, Spirifer, Athyris, Streptorhynchus, Terebratula, Fenestella, Retepora, crinoids,* corals, &c. The lower beds usually contain many *Bryozoa* and further up *Fusulina.* In the middle of the group, corals, *Terebratulæ* and *Productæ,* prevail with many other forms, and among the upper beds *Bellerophon* and *Goniatites* are characteristic. Upon more than one horizon I have found the unnamed fossil[1] of the Salt Range, a flattish organism of a few inches dimensions, the sub-concave side showing a number of raised slightly-curved septa, arranged nearly at right angles on each side of a midrib or depression. The other surface when preserved is correspondingly, but much less deeply, corrugated and covered with very small pustules. The fossil being composed of carbonate of lime is never, so far as I have seen, found in a complete state, but only in fragments, weathered or broken, and frequently so situated on a large surface of the rock that it cannot be removed. It occurs of different sizes, as though the forms were those of old and young specimens; it is sometimes nearly a quarter of an inch in substance, sometimes a thin film only, generally of a flattish slightly curved form or rarely longitudinally folded nearly at a right angle. This fossil occurs in both the lowest and the upper part of the middle of the formation, probably elsewhere besides. In the top beds of the formation close to the *Bellerophon* beds I have met with some fossil bones or large fragments of fish spines. The formation is found in the Chicháli range, all along the Khasor ridge, and on the southern cliffs of the Shekh Budín hill.

6. *The triassic Ceratite group*—Is as usual to the east stratigraphically simply a superior part of the carboniferous formation. It always

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[1] Dr. Feistmantel considers it to be *Bellerophon.*

accompanies the latter here, and it shows the same characteristic thin-bedded gray limestone and greenish gray shales or clays by means of which it was first distinguished in the west Salt Range sections. Its *Ceratites* are in some places numerous, in others large, and its whole aspect is that which it presents on the other side of the Indus, without any strongly marked line of stratigraphic demarkation separating it from the palæozoic beds.

7. The jurassic formation.—These rocks have here a somewhat different appearance from that which they present in the west Salt Range, yet the likeness is so strong they could not be readily mistaken. They have increased largely in thickness, and their lower arenaceous and uppermost calcareous portions of that region have now separated into distinct zones, most clearly marked in the westerly sections. In these the lower part of the formation is chiefly made up of variegated, soft, red and white sandstone, with gray and coaly shales and numerous obscure remains of woody plants, while the upper consists of variously light-coloured and generally thin-bedded limestones, full of marine fossil shells, both divisions containing bands of magnesian limestone, and sometimes the peculiar golden oolite found in Kach, as well as in the Salt Range and in the Chichâli pass and recorded also in European jurassic rocks.

The highest band of this group is one of nearly black, tough, sandy clay or earthy sandstone containing *Belemnites, Ammonites, &c.*, among which in some places (Chichâli pass for instance) a cretaceous (neocomian) Ammonite occurs in the upper part of the zone. Similar dark beds containing apparently jurassic fossils only, or chiefly, recur at Shekh Budín in situations which render it doubtful whether there are not more bands than one of the same nature in this formation. The whole group is one of the most largely developed of the local series, having an estimated maximum thickness of quite 1,500 feet. The formation is supposed to be connected with that of Kach[1].

8. The cretaceous group.—Rocks of this age were first recognised by Dr. Waagen at Chichâli pass in consequence of the occurrence of a

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[1] Waagen: Pal. Ind., Series IX, p. 236.

neocomian fossil at the top of the jurassic group in the dark-coloured band as above described, but here at least, the group is inseparable stratigraphically from the underlying formation. Its upper limits were assigned from slight appearances of unconformity between this zone and the lowest eocene beds, appearances as strongly seen in one of the glens not far to the west, to occur between the jurassic limestones and this cretaceous zone itself; such local symptoms of discordance have, however, little value. The black transition band at the top of the jurassic beds is succeeded by a thick layer of soft yellowish unfossiliferous sandstone which increases much in thickness, but maintains otherwise the same general character westwards. In many places, this band and the underlying jurassic formation occupy nearly the whole of the southern side of the Chichâli range beneath the eocene limestone.

If the lower boundary of this cretaceous group is thus indistinct, lying actually in the very bed with fossils of an older period, its upper limits are no better defined in its most westerly exposures; for quite the same kind of light yellowish sandstones there, in the same position with regard to the jurassic group, enclose pebbles of alveolina-limestone such as often forms the Kohât representative of the eocene formation and cannot therefore be of cretaceous age. Here the whole sandstone zone must be considered as intermediate between jurassic and Siwalik, without any appreciable limits as to the parts of it strictly referable to the cretaceous or post-eocene periods.

9. *The eocene group.*—Where represented, this consists chiefly of nummulitic limestone of the Salt Range character, a white hard compact or nodular limestone often filled with casts of fossils, but rarely affording any well-preserved specimens; the lower part is in places sandy or marly, sometimes a sandstone of a whitish yellow colour; not unfrequently in others black alum shales and carbonaceous shales are present. In some sections orange or greenish and olive calcareous and concretionary sandstones with gray shales, overlying a limestone conglomerate band, form the top beds of the group, and among these beds the sandy bands sometimes contain nummulites. The whole aspect of this upper part of

the series is that of the more argillaceous and sandy portion of the uppermost eocene rocks.

The eocene formation is locally absent at Kálabágh, but increases, rapidly from the Kálabágh hills westward, till at the great cliffs of the Maidán range it attains a thickness of at least 1,500 feet and perhaps even more. Beyond this range the formation is unknown among the hills on the Punjab side of the present frontier in this neighbourhood.

10. The Murree (or Nahan?) beds of the Salt Range region are only feebly represented trans-Indus. Among the disturbed strata of the Kálabágh hills there are some red and purple rocks of the usual aspect of those next succeeding the greenish sandstones with reptilian remains, which rest upon the eocene limestones in the Salt Range. Further westward a narrow band of red clays may be seen between the nummulitic beds and the Siwalik rocks, being reduced to merely a few feet at the last exposure of the limestones west of Isa Khel. Red clays of similar appearance are often seen close to the base of the tertiary sandstones overlying the older rocks of the Khasor range, but it is not possible to identify a disconnected band of such clays with any particular zone of the tertiary sandstone series where the succession is known to be interrupted and no fixed tertiary horizon exists near it.

11. The Siwalik group of this district occupies a great portion of the mountains, following the outcrop of the older rocks. Towards the Indus, rocks having the normal appearance of the rapidly alternating red-clays and gray sandstones of the lower Siwalik beds, are seen in the Lún nala, overlaid eastward by the massive sandstones of the inaccessible Dangot cliffs in thick beds mostly without clays, which gradually pass upwards by pebbly alternations into the conglomerates of Makad, of the Lakargarh mountains, of the north of the Shíngarh and west of the Maidán ranges.

The conglomerates, which are composed of crystalline boulders from the Himalayan chain, are most largely developed near the Indus, the early channel of this river having afforded the detritus a passage southward. Where the conglomerates are poorly represented further from this stream, in the Marwat range for instance, drab clays form much of the uppermost part of the Siwalik group.

Compared with the Siwalik beds elsewhere, the formation here, from the Indus westward, particularly the upper part beneath the very uppermost beds, presents an unusual absence of clays and a preponderance of thick soft gray sandstones.

It is quite uncertain whether the conglomerate of eocene limestone fragments and some accompanying sandstones which in places form the base of the series should be united with the Siwaliks or attributed to some early post-eocene period. The Siwalik group, besides occupying so much of the trans-Indus extension of the Salt Range, seems to form most of the outer Sulemáni ranges beyond the frontier.

In my memoir on the Salt Range at pages 108, 109, I have noticed the observation by Mr. Medlicott[1] that in the east Salt Range the newer tertiary, *i.e.*, Siwalik rocks, come immediately upon the Salt Range nummulitic limestone and rest upon a denuded surface of the latter rock. The same observation is repeated even more forcibly in the lately published Geological Survey Manual, pages 506, 512, and elsewhere, but the points alluded to in support of the opinion are all capable of a different explanation.[2]

Notwithstanding the strength of the assertions in the Manual, I am still of opinion that there does exist, both in the Salt Range and in parts of the present district, a band of tertiary sandstones, &c., lithologically somewhat different from the upper tertiary Siwalik beds, and more or less closely identical with certain of the Murree beds: identical also with the supra-nummulitic beds of the Kohát salt region which can be traced into the Murree group of the north side of the Ráwalpindi plateau, lying not far from, and lower in the series than, where the pre-Siwalik fauna of Kushálgarh is said to have been found (Manual, pp. 514, 515).

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[1] Mem. Geol. Surv. India, Vol. III, 2, p. 91: Rec. Geol. Surv. India, Vol. IX, p. 56.

[2] See Rec. Geol. Surv., Vol. X, pp. 115, 117, 118: Mem., Vol. XIV, pp. 109 & 139, and foot note to the last, with several references to Mem. Geol. Surv., India, Vol. XI, pt. 2.

The fossil evidence to the contrary adduced in the foot note to page 512 of the Manual I look upon as inconclusive, for *Mastodon latidens* has been collected by myself and identified by Mr. Lydekker from the rocks near Kushálgarh as well as from the beds lithologically identical with the Murree group near the Bakrála pass, east Salt Range.

As to the unconformity upon a denuded surface of the nummulitic rocks, I have followed the boundary between the latter and the succeeding sandstones, &c., for some hundreds of miles over the Upper Punjab and have never found an instance of either. I am therefore sceptical as to its occurrence anywhere within that region. An unknown interval may of course occur between the deposition of any two beds of rock however parallel, but that this has taken place at the horizon indicated, accompanied by unconformity, I think the evidence available is insufficient to prove.

I have always stated that much irregularity of deposition over the whole area has prevailed during the tertiary periods represented, and this might occur even accompanied by strong evidence of overlap without the presence of the decided unconformity which has been said to exist.

12. *Post-tertiary.*—The unconformable limestone conglomerates that cap the mountain over Kálabágh have evidently occupied their present position so much before the full results of the denudation which fashioned these mountains into their present form took place, that they may be regarded as the oldest post-tertiary beds of the district. They are formed of the harder local debris of the Salt Range series, and are presumably due to exceptional exertion of the denuding agency as the Indus reduced its channel; these conglomerates having been very probably old valley beds of that stream. On the western side of the patch which covers the hill of Kálabágh, the conglomerates are tilted and lie at higher angles apparently than those of deposition.

Among the newer post-tertiary deposits are included some part of the coarse detrital fan and terraced accumulations of the district which have been in process of formation ever since the recent denudation connected with the present drainage system began to act.

Alluvium.

The newest alluvium has been already described as largely formed of sand (such as would result from decomposition of the Siwalik beds) in the Deraját, and most earthy in such other low situations as the more fertile portion of the Bannu plain.

PART II.

DETAILED DESCRIPTIONS.

Commencing at the point nearest to the Salt Range for convenience of reference, I shall divide the observations to follow into sections, thus—

I.—NEIGHBOURHOOD OF KÁLABÁGH.
II.—THE CHICHÁLI RANGE AND MOUNTAINS TO THE NORTH.
III.—THE MAIDÁN RANGE.
IV.—THE DOUBLE CHAIN OF THE MARWAT AND KHASOR RANGES.
V.—SHEKH BUDÍN GÚND.
VI.—THE BHATTANI HILLS.

I.—NEIGHBOURHOOD OF KÁLABÁGH.

Appearance of Kálabágh.

In the appendix to the Salt Range Memoir[1] previously referred to, I have given some particulars as to the geology of the hills in the neighbourhood of Kálabágh, an interesting and extraordinary place which has always attracted the attention of visitors. It is thus referred to by Thorburn, who states that the town was devastated by the Indus flood in 1841[2] :—

"The houses rise one above the other on the hill side, nestling close packed in "an abandon of dirt and confusion amid the glistening carnation-coloured salt of the

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[1] See pages 268, &c., 272, &c., of Salt Range Memoir.

[2] "Banu," p. 8, note.

" rocks. It has a municipality and an old standing grievance; for as Government " levies a duty of about 8*s.* and 4*d.* on every hundredweight of salt quarried in the " range, and as half the town is built of salt and on salt, the people are fined heavily " should they attempt to eat their houses, and their cattle when they loiter by the " way in order to lick the rocks or the house walls are ordered to " move on " by " stern-visaged constables whose mud and salt-built sentry boxes are perched about " on every commanding knoll."

Hill overlooking the town.

The hill directly overlooking the town rises about 2,000 feet above the Indus and carries on the north-north-west strike of the western part of the Salt Range up the right bank of the Lún nala. It presents a curiously deficient and strangely discordant assemblage of the geological series beyond the river. Round the southern end of the hill and extending a short way up the Lún valley (or "Drung gorge") the red salt-marl, salt, and gypsum of the saline series are largely exposed, but in such disorder and so contorted that the stratification, where any is seen, can scarcely be said to lie in one way more than another.

Salt quarries, Lún nala.

At the salt quarries in the Lún valley, there is a general dip of the salt beds and saline group for 200 feet up the hill side at 40° and 70° to the west; while a directly contrary dip in this saline series is mostly seen on the opposite side of the hill, but the salt beds do not re-appear there. The inclinations are chiefly marked by gypsum and dolomitic layers in the marl.

Next rocks seen above the salt-marl.

The next rocks above (if not in) the salt-marl are some 50 feet of dark-coloured shales overlying a hard band of thin-bedded, dense, white dolomitic limestone with a narrow layer of granular quartzitic grit. In the shales are also dolomite layers of a dark gray colour, with rusty patches and pyritous cavities.

The purple sandstone, which ought to succeed the salt-marl, is absent, nor have any other of the palæozoic groups of the country been observed until the carboniferous limestones, &c., appear.

Carboniferous.

The last-named rocks, in a ravine a mile north of the village, form a steep, sharply compressed, nearly east and west anticlinal fold apparently let into its present place by faults on the west and south-east. The gray carboniferous limestones and calcareous sandstones contain crinoidal bands and, amongst other fossils, large *Productæ*, *Dentalium*, &c. Overlying these beds in a transitional sequence are the thinner-bedded limestones of the triassic Ceratite group, some layers showing many of these forms, and its upper portion consisting of a thick (300 feet) mass of the usual greenish-gray Ceratite-shales with subordinate fossiliferous limestone layers.

Trias.

Jurassic.

Upon these shales come thick soft sandstones of the jurassic formation, with obscure plant impressions, passing up into a large series of red and white yellowish variegated sandstones and dark sandy pyritous alum-shale with hæmatite beds or masses. These alum-shales contain the fossilized plant stems which furnish the Kálabágh lignite. Among the efflorescences on the dry part of the banks of the Tilla-kas and its tributaries, when they traverse the alum-shales, bunches of hair-salt occur, chiefly composed of magnesian sulphate.

Variegated group and eocene.

The variegated group is succeeded by light gray jurassic limestones and dolomitic layers; the former contain some fossils. A bed of dark earthy supra jurassic sandstones in places divides these from the lower eocene alum-shale and limestone, which is again overlaid by thick alum-shale and strong lumpy or nodular nummulitic limestones, forming a scarped outcrop crossing the hill obliquely. Some of the red clays and gray sandstones of the tertiary series rest upon the limestone, and have much the appearance of the lowest tertiary sandstone beds.

Post-tertiary.

Extending unconformably over the latter, as well as over the saline series, and faulted or slipped into contact with other groups, is a thick mass of limestone-pebble conglomerate, overlying as large a group of brown clays and gray coherent sands very like the "orange and gray" part of the tertiary sandstone. Similar brown or reddish clays are interstratified in the conglomerate above. This conglomerate is so largely composed of carboniferous, eocene, and other limestone pebbles, it can be readily distinguished from the Siwalik metamorphic-pebble conglomerates which also occur in the neighbourhood. It is disposed partly in a basin-like form tilted considerably to the west and nearly horizontal on the opposite side of the exposure capping the hill.

Section.

The rocks forming so much of the sequence as can be traced in this part of the hills, and, combined with the list previously given in the Salt Range Memoir (partly from Dr. Waagen's notes), page 273, show the following succession :—

POST-TERTIARY ...	Limestone boulder conglomerate	up to 500 feet.
	UNCONFORMITY.	
PLIOCENE ...	Brown clays and gray sands, Siwalik ? ...	About 9,500 „
	UNCONFORMITY.	
MIOCENE ...	Red clays and gray sandstones, Murree or Nahan ?	About 400 „
EOCENE ...	Nummulitic limestone (part of)	50 to 60 „
	Soft gray-marl	20 feet.
	Thin-bedded marly limestone	15 „
	Ashy-gray calcareous marl with numerous *Conoclypeus*	20 to 30 feet.
	Alum shale, inferior quality, a little coal, and many fossils	20 to 30 „
	Yellow nodular limestone, irregularly bedded, many *Nummulites*	10 feet.
	Alum shale with *Nummulites* (many pits, but few workable beds)	50 „
	Hæmatite	10 „
		200 feet.
CRETACEOUS ...	Dark gray glauconitic sandstone with *Belemnites*, badly seen	10 „
		10 feet.

UNCONFORMITY.

JURASSIC ...	Gray clay, with gypsum in thin beds, numerous canaliculate *Belemnites* and *Pleurotomaria*	6 to 10 feet.
	Yellow marly limestone, numerous *Mytili* and other bivalves	20 „
	Ashy-gray nodular marls	6 „
	White hard splintery limestones	10 „
	Yellow thin limestones with *Pecten* and indistinct *Myacites*	50 „
	Variegated sandy clays	10 „
	Sandstone and limestone alternating ...	30 „
	Soft yellow sandstone with whole beds of fossils, *Nerinæa, Cerithium,* and bivalves ...	50 „
	Variegated sandstones and shales with thin coaly layers and alum shales on 3 horizons...	300 „
		486 feet.
TRIAS ...	Gray shales, weathering greenish, with subordinate highly fossiliferous limestone bands, *Ceratites.* Thin-bedded limestones, *Ceratites,* &c.	370 „
CARBONIFEROUS ...	Thick and thinner gray limestones with calcareous sandstones, fossils locally numerous. *Producta* common.	400 „
SALINE SERIES ...	Dark gray shale with thin dark dolomite layers Hard white dolomite band, including a layer of quartzite grit. Salt-marl, gypsum, and salt-rock ... Occasional bands of dark shale and flaggy dolomite.	350 ? „

Disorder.

It would be difficult to give within any reasonable space an adequate idea of the disorder in which these groups occur; the saline series seems to form the core of the ridge, and this is capped by the post-tertiary conglomerates. Its eastern side shows the salt beds and other parts of the saline group, or else tertiary sandstones and clays of a purplish and gray colour, but on the opposite side a long vertical rib of the nummulitic limestone is conspicuous near the base of the hill, and a great mass of the post-tertiary conglomerates seems to have slipped down from its place. The main mass of the latter group slopes slightly to the northward, and in that direction the newer members of the whole series prevail, until cut off by a fault from the eastern end of the Chicháli range.

Upper Siwalik.

To the south, in the bank of the river Indus, just beneath the eastern end of the town of Kálabágh, as well as to the north of Uch-Tandar Khel, thick sandstones and conglomerates are seen, the boulders in which are large, and chiefly of the ordinary metamorphic kinds, to be found in the bed of the Indus and in the uppermost Siwalik beds. In the river bank they dip west-by-south at 50°, striking directly at salt-marl on both sides of the river. In the northern and much more extensive patch these beds are likewise highly inclined, or curved and faulted against the adjacent rocks. In both cases their occurrence is important, as fixing the date of the dislocation in their vicinity within certain limits.

Faults.

The faults of the locality run in various directions; they are too numerous to describe in detail, but one longer than the rest runs up the Lún valley for ten miles, bringing the salt-marl and tertiary sandstones into contact at both ends of its course.

East of the Lún nala.

East of the Lún nala the Dangot range and Bangali Sir mountains are formed of a huge mass of the tertiary sandstones, presenting bare rugged cliffs towards the valley, but on the eastern side closely mammellated slopes formed of the conglomeratic upper Siwalik beds. These all bend round to the west-by-south, joining with the rocks of the Lakargarh range, 14 miles north of Kálábágh. The thickness of these sandstones and conglomerates is here estimated at 9,500 to 10,000 feet.

Complications of the neighbourhood.

In the effort to explain the incongruous chaotic state of the rocks in this Kálabágh neighbourhood, elevation, absence of deposition, dislocation and denudation may all be appealed to, and whichever way one turns, it will be necessary to look far backwards for a clue to the entanglement.

Taking the country on both sides of the Indus as one complex of disorder, it is strange that in spite of the disruption of the series, the strike of the range retains its local north-north-west course for 10 miles. Within this distance, the formations, of which fragments are present, may be fairly presumed to have once extended over the whole ground, their local absence being due to dislocation, but whether those entirely wanting ever existed here can only be guessed at from their character elsewhere. Thus the purple and the speckled sandstone groups seem to have died out, one or both, here or there, before their disappearance some way south of Mári, but beds belonging to the fugitive soft boulder group are seen in a few places. Hence it appears the partial distribution of the older groups leaves it possible the ubiquitous red salt-marl may never have been entirely covered over by them here. This seems more likely than that the missing series has been removed by denudation, sparing only the very softest and most soluble deposits. The irregularity of accumulation of these absent members seems to be due rather to the set of currents than to surface inequalities of the marl, reaching above and below water-level, because the marl would always have formed a soft mass, the insoluble part of which would have gone to form detrital beds formed by exposure to denudation, and no rocks attributable to this origin are known in the series.

However this may be; as in one place carboniferous limestone, and in another tertiary clays and sandstones, rest upon the salt-marl, amid such complicated disturbance too as is evidently present, it is difficult to guess how far solution of the salt rock or slipping of the whole series in consequence may have contributed to conceal the true succession of the deposits.

We have then the carboniferous as one of the oldest groups known to have succeeded the salt-marl here; followed by the trias, jura, eocene, and lower tertiary sandstone formations, an alternation of hard and soft rocks likely to break up irregularly under the exertion of such forces of rending and pressure as were encountered; and there are no facts to show that any of these were unconformably deposited.

One great master-fault has been said to run along the Lún and Mári valleys; if it could be assumed that the older members of the series are buried by this fault, then the ground to the westward would much resemble the usual state of the southern Salt Range hill-sides. Against this, however, the fault referred to appears to have no such great downthrow as would conceal the whole series, the absence of which, along the fault, is more probable also from this exposing a limited contact of the salt-marl and salt with the tertiary beds, where the latter are rather regularly and very largely exposed, 12 miles from the Indus, at the head of the Lún valley. In this Lún valley there are detached masses of the carboniferous and nummulitic groups, the former being about 20 feet wide. Both masses seem to be associated with the portion of the great Indus system of fractures which longitudinally traverses this glen, but even this fragmentary evidence of the presence of the middle portion of the series is wanting at the head of the valley. The map used at the time they were observed (several years since) cannot now be found, so that their exact position in the one accompanying this paper is slightly doubtful.

From the above observations it appears possible that deposition of most of the older palæozoic beds, superior to the salt-marl, may have been suppressed in this neighbourhood, also that the series, so far as represented, has suffered enormous dislocation. This dislocation alone, however, is scarcely sufficient to account for the condition of the ground without the aid of denudation to remove most of the disjointed masses.

We accordingly find that great denudation of the local carboniferous and eocene limestones and other beds has resulted in the production of the post-tertiary conglomerates, but this denudation, so far as any evidence from detrital deposits, was not of earlier date than post-Siwalik.

In the section represented in fig. 1, at page 46, the rocks of the Siwalik series (No. 7) to the west are supplied from some distance; the other groups follow as shown, but the carboniferous and triassic are introduced from the next glen to the south.

A part of the field map is annexed (at this page), from which some of the positions of the rocks will be seen more plainly than in the smaller scale map with this Memoir.

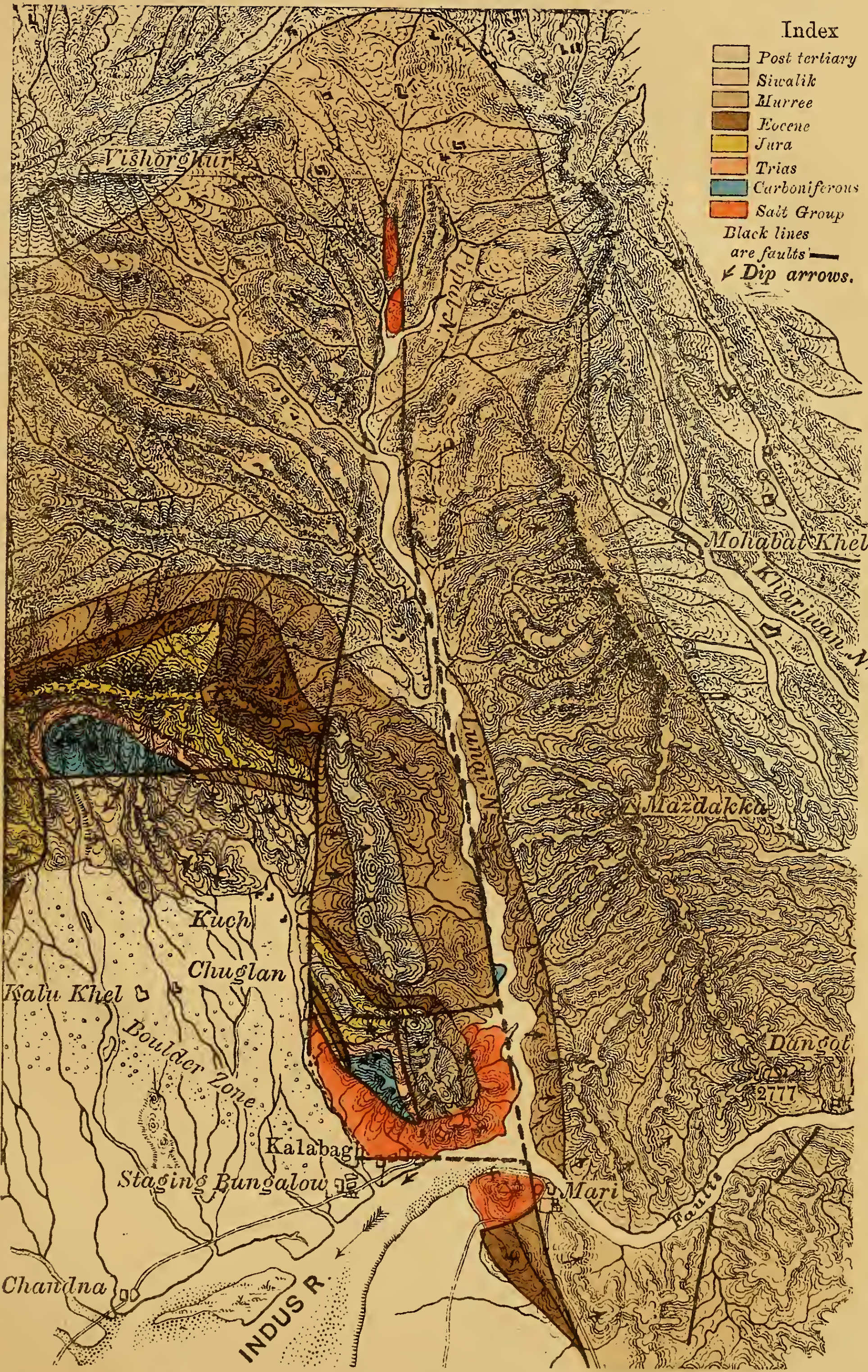
SECTION II.—THE CHICHÁLI RANGE AND MOUNTAINS TO THE NORTH.

The Chicháli range extends from the dislocated hills of Kálabágh to the westward, with a frontage often nearer 4,000 than 3,000 feet above the plains, and chiefly occupied by the outcrop of the mesozoic and eocene rocks.

Recess north of Kálabágh.

In the recess north of Kálabágh the first beds seen in the low hills at foot of the scarp may be 700 or 800 feet of thick Siwalik sandstones and conglomerate let down and crushed against the base of the higher hills to the north and east. In the former direction some older looking purplish tertiary beds with redder clays intervene, close to the fault, on the further side of which rises part of a large anticlinal curve composed of the carboniferous, trias, and eocene beds of these mountains. The white nummulitic limestone and its soft underlying zone make a high double peak to the east, over the Lún valley, the beds cropping steeply in the opposite direction. Their basset edge then descends into the valley to the north, rising again slowly to the Túrgegarh summit (4,425 feet) on the western side of the recess. By this arrangement part of the crest of the ridge is formed of the limestone and variegated series of the jurassic group, the latter from its softness being cut into high cliffs, making ground very difficult to traverse. The jurassic rocks, particularly the variegated parts, are largely developed here. The triassic beds are mostly exposed in vertical cliffs, and the harder carboniferous limestones form a high bench intersected by very deep ravines. The axis of the anticlinal once formed by the latter formation and succeeding beds plunges downwards at a steep angle, passing west directly under Túrgegarh summit.

The carboniferous rocks are as usual strong gray limestones, and



NEIGHBOURHOOD OF KALABAGH

Scale 1 Inch = 2 Miles

PHOTOZINCOGRAPHED AT THE SURVEYOR GENERAL'S OFFICE, CALCUTTA, APRIL 1880.

A. B. Wynne fecit. J Schaumburg Lith:

THE DARWÁZA, CHICHÁLI PASS.

magnesian limestones, with subordinate shales and arenaceous beds; the Ceratite group shows its thin limestones and characteristic clays, and the jurassic has its two divisions—a great mass of variegated red, white, and yellow sandstones with black and gray clays, and yellowish magnesian or gray limestones below, succeeded by hard limestones with marine fossils. The eocene limestones, black alum shales, &c., are quite of the usual type; the white or yellowish, nodular, compact and nummulitic limestone containing many fossils, among which the nummulites only are well preserved. Fossils also are numerous in the older mesozoic and carboniferous rocks, among the latter being the unnamed fossil of the Salt Range, already mentioned (page 30).

Carboniferous.

Peculiar fossils.

The sections north of Kálabágh, represented in fig. 2 at page 46, are estimated to expose the following thickness of each group :—

Tertiary sandstones	... ...	Several thousand feet.
Eocene limestone, &c.	... ...	800 „
Cretaceous, not found	... ...	(10 ?) „
Jurassic Upper part	... ...	500 „
Jurassic Lower „	... ...	800 „
Triassic	... ...	350 „
Carboniferous	... ...	800 „

From the summits of this part of the range one looks northward for 5 or 6 miles across a large valley, a very wilderness of bare sandstone rock in gray monochrome, some thousand ledges rising one above another, and the cliffs growing more vertical and inaccessible as the summit of the Lakargarh is reached.

Valley to the north.

To the westward of the embayment the range rises higher than elsewhere in the vicinity, and there cannot be much less than 4,000 feet of rocks in the section. Allowing somewhat for undulation and concealment below, the groups would

Range towards Chicháli pass.

give about the following proportions on the southern aspect of the mountains :—

	Ft.
Nummulitic	1,000
Jurassic	1,100
Trias	450
Carboniferous	1,000

A massive outcrop of nummulitic limestone forms the crest, shedding masses of debris over the lower slopes. These, nearly to the base, are formed of the jurassic rocks; and a large dislocated and subsided mass of the nummulitic limestone lies along the base of the range, broken but nearly continuous as far as the village of Kotki. Here it is closely flanked by a quantity of the tertiary, gray sandstones and red clays, having much more the appearance of the lower portion of that series than the Siwalik beds at Uch.

Chicháli pass section.

The nummulitic limestone was evidently once in anticlinal form, continuous with that of the crest and northern side of the range, but is now separated by faults, such as are (some of them) visible in the Chicháli pass section.

This important section is described at page 276 of the Salt Range Memoir, and figured on Plate xxxi, fig. 55, of which a copy is here given in fig. 3 (opposite). The southern portion shows partial inversion and much crushing and displacement; the northern part is regular and gives the following succession within the glen, in which the formerly more extensive alum works are situated. It is extracted from the source mentioned :—

SUCCESSION.

TERTIARY SANDSTONES, &C.	Red clays (17) and gray and greenish tertiary sandstones (16) with some beds of pseudo-conglomerate containing bone fragments (15).	Very thick.
		Ft.
NUMMULITIC ...	14. Strong compact light gray nummulitic cliff-limestone of the Darwaza	500
	13. Nummulitic marls and (12) dark shales	150?
	11. Lower nummulitic lumpy limestone	150 to 200
	10. Alum shales resting parallel on an eroded surface of the beds below	30 to 40

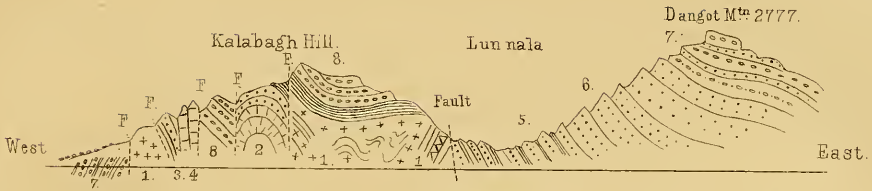


Fig. 1 Sketch section across part of Kalabagh Hill at Pakli kass (P. 43.)

1. Salt: marl and gypsum. 2. Carboniferous and Trias. 3. Jurassic.
4. Eocene 5. Lower Siwalik sandstones. 6. Dangot sandstones.
7 Siwalik conglomerate. 8. Post Tertiary. F. Slips and Faults.

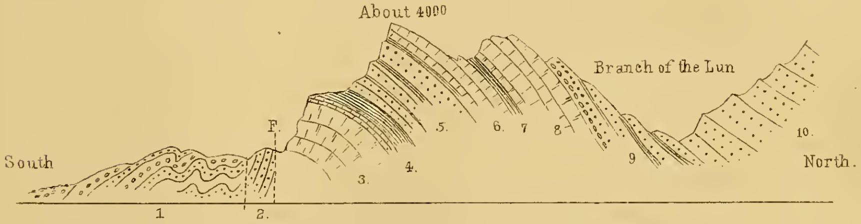


Fig: 2. Sketch section north of Kalabagh (P45.)

1. Upper Siwalik. 2. Lower Siwalik?. 3. Carboniferous. 4. Trias. 5. Variegated jura.
6 Marine jura. 7 Lower Eocene. 8 Nummulitic. 9. Lower Tertiary sandstone.
10. Lower and Middle Siwalik. F. Fault.

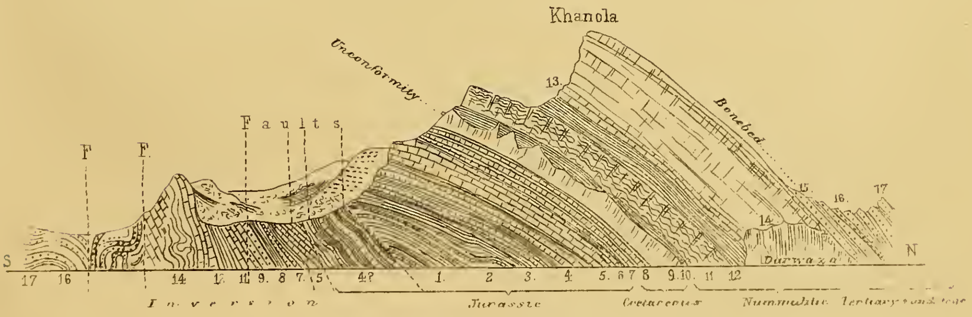


Fig: 3. Sketch section in the Chichali pass.
(For index see P 46.)

SLIGHT UNCONFORMITY.

CRETACEOUS NEOCOMIAN. ?	9. Strong light-coloured sandstone, eroded at top, lower third black	60
	7 & 8. Dark blackish green sandy and shaly bed, tough inside, passing down into—	137
JURASSIC ...	6. Dark olive sandstone and clay with oolitic patches (equivalent to upper band of golden oolite?); contains *Rhynchonella*, large planulate *Ammonites*, *Belemnites*, *&c.*	
	5. Splintery hard white limestones	180
	Shale band.	400
	4. Calcareous shaly and sandy beds and yellow limestone.	
	Gray limestone.	
	Brown marly limestone.	
	3. Shales with thin sandstones; a 2-feet bed containing fucoids.	
	Shales, sulphuretted hydrogen spring.	
	Hard sandy limestones and shale; *Rhynchonella* and fish-teeth.	
	2. Lower golden oolite, variegated sandstone, and thin coaly shales.	
	1. Gray and blue thin limestone and gray shales.	

"The lower part of the cretaceous band and the upper part of the jurassic form one thick bed of 137 feet, the *Ammonites* and *Belemnites* from the upper part having a neocomian character, while those from the lower part of the zone are jurassic. Two chief bands of alum-shales occur, one above and the other below the lower lumpy nummulitic limestone; and there are other less distinct bands besides, in the lower part of the variegated jurassic series, near No. 3 in the section."

In the branching glen north of the Darwáza, immediately overlying the nummulitic limestone, and rising upwards on its slope in large V-shaped masses, are the greenish and dark purple sandstones and pseudo-conglomeratic concretionary beds, with much red clay, belonging to the lower portion of the great tertiary sandstone series. They occupy a considerable space in the section, the dip here becoming lower, and there being some undulations on the north flank of the range, though not sufficient to affect the ridgy form of the ground. Even among the lowest of these red beds bone fragments occur, but I saw none of the sandy nummulitic layers which elsewhere intervene at this horizon between the limestone and sandstone.

Towards Prangzai Sir.

The mountains to the northward, culminating at Prangzai Sir (4,797 feet), are composed of the bulky Siwalik deposits. Scarcely less than 15,000 or 17,000 feet are exposed, and probably a good deal in excess of this amount concealed. This result is arrived at from calculating their dip for 8 miles, at only 25°, to the northward, while it seems to slope at a higher angle.

Westward of Chicháli the crest of the range bends slightly to the north, having an open plateau-like space near the summit, on which is one of the mountain hamlets dotted over this wild country. A number of abrupt broken spurs branch to the southward, intersected by deep and often very narrow ravines. The upper part of the section continues the same; the spurs are largely formed of jurassic beds, probably slipped from above.

West of Chapari village.

About a mile west of Chapari village the tertiary beds are interrupted at the foot of the escarpment, and a small anticlinal fold brings up the Ceratite marls. A little way above them, in the base of the jurassic variegated group, is a thick zone of dolomitic and splintery, gray and yellow, sometimes cherty limestone; some of the layers in which have semi-oolitic parts approaching the golden-oolite character; and others are crinoidal; sandy flagstones also occur in the zone. To this the great mass of the variegated beds succeeds, some of the sandstones being very white, covered with a white and yellow efflorescence, and so soft and tender from the presence of salts that they fall to powder. The whole group presents a rapidly varying succession of such beds as these, with dark gray and mottled, reddish and gray clays,[1] thin-bedded limestones as usual forming a tolerably distinct sub-division at the top of the group. Near the mouth of the Spelagázun gorge the thick dolomitic zone is bent into an arch, bringing up the car-

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[1] The exposures of the carboniferous and triassic beds along the foot of the range here are very local. My guide did not know which was the "Pílawán," and although I must have been close to it, this exposure escaped my observation.

boniferous (and trias) rocks to the west according to Dr. Fleming's paper (*l. c.*, p. 367), which gives a section across the range here, repeating much of the dislocation seen at Chicháli pass.[1] There are, as usual, signs in this part of the range of disturbance along the foot of the escarpment, but the outcrops of the jurassic and eocene rocks occupy all the prominent features of the frontage.

Shoh.

These form high cliffs to the south of Shoh, a village only inhabited in the hot weather, and situated in a rocky depression among nummulitic limestone crags high up on the north slopes of the range, near the elevation marked 4,063 feet. A local anticlinal in this nummulitic limestone forms the crest of the range, and increases somewhat the apparent thickness of the group; just below which the thick supra-jurassic sandstone shows itself strongly, with its accompanying black underlying zone. At one spot this appeared to have been unconformably deposited upon an eroded surface of the jurassic limestones, but the general relations of these groups would not indicate any great amount of discordance between them. The jurassic groups form a wild rugged and precipitous tract full of inaccessible places in that portion of the escarpment overlooking the neighbourhood of Chashmai.

Paranga.

A short distance beyond this hamlet to the westward, at a place called Paranga, the carboniferous beds re-appear, dipping under the escarpment at 60°, and as usual succeeded by the triassic beds; the latter being sharply folded, and from their nature and position at the foot of the hills, imperfectly exposed. The carboniferous formation shows alternating bands of gray sandstone and limestone, with *Goniatites* and *Bellerophon* above and *Productæ* prevailing below; the whole of the formation is not seen. In the dark upper part of the jurassic group *Belemnites* occur, and a large flat form of *Ammonites*.

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[1] The soluble matter from these beds forms a thick gelatinous scum along some of the nearly dried up streamlets. On examination by Mr. Mallet at the Survey laboratory, this was found to consist of silicate and sulphate of alumina, with oxide of iron, carbonate of lime and organic matter.

General features continued to west.

From this place to Mulla Keyl the same general features are seen. A strong cliff-line of nummulitic limestone occupying the crest is more than usually tilted, dipping northwards at the peak called (on the map) Shekh Nikka Zyárut, and from beneath this the thick light-coloured sandstone first appears, then the jurassic groups, and below these, near the foot of the hill, are occasional exposures of the Ceratite shales or limestones and the underlying carboniferous group.

All along the southern foot of the range lies the broad zone of boulder ground; while to the north, beyond a long narrow valley called the Khwurra-darra, coinciding with the strike of the rocks, and at its head continuous with part of the Baroch-darra, rises the Shíngarh range, having heights of 4,836 and 4,926 feet. Still further north on the other side of the Lawagarh stream is a parallel, but much lower, spur from the Lakargarh scarp.

All these last-named mountains are formed of the same Siwalik beds as border the Chicháli range elsewhere, conglomerates prevailing mostly in the highest part of the group, and massive sandstones forming the rest, except a narrow band of older-looking red clays and gray sandstones just near the base, low down in the scarp facing the Chicháli range itself. The bare sandy surfaces of the Shíngarh peaks are visible from a great distance, and it is evident there is barely sufficient variety of texture among its beds to mark its stratification and give it the ridge-like form it possesses.

The section across this range, in figure 4 (at p. 58), is reduced from that given on Colonel Walker's map, and with the sub-divisions of the older part of the series added. The dip of the tertiary sandstones (Siwaliks) did not appear so high as those given in the original section, otherwise as a general representation it seems to express the features.

SECTION III.—THE MAIDÁN RANGE.

This is but a different name applied to the double chain of the Chicháli and Shíngarh ranges after it has curved to the south; indeed the Shíngarh chain has no separate existence east of the Chicháli pass, and is closely united with the Maidán range to the south.

Baroch valley. Mulla Keyl.

At Mulla Keyl the narrow longitudinal Baroch valley, lying between the two ranges and bending with them and the strike of the rocks, discharges the drainage from both its northern and southern branches upon the Ismail Keyl plain, cutting a crooked but fine gorge, called the Harma Kas, across the very heart of the outer ridge.

The fine section in this stream and the adjacent cliffs exposes a great anticlinal curve, sinking to the south, and coinciding with the axis of the outer range. In the centre of the arch nothing is exposed below variegated jurassic beds, and not the whole of these. Overlying them are the upper calcareous part of the group, the supra-jurassic sandstone, and the nummulitic limestone, which forms all the highest ground.

Ascending the stream the first rocks seen, forming a low spur behind the village, are greatly crushed, faulted, and displaced masses of upper tertiary sandstone, upper eocene sandstone and conglomerate, white nummulitic limestone, and the underlying thick, pale, sandstone, belonging before dislocation to the outer limb of the anticlinal.

Next seen are some 400 feet of the upper jurassic limestones, the lower part shaly and with but few fossils, amongst which are some *Corbulæ*, *Rhynchonellæ*, *Naticæ*, and whole beds formed of small thick bivalve shells impacted in the rock. Among these limestones are a few sandy bands; some beds are lumpy, some pebbly with limestone pebbles, and others show small branching fucoids; most of the beds are fine and earthy like lithographic limestone. These beds form all the cliffs south of the stream. To the west they seem thicker than 400 feet, and from beneath them rises the bulk of the variegated group towards the north.

In the centre of the arch the variegated beds are composed of gray and variegated sandstones and dark gray pyritous shale below. Some of the sandstones become coarse, gravelly and conglomeratic, with quartz pebbles and ferruginous concretions.

Beyond the centering of the arch formed by these beds the upper group is similar to its counterpart previously described, and from one gray lumpy limestone band a small sulphur spring issues, the place, as usual, smelling of sulphuretted hydrogen. The stream here for some distance coincides with the strike of the rocks, running in a deep V-like trough, blocked here and there by enormous fallen masses from the cliffs above, but turning again it crosses the beds, giving a section through the supra-jurassic sandstone and the eocene limestone.

The black band at the base of the pale sandstone group is present: whole layers, some inches thick, of *Belemnites* occur in its lower part, but only a few *Ammonites* were found, and these impossible to obtain entire.

Harma Kas.

Here, at the place called the Harma Kas, the supra-jurassic sandstone, from such measurement as could be made, is 450 feet thick, dipping at 40° to the west. Midway through the gorge cut through this soft, warm yellow-tinted sandstone is a carbonaceous shaly layer 2 feet or so thick, but irregular. Another such black layer occurs higher up, and there is a thin parting of the same a few feet below the nummulitic limestone.

The upper part of the sandstone is shaly, a few layers of brown sandstone with coaly strings succeed, then knots of limestone in a gray calcareous matrix, and this immediately passes up into the usual solid whitish gray nummulitic limestone without the least symptom of the unconformity observed in the Chicháli section, or the presence of the basal nummulitic alum shale, unless represented by the gray shaly upper portion of the sandstone itself.

Section.

Where the contact occurs the stream falls over a bluff of the limestone, 60 or 70 feet high with lofty walls of this rock on each side, into a deep pool, the fall being called Spín-zdthow from the white colour of the limestone; here perhaps

GEOLOGICAL SURVEY OF INDIA

Wynne

Memoirs. Vol XVII. Pt [illegible]. Pl: V.

A. B. Wynne fecit.

J. Schaumburg, lith:

THE HARMA KAS, MULLAKHEL.

less thick than the full amount seen to the north and to the southward. Beyond this point in the section I was not able to proceed upwards.

A little way south of Mulla Khel there is a more practicable route over the outer range into the Baroch-darra ascending the Karandi Algad (see fig. 5, at p. 58). At the first part of the ascent the black zone forming the neutral ground between jurassic and cretaceous (?) is seen as usual containing many *Belemnites*. The zone is close to the outer faulted region at the base of the hills, and is succeeded by a quantity of coarse soft cream-coloured sandstones full of large ferruginous concretions. Over them comes a quantity of nummulitic limestone, making a great show as it curves over the anticlinal axis of the range, but the junction between it and the sandstone beds is concealed by waste from the hills, and in the glen, by a massive accumulation of calcareous tufa.

Karandi pass.

The top of this pass is (by barometer) about 2,500 feet. and at a few score yards beyond it, on the Baroch side, a set of rusty-looking sandstones is found resting upon the nummulitic limestone and associated with dark olive-gray shales. These sandstones contain numerous scattered pebbles of quartz and nummulitic limestone, and they appear to be the representatives of the uppermost nummulitic beds of other regions. The group may be 200 or even 300 feet thick, but is frequently concealed by grass, &c.; it covers much of the eastern slopes of the Baroch glen, on the other side of which are a few red clay layers in the sandstones representing the red zone north of the Salt Range. Above these is the massive tertiary sandstone outcrop (Dangot beds) of the Lawagarh or Shíngarh chain.

A mile or so further to the south the eocene limestone has folded over the anticlinal, but may be perhaps partly dislocated, producing the bold cliffs of this rock which form the crest of the range. The limestone covers the ground and forms the undercliffs for a space, but the deeply cut miniature cañons show the cretaceous (?) and some of the jurassic beds beneath. That the anticlinal, if not perfect now, once was so may be judged from the

Towards Súltan Khel.

occurrence again, at the base of the range not far from Karandi, of the same beds above described as representing the upper nummulitic rocks, and with them there is again a band of conglomerate wholly made up of nummulitic limestone pebbles. As usual, in such a situation these beds are dislocated and disturbed.

A deep *kas* to the southward again exposes the supra-jurassic sandstone, and still further south, between Karandi and Sultán Khel, a larger anticlinal exposure of these and the jurassic beds occurs, the newer limestone having been denuded over the axis of the main anticlinal of the range.

Some of these deep cuts with vertical sides enable black alum shales situated towards the middle region of the nummulitic limestone to be seen, having a thickness of about 150 feet; but though the central portions of the limestone is frequently shaly, it is not certain that this alum shale is present everywhere in the group.

Cliffs of the Maidán range.

The summit of the Maidán range opposite to Súltan Khel is marked as having an elevation of 4,357 feet; the Indus to the east as 782 feet. Of the difference (3,575 feet), if 375 be allowed for the rise from the river to the foot of the hill, this would leave 3,200 feet for the height of the escarpment, at least half of which is occupied by mural cliffs of the nummulitic limestone, the beds being so slightly curved from the horizontal that the formation here may be fairly estimated at 1,500 to 1,600 feet. For height and boldness these precipices are as grand as any in the whole district, those of Dangot perhaps excepted.

Near Mitha.

In the neighbourhood of Mitha, 4 miles south-west of Súltan Khel, the eocene limestone part of the anticlinal disappears, being wrapped round and covered over by the tertiary sandstones of the uppermost nummulitic and Siwalik groups. The beds which succeed the limestone are a mass formed about equally of greenish and red clays, with dull brown sandstones and thick conglomeratic zones, layers of conglomerate being scattered through 30-feet spaces among the sandstones, in beds of 5 to 10 feet thick, and the whole group is at least

300 feet in thickness. The conglomerates include pebbles of coarse sandstone, some of black chert and of white quartz, but they are chiefly of compact yellowish *alveolina* limestone, not of the white local nummulitic limestone rock, but rather of the kind which occurs in the Kohát salt district to the north. Blocks of this occur in some of the beds up to a foot in diameter.

This group of clays, sandstones, and conglomerates has greatly the appearance of those recognised as identical with part of the Sabathu group in other parts of the Upper Punjab, and, like it, presents, where the contact can be seen, perfect conformity of stratification with the underlying nummulitic limestone, although containing fossiliferous nummulitic limestone pebbles derived from other localities.

Upper eocene.

In some places here a clay band forms the junction between this group and the strong lumpy limestone below. In others the lowest layer of the upper group is a conglomerate band 17 to 20 feet thick, in close contact with nodular limestone; the interstices between the nodules and those between the pebbles being both filled by the calcareous sandy base of the conglomerate, so that, although the transition is sudden, there is no sharp line of demarcation.

The next beds below the junction are about 300 feet of lumpy white limestone, then 400 feet of white marly beds, at the base of which are massive beds of nummulitic limestone for a great thickness, without the alum shales being exposed.

Sulphur springs.

In the principal stream here the water is rendered of a bluish opaline tint by the suspended mineral matter derived from the numerous sulphur springs in the nummulitic limestone; so numerous indeed are they that the air is strongly tainted with the sulphuretted hydrogen gas evolved. This confined gorge terminates in what resembles a gigantic pot-hole a few yards across, but surrounded by lofty, in some parts overhanging, limestone walls, giving the impression of looking upwards from the bottom of a well.

Súrgarh anticlinal ellipsoid.

It has here become plain that the whole Súrgarh range from near Tandar Khel (north of Kálabágh) to Mitha, is but another example of the ellipsoid anticlinal structure prevalent in the Kohát salt field. In this case the long narrow anticlinal is bent nearly at a right angle at Mulla Khel, but both its extremities—that north of Kálabágh as well as its termination near Mitha—show the opposite curvilinear dips, where the axis of the curves bend downwards at the convex ends of the ellipsoids, as described in the Kohát country. It is not unusual there to find one side of an ellipsoid cut off by faulting or much disturbed, and the same thing occurs here on a larger scale.

Darsoligarh hills.

The remainder of the Maidán range to the southward, locally called the Darsoligarh, as far as the Kuram river, is formed of the thick Dangot Siwalik sandstones, with but one small exposure of the nummulitic limestone and Sabathu beds to the west of Isa Khel, the anticlinal axis continuing, together with its parallel dislocation, on the side towards the plains.

Sand banks.

So far as the escarpment is formed of hard rocks, the belt of detrital boulder-covered ground extends, but here, where the hills are chiefly composed of sandstones, hard fragments of any kind are rare, and their place is taken by banks of gray sand along the eastern foot of the chain.

Tangdarra.

For some distance before reaching the Tangdarra, or last gorge of the Kuram, the Maidán range sinks into comparatively low hills composed of the upper portion of the Siwalik silvery gray sandstones, belonging to the western side of the anticline. At the gap itself these beds dip to the westward at 10°, and are succeeded by the usual upper Siwalik conglomerates; these, however, not being so largely exposed as is their metamorphic-pebbly debris. The strike of the range and its beds is here a few points east of south, but just beyond the Kuram, the beds become nearly horizontal before taking a south-westerly strike.

SECTION IV.—THE DOUBLE CHAIN OF THE MARWAT AND KHASOR HILLS.

Níla Roh.

A few words will suffice to describe the whole of the Níla Roh from Tangdarra to Shekh Budín. It is a long narrow anticlinal fold in the upper Siwalik sandstones, its steepest side to the south-east and its longer slopes towards the Bannu plain. These sandstones contain, as is usual, mammalian bones and teeth, but apparently only in such numbers as would require an organised and special quest to obtain anything like a satisfactory collection. Occasionally specimens met with by the more intelligent shikaries in their pursuit of Markhor, or by herdsmen, have reached the hands of visitors to Shekh Budín, and thus their existence has become known. My efforts in the vicinity only procured a few specimens of little worth.

Kiri Khasor range.

The parallel outer, or Kiri Khasor, range lying south-east of the Níla Roh, from its greater variety of structure, will require more notice. This annex of the Marwat hills, separated from the Níla Roh by the long parallel valley of the Lwargi pass, draining to both ends, is in parts both wider and more lofty than the Níla Roh itself, the main trans-Indus continuation of the whole Salt Range anticlinal.

Section at northern end.

In the north and south Basti valley at Kundal (not the main *Algad* of the Rumani Khel part of the valley), the tertiary, red and drab clays and pale gray sandstones dip to the westward at 25°, alternating with and mainly underlying the same sort of Dangot thick sandstones as form the Níla Roh. On the east side of this valley rise the sloping beds of the northern end of the Khasor range, also dipping west, and sheeted by a harder conglomerate composed of quartz, quartzite, sandstone, limestone, red granite; in short, all the harder rocky debris derivable from the Khasor range and some from unknown sources. This conglomerate forms a bottom bed to the tertiary series, and rests with but slightly apparent discordance upon a thick zone of earthy and cherty, well-bedded, magnesian, unfossiliferous limestone. The ground is rather broken, and subject to displacements on the outcrop, but still this magnesian band appears to be between 100 and 200 feet in thickness.

Below it on the eastern side of the range are from 200 to 350 feet of the Ceratite shales, the lower part containing thin-bedded limestone layers, some full of broken shell fragments, others containing *Ceratites* as usual; these beds alternate downwards with coarse pebbly sandstones and flags, and among the lowest seen (apparently) are the usual thin and somewhat shaly Ceratite limestones more than 100 feet thick.

This part of the section on the shattered side of the outcrop is more or less obscure, and repetitions of the beds might occur; but superficial subsidence of the rocks will not entirely account for the presence of a group of white, red, and mottled sandstones, clays, and magnesian limestone layers, having exactly the appearance of the variegated portion of the jurassic group. I suppose these to represent some of the sub-carboniferous rocks brought into this position by faults; unless indeed the group be altogether a new one intermediate between the carboniferous and trias. These are the rocks, doubtless, referred by Fleming to the salt group of the Salt Range, and by Verchere to the same horizon, called by him saliferian.

In a deep *kas* between Ramkúnd and Duman-wáli hamlet, or *kiri*, I found these beds dipping west at 35°, apparently underlying the Ceratite beds without discordance of any kind, which nevertheless might still be present, and thus arranged:—

Ceratite flags, flaggy limestones, and marls: much more than	30 feet.
Thick reddish purple clay with small strings of a white fibrous mineral, soft like gypsum and slightly saline	250 feet.
Mottled sandstone and clays with gypseous strings	
Coarse gravelly white sandstones	
Mottled purple and white sandstone	
Fine-grained soft white rock like a weathered sandy dolomite	
Variegated pink, lavender, white, and greenish clays and white sandstones	
White soft sandy rotten rock	
A few beds of white earthy limestone (magnesian?), white and green clay partings	
White sands or decomposed sandstone (once calcareous or magnesian ?)	
Variegated purple and greenish gray clays	

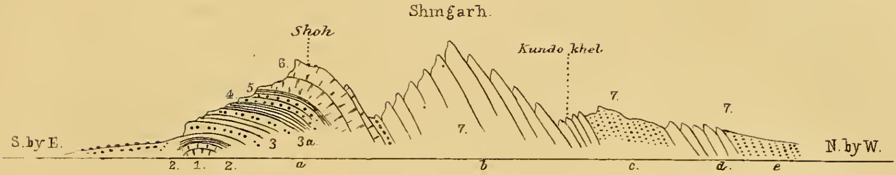

Fig: 4. Section over Chichali (Shingarh) range (P. 50)

Scale: 5/8. inch = 1. mile · Vertical = double the Horizontal.

1. Carboniferous. 2. Trias. 3. Variegated group, jurassic. 3a. Black zone. partly jurassic. 4. Sandstone. partly Cretaceous?. 5. Upper alum shale. 6. Eocene limestone. 7. Siwalik sandstone and conglomerate. 8. Detrital boulder zone.

a. "Limestones." b. "Sandstones." c. "Conglomerates." d. "Sandstone" e. "Conglomerate" (Walker)

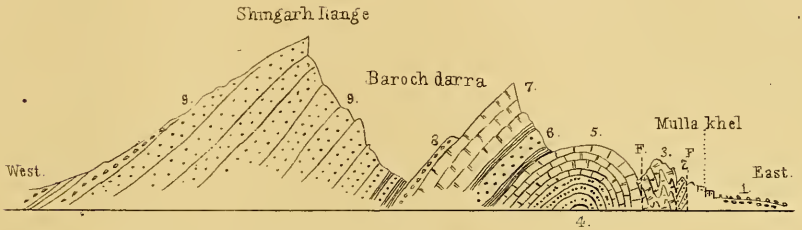

Fig: 5. Sketch section of the Hills near Mulla khel (P. 53)

1 Boulder zone. 2. Crushed tertiary sandstone and limestone. 3. Eocene limestone. 4. Variegated sandstone Jurassic. 5. Limestone Jurassic. 6. Sandstone. cretaceous? 7. Eocene limestone. 8. Upper Nummulitic. representative conglomerate. 9. Siwalik group. F. Fault.

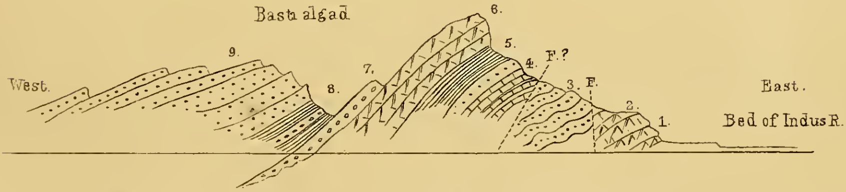

Fig: 6. Sketch section north end of Khasor range (P. 59)

1 Carboniferous. 2. Magnesian limestone. 3. Variegated sandstones. 4 Ceratite limestones. etc: 5. Ceratite marls. 6 Magnesian limestones 7. Conglomerates. 8 Clays and sandstones, tertiary. 9 Siwalik sandstones. F Fault.

In the next *kas* to the southward these beds are seen to undulate, and a group of gray and white sands appears below them, underlaid by greenish muddy lithographic textured limestones and green shales, beneath which comes a great mass of magnesian limestone, greenish-gray shales, and thin limestones, irregularly deposited. Some of these limestones are dark and splintery, and the more shaly parts include whitish, flaggy, and sandstone layers. This lower part of the group may be from 150 to 200 feet thick. A sketch section through the north end of the Khasor range is given in fig. 6 at page 58.

Asphalte locality.

About 2½ miles from Kúndal, to the south, up the course of the Basti *algad,* in which the conglomerate is seen at the base of the Siwalik rocks, a petroleum or asphalte locality occurs. The stream in this valley is saline; but this would seem to arise from its being rather a concentrated solution of the *reh* or *kaller* salts than from its connection with any deposit of rock salt.[1] The water in the more stagnant pools leaves the usual black and white precipitates observable at the sulphur springs of the country.

The oil locality is situated in a small tributary nala on the western slope of the limestone range. Approaching it a higher portion of the basal conglomerate is passed, this bed containing fewer limestone pebbles, and those chiefly of carboniferous or triassic origin, but none enclosing nummulites that I could find. Most of them are of quartz, quartzite, red and purple sandstone, chert, yellowish and red granitic and other crystalline rocks, and the fragments are larger than in the conglomerate nearer the mouth of the valley, which is on a lower horizon by about 30 feet, the intervening space being occupied by red clays.

At the base of this lower conglomerate there are some layers of hard rusty-looking sandy limestone, parts of which seem to have been broken up and slightly shifted in the conglomerate as a matrix; but none of the rounded pebbles are exactly like this rock.

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[1] Salt springs are said to issue from the variegated rocks of the opposite side of the range described in the preceding paragraphs. They are mentioned both by Fleming and Verchere.

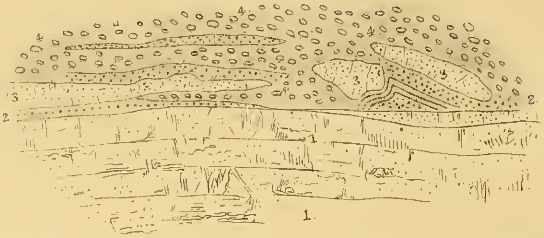

Fig. 7. Junction of the conglomerate and underlying beds of Basti algad at the petroleum sources.
1. Sandy limestone. 2. Sandstone passing into conglomerate. 3. Sandy limestone with detached fragments.
4. Conglomerate.

The section seen at this place is as follows:—

SIWALIK ?	10. Red and gray clays with pebbly and other soft sandstones of grayish colour	500 feet.
	9. Thick conglomerate with irregular sandy limestone layers at base	15—20 „
UPPER PART OF THE CERATITE GROUP ?	8. Brown limestone with white carbonate of lime geodes	5 „
	7. Sandstone layer	1 foot.
	6. Brown calcareous sandstone, joint-spaces filled with calcareous mudstone, thickness varying much	10 feet.
	5. Grayish-pink shale with calcareous sandy layers, pink at top	3 „
	4. Brown slightly calcareous layer saturated with mineral tar	7 „
	3. Soft grayish-white sandstone	100 „
CERATITE BEDS	2. Shaly variegated pink, purple, gray, and olive flaggy beds and brown fossiliferous limestone layers with small Ceratites	50 „
	1. Hard thin limestones with Ceratites	...

Mr. Lyman's account.

Of the petroleum springs of this locality Mr. Lyman says in his report[1] :—" The asphalte deposits extend in spots for about a quarter of a mile along the east side of

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[1] Report on Punjab Oil-lands by Benjamin Smith Lyman, published by Public Works Department at Lahore, 1870. Aluggud oil-lands, p. 36, &c. The name given to this locality should have been the Basti algad. *Algad* or *algada* is the Pashtu for *Nala* or stream-course.

A. B. Wynne fecit.
J. Schaumburg Lith.

SIWALIK CONGLOMERATE AND SANDSTONE.

BASTI ALGAD.

the brook and amount in all to about 350 cubic yards. It is somewhat impure from sand and pebbles mixed with it, and would weigh perhaps in all 550 tons. Of liquid tar in pools, there was in May 1870 about 100 gallons." He did not consider it likely the oil-bearing beds continued bituminous to any great distance, but, owing to their thickness, thought it highly probable that borings would meet with success as to the yield of oil.

Mr. Lyman's description of the section differs a good deal from that recorded in my note book (perhaps he refers to some neighbouring locality), and he states that a brown sandy lime rock, evidently about the horizon of the layers from 4 to 8 in the above list, contains "*Productus* and other fossils." Of these I have found no trace, nor of any recognizable fossil until I had reached the shaly and flaggy beds with small Ceratites, beneath the soft greyish-white sandstone No. 3 above.

Rocks below the tertiary conglomerate.

It is difficult to fix the ages of the middle rocks in the last section. Such limestone as occurs here intercalated or entangled with the lowest part of the tertiary conglomerate might be found in either the trias, cretaceous (?), or basal eocene rocks; it contains no fossils, and the presence of the petroleum rather adds to the difficulty, the usual place of this being near the top of the eocene limestones, which are altogether absent here. In no place is such limestone or any limestone known to form layers in the Siwalik beds, so the presumption is that the calcareous rock is here older, and that its fretted shore surface was so filled by the material of the conglomerate, that where sandy layers of the latter meet others of the limestone the distinction becomes effaced. The thick soft sandstone too (No. 3), being so far as I could see unfossiliferous, is not easy to refer to any fixed horizon; it is not seen to occupy its place for any considerable distance, and though bearing a certain amount of resemblance to the sandstone on the suprajurassic horizon, it may just as possibly belong to either of the next underlying groups. Below it the rocks are a part of the Ceratite group, and as the black Belemnite zone does not occur beneath the sandstone, it may, for the present at all events, be left together with the group on which it rests.

Faults.

On the mountain slope above the junction there are large patches of the conglomerate somewhat displaced by faults, but so clearly resting upon a lower part of the Ceratite group that its total unconformity to the triassic rocks is proved.

North-westerly slopes of the range.

For many miles to the southward of this, the north-westerly slopes of the range show a steady highly inclined and somewhat curving dip corresponding with its general surface, the triassic and upper part of the carboniferous beds forming zones with deeply mitred edges, the V-like points running upward between every considerable nala. The tertiary beds form a long scarp at the foot of the hill; they are mainly gray sandstones, but a few bands of red or dull orange clay are often seen among the lowest layers.

Eastern face of the ridge.

Returning to the scarped south-eastern face of the ridge, the carboniferous formation first appears at the Dumanwáli hamlet (already mentioned) in high bluffs of dark coloured unfossiliferous and rather magnesian-looking limestone; but in the nalas near, the beds are seen to undulate in bold curves, corresponding with an open anticlinal structure, and to contain numerous *Productæ* and others of the common carboniferous fossils.

Káfir Kôt (North). Carboniferous.

At the extensive ruins of the northern, or Til Rajah, Káfir Kôt, the enormous blocks of which the walls are built have been chiefly taken from the carboniferous limestones of the neighbouring hills. Greenish sandy, gray or rusty, limestones are the most common, but a beautiful white compact or crinoidal kind, which rings like a bell when struck and seems to have been dressed with facility, occurs *in situ* in the nala to the west, and a very similar zone also occurs at the foot of the cliffs, here bordering the crest of the ridge. All the lower parts of the hill-flanks expose undulating strong limestones, often with the appearance of having slipped, but still belonging mostly to the lower parts of the formation. Many of the beds are fossiliferous, chiefly containing *Bryozoa, Producta,* many Corals, and some *Terebratulæ.*

Above the lowest 200 or 300 feet of these rocks is a hard sandstone band of 30 feet or so; and at some distance further up in the section are soft sandy beds containing *Bellerophon.* These continue to the base of the cliffs overlooking the slopes, at which point longitudinal slippage or faulting seems to have taken place, and the cliff limestone is chiefly white and highly fossiliferous, containing *Producta, Spirifera,* a large flat pectenoid shell 6 inches in diameter, Corals, *Bryozoa,* and in the uppermost of these cliff beds several fossils of the unnamed form previously referred to (p. 30) occur in the same beds with the club-shaped spines of an *Echinidea.*

Towards Omar Khel.

Similar relations continue for a long distance southward: the crest of the hill carries with it a lower cliff escarpment than is usual; the upper beds dip into the L'wargi or Rumáni Khel valley, and the lower part of the group, slipped about and undulating, covers the whole south-eastern slopes with crags and shingle. Towards Omar Khel the crinoidal limestone, though shattered, seems to overlie rusty calcareous and greenish sandy beds with *Fusulina,* and from beneath these come a mass of grayish and red, but chiefly red, clays and sandstones.

Boulder group.

These red and earthy beds belong to the boulder group; they project from the hill side at such a height that the group must occupy a considerable space in the section, and they are largely exposed in the Chedála wán, a little way southward from the village. The beds are disturbed, somewhat over-slipped by higher portions of the same group, and appear to be also more or less contorted, but their general dip is to the north-west, at first high, then vertical, and again lower, passing under the carboniferous limestones. Although it is not certain, still there is, from the general appearance of the section and the occurrence twice of boulder beds, just a possibility of a crushed denuded anticlinal fold occurring here. The succession is as follows :—

Carboniferous	9. White crinoidal limestone.
	8. Calcareous sandstone and limestone of rusty colour, *Spirifera*, *Streptorhynchus*.
Boulder beds	(*Concealment for many yards.*)
	7. Very thick dark liver-coloured coarse sandstone and boulder-beds. The latter are dark clays full of metamorphic, granite, and other pebbles.
	6. Gray clay.
	5. Mass of shivered gypsum, red and white : dip north-west, high. Much distorted layers of thin-bedded white, red, and gray gypsum, alternating with thin gray dolomitic limestone; bipyramidal and other quartz crystals in one gypsum layer : another showing large ripple mark; may be 50 feet.
	4. Blackish-purple clay.
	3. Crimson and white, mottled sandstones and red clays, the latter containing boulders of quartzite, red granite, dun-coloured lithographic-texture limestone, &c., dipping at 80° to north-west.
	(*Interval 200 yards.*)
	2. Mottled white, greenish-gray, and purple clay with coarse sandstone and gravelly layers, dip at 30° to north-west.
	1. Red sandy clay with enclosed blocks of white, lavender, and speckled sandstone.

This succession is so often interrupted that the thickness of the different parts becomes uncertain. From Nos. 1 to 3 inclusive the beds may be at least 500 feet, and the whole group, which occupies more than half a mile horizontally, can scarcely be less than 1,000 or 1,500 feet, unless a repetition occurs from the presence of an anticlinal, which is doubtful.

Shínki.

The boulder beds are occasionally seen in ravines on the road to Shínki from Omar Khel, but the slopes above are overrun by hard shaly and sandy limestone debris concealing the brown basal part of the carboniferous group. Near Shínki in a small *kas* some dark splintery and some sandy limestones occur, the lower part being fossiliferous and containing *Productæ*, *Spiriferæ*, *Fusulinæ*, &c., the whole underlying lighter-coloured crinoidal limestone. These beds belong apparently to the lower, but not lowest part of the group.

Kíri.

At the northern end of the scattered village of Kíri, just at the base of the hill, there are some curious highly inclined sands, clays, and recent conglomerates quite like local river drift, but dipping to the southward at 50°. It is rather difficult to account for such beds as these having so steep a dip; they are situated rather too high to be very recent river deposits of the Indus, and may perhaps be accounted for by supposing this river to have cut away soft deposits at the mouth of a ravine for a considerable depth, and the newly forming ones to have filled the vacancy too rapidly to assume any other than a steep angle of rest.

The possibility of beds, particularly stream deposits, being formed at this angle, would have an important bearing upon the argument as to mountain disturbance derived from the tilting of such strata as the post-tertiary conglomerates near Kálabágh (see page 19). /

About Kíri Khasor the lower beds of the carboniferous appear to be chiefly crinoidal gray or white limestone, also bands of white calcareous sandstone or decalcified sandy limestone. At the first benches on the hill sides are contorted dark sandy *Fusulina* limestones, and over them sandy crinoidal or cherty limestones with Corals. At the top of the ridge crinoidal beds are chiefly seen in the cliffs; overlaid on the north-west slopes by sandy limestone with *Goniatites*, *Bellerophon*, and *Dentalium*.

In this sandy limestone near the hill top I found a part apparently of a rib-bone, also part of another bone, both of considerable size; the latter may have been a portion of a spine.

A little higher up in these sandy beds a finely preserved *Pecten* and an *Aulosteges* occur.

Resting upon these upper carboniferous rocks are 150 to 200 feet of alternating Ceratite limestones, gray micaceous flags, and shales; these are in contact with the reddish drab clays of the tertiary group, to the exclusion of the triassic Ceratite marls, the whole of the jurassic rocks, and likewise of the basal conglomerates of the tertiary series, a circumstance which may indicate much post-triassic local erosion.

Ghulámi.

Near the hamlet of Ghulámi, one of the rarely seen junctions of the boulder group with the overlying carboniferous limestone occurs (see fig. 8 at page 78). The beds are all steeply inclined, dipping to the westward, and the succession is as follows:—

		Feet.
LOWEST CARBONIFEROUS.	9. Dark flaggy limestone	20
	8. Splintery limestone	40
	7. Hard, earthy, obliquely laminated yellow and gray crystalline crinoidal limestone and black shale, with dull olive sandstone parts and masses	30
	6. Bryozoan limestone and sandstone with *Producta, Spirifer, &c.*	
	5. Variegated and gray shale, hard, white marl and marly limestone, no fossils . . .	12
	4. Rusty sandy limestone with *Fusulina* . .	
	3. Light-brown sandy Spirifer limestone and Bryozoan limestone, Corals, Crinoids, *Terebratulæ*	40
BOULDER BEDS (TOP OF).	2. Coarse white sandstone	130
	1. White sandstone and crimson clays . . .	

In the Bariawáli wán the upper portion of the boulder beds forms a small arch immediately overlaid by dark shales, and these by Bryozoan limestone. Here the lower impure part of the carboniferous limestone is at least 250 feet thick, and the top portion of the boulder group has a mixed appearance somewhat resembling the lavender-clay part of the Speckled Sandstone, underlying the cis-Indus carboniferous: the coarser beds of sandstone here associated with the boulder group are not unlike the speckled sandstones; but the colour of the lower part of the section has even more resemblance to that of the purple sandstone (No. 2) in the Salt Range series.

Bilot.

Between Kíri Khasor and Bilot, and about the latter place, the later denudation has removed a good deal of the carboniferous rocks, leaving the boulder beds more or less exposed, with the general form of an open arch. The boulder beds of the group are not often seen; there seem to be more sandstones and less clays than before, but the red bole-like beds of the group stain and give a prominent red colour to the whole. The carboniferous rocks resting on the red group showed the following succession in the lower part at one place:—

LOWER PART OF CARBONIFEROUS	Pale earthy and lumpy limestones underlying a thick shale zone	150 feet.
	Hard splintery limestones	
	Hard yellow sandstone, 80 feet	
	Flaggy limestone with sandy bed . . .	
	Dark *Bryozoa* limestone	
	Shaly beds	

As a rule, there seems to be present in this region about 100 to 130 feet of pale, micaceous, sandy, carboniferous beds with some limestone layers closely succeeding the red boulder group.

Higher up are beds of purplish, pink, and light-coloured, compact, coral-limestone, with large cylindrical Corals, Crinoids, and ill-defined impacted shells. In the next layers above are *Fusulinæ* and the unnamed form mentioned at page 30.

At the summit of the ridge here the uppermost carboniferous beds seen were crinoidal and coral-limestone, with yellow crystalline and white, sandy, thinly-bedded layers, containing two or three species of *Productæ*, as well as many individuals of a *Bellerophon* common in the Salt Range, a large nodose *Goniatite* and other shells, as well as parts of large fish-bones or bony spines. *Ceratites* also occasionally occur in these beds, so that there seems to be the same mingling of triassic and carboniferous genera at the junction here as occurs in the Salt Range. The thin-bedded limestones and olive marly clays of the Ceratite group with apparently less than their usual thickness immediately succeed the fossiliferous layers just mentioned, and are in contact with the soft gray sandstones and reddish and gray clays of the overlapping Siwalik group.

Káfir Kot (South).

Boulder beds.

In the neighbourhood of Káfir Kot South (or Bil Rajah Káfir Kot), the red boulder group, with a thickness of 100 to 150 feet, is occasionally exposed close on the bank of the Indus, appearing from beneath shattered and disturbed carboniferous limestone layers. Here the beds with boulders are somewhat below the top of the group; they contain blocks, up to one and a half feet across, of red granite, dark basalt, limestone, white metamorphic limestone, quartzose and other indurated rocks; imbedded in a dark grey clay: the assemblage strongly recalling both the western Salt Range infra-carboniferous beds and also the much newer conglomeratic clays of Chel hill in the eastern part of that range, supposed to occupy a cretaceous horizon.

Many of the blocks are smooth, parts quite so, almost polished, and on these surfaces some show slight striation in two directions; these were rendered more visible, while wet, by washing the boulders in the adjacent river.

The limestones of the range here and towards Kingriáli summit are much curved in different directions, and they form a short and rugged ridge parallel to the main crest of the range, the undulation of the beds producing at this locality the widest surface exposure of the carboniferous group in the whole range.

Accompanying this expansion the height of the range increases, but is not given on the maps. By a rough angular observation, compared with aneroid readings, it was conjectured to have an altitude of 3,150 feet above the sea.

Westward of Káfir Kot (South).

Westward of Káfir Kot (South) and of Fatteh-jai on the Indus, there is a singular large bay-like recess, 3 miles across and 1½ deep, eroded from the frontage of the range, near the village of Saiduwáli. As the ground rises this recess is bordered by fine cliffs, reproducing for its extent all the most characteristic appearance of the bolder Salt Range and trans-Indus escarpments, with the usual fan talus of coarse detritus at foot, sloping upwards to a height of 300 feet above the plain.

The singularity of this feature, together with the less marked sinuosities of the escarpment north of Káfir Kot (South), near Bilot, &c., suggests former curvatures of the Indus having impinged upon the range at these points, though there now remain no traces of elevated ground on the eastern side of the river to have caused its deflection.

Cliff series.

Within the recess, its erosion having reached deeply into the structure of the range, a fine section of the rocks is exposed and some new features are presented. By similar rough observations to those previously mentioned, the height of the cliffs here was estimated at about 1,650 feet above the plains, all of which height, except some 300 feet, being occupied by a regular ascending series. In this there is exposed, beneath the carboniferous formation which forms the top of the escarpment, a mass of clays, sandstones, and boulder beds resting upon a very prominent thick zone of some 450 or 500 feet of alternating dolomite and gypsum bands. From beneath these at one place on the western side of the embayment, a lower group of some 250 feet of purple sandstones is seen to project. This purple sandstone has the very uniform character of that which I have distinguished as the Purple Sandstone group in the Salt Range, but the mass of gypsum and dolomite succeeding it has no analogue in any other section of the whole range with which I am acquainted. Gypseous and magnesian beds are found among the red rocks of the boulder group at Omar Keyl, as previously noticed; they are not, however, in the same quantity, or so distinctly separated into a great group by themselves, plainly underlying the red boulder band. The distance (19 miles) between the localities might be considered sufficient for the change to have taken place in, but in none of the sections near the intervening exposure of the infra-carboniferous rocks at Bilot was this great gypseous group to be seen. Hence it appears probable that the conditions favourable to the production of these chemically formed rocks were prolonged in these westerly regions to a later horizon than in the Salt Range itself.

Escarpment section upwards.

From the escarpment the section continues upwards through the trias, and either at the top of this or in the base of the jurassic formation, which now appears, there is, resting upon the uppermost triassic sandstones—here strongly developed—a thick zone of light-coloured unfossiliferous dolomite, very like the rock upon which the unconformable Siwalik conglomerate rests at the extreme northern termination of this range near Basti or Kúndal.

The series in the Kingriáli cliffs and this part of the mountains is as follows (see fig. 9 at page 78) :—

		Ft.
	23. Thick Siwalik gray sandstones, some clays present below.	
JURASSIC ...	22. Loose, white, yellow and red mottled and variegated sandstone, sometimes with calcareous or dolomitic layers. Some layers of ferruginous breccia alternating with gray clays, the latter containing impressions somewhat resembling the pinnules of *Ptilophyllum.* Red calcareous shaly band below.	500 to 700
	21. Whitish and yellow sandy beds rapidly alternating with clay partings.	
	20. Greenish-gray clays, sometimes gypseous.	
	19. Thin-bedded white dolomitic limestones alternating with hard white marls, contain crinoidal bands and a few Cephalopoda; laid down on a very uneven surface of the group below; 100 to 250 feet.	
CERATITE BEDS. TRIAS.	18. Hard zone of dolomite and limestone, a few bands of the latter crinoidal; 150 to 250 feet.	500
	17. Light-coloured and white sandstones with a few crinoidal rings having small central canals: 100 feet.	
	16. Flaggy limestone and greenish marls with Ceratites: sandstone and flaggy limestone more frequent upwards. A thin hard limestone band at base.	
CARBONIFEROUS ...	15. Bellerophon sandstone and *Dentalium* beds ...	650
	14. Strong cliff-limestones	
	13. Sandy limestone with *Terebratulæ* and corals. Thick splintery magnesian layers without fossils.	
	12. A few alternations of sandy and dolomitic rusty limestone.	

BOULDER GROUP.	11. Gray clays overlying a boulder bed in places ...	500
	10. Purple and crimson sandstones and clays ...	
	9. Earthy dark coloured boulder beds; under 200 feet	
	8. Dark gray concretionary shales or clays containing little fragments of thin Bivalves and Gastropoda, also little lanceolate bodies; 100 to 150 feet.	
GYPSEOUS GROUP.	7. Gypsum and dolomite, and clays with cherty, dark platy, bituminous, bands alternating with pink and white layers of rock gypsum.	450
	6. Gypseous clays, gray dolomite, gray gypsum ...	
	5. Pale yellow warty sandstone	
	4. Gray gypseous dolomite	
	3. Red clays and sandy dolomite	
	2. Pale gray, obliquely laminated, finely crystalline dolomite.	
PURPLE SANDSTONE GROUP.	1. Dry-looking purple, red, and whitish sandstones ...	250 to 300

West of Saiduwáli recess.

Westwards from the Saiduwáli recess the Khasor range declines in elevation, with the appearance of a much compressed and crumpled declining anticlinal axis, covered over by the jurassic rocks and trias beds mentioned in the last section, the many deep ravines exposing the lowest part of these rocks, and one towards the west not only the carboniferous but some of the red boulder beds below.

Paniála.

In the neighbourhood of Paniála the rocks appear to have suffered much from compression and fracture, a detached mass of the Siwalik tertiaries being forced into faulted contact with the jurassic rocks, in a ravine due south of the village; and from near this place to the eastward the boundary between the jurassic and tertiary beds appears to be a fault, the drab and olive clays of the latter formation resting in places against inverted beds of the variegated jurassic group. The contact was originally one of unconformable overlap no doubt, but subsequent disturbance seems also to have been accompanied by displacement.

The tertiary beds are here chiefly soft gray thick-bedded, and in parts pebbly, sandstones with subordinate bands of clay, and the Indus pebbles enclosed in these upper or middle Siwalik rocks are not greatly less in size than those in the Siwalik conglomerates of Makhad (on the Indus), while those at present brought by that river into the recent deposits near Bilot and Káfirkôt (South) have dwindled to the size of walnuts and less.

Paniála is famous for the fine springs of fresh water which issue near it and from which the hill station of Shekh Budín is supplied. A sandy plain stretches away to the frontier mountains to the west, and the fine mass of the Gúnd or Shekh Budín rises boldly 3 miles off to the north-west, while the homogeneous, bare and deeply fretted sandstone range of the Níla Roh blocks the view to the north and north-east.

SECTION V.—SHEKH BUDÍN GÚND.

Form of the ground.

This peak forms as it were a large protruding boss about 6 miles long by 2 wide, rising some 1,500 feet or more above the Níla Roh, just at the angle which this ridge makes with the lower Bhatani range. Its summit is marked 4,638 feet above the sea, at the most lofty part of the frontier hill station situated thereon. The mountain is sparsely wooded with scattered scrub, and has, over most of its stony surface, an orange tint contrasting with the bluish-gray colour of the Níla Roh, except to the southward and east, where lofty precipices display the many-coloured variegated portion of the jurassic series and some of the underlying formations.

One profound ravine, that of the Hásham tanga or algad, nearly cuts off the northern from the southern part of the mountain, and there are others, shorter, but of great depth and steepness, on the north, east, and south, most of them radiating more or less from the culminating peak or *gúnd.* All are waterless or nearly so, and to the south and westward terminate in broad stony *vaans* (*wáns*) crossing the belt of boulder ground which borders the hills in these directions; while to the northward they enter the small sandy flats forming the Pezu pass amongst the tertiary sandstone hills.

Surrounding country.

From the top of the gúnd an extensive prospect is obtained. The soft greenish sandstone rocks of the Níla Roh, without a visible trace of vegetation, stretching from beneath one to the east-north-east, are seen to form a bold anticlinal curve, folding over the same axis as that of the northern lobe of the Shekh Budín mountain. To the northwards the same sandstones, with gently dipping inclinations towards Agzar Khel, rise rapidly nearly to the vertical, as they border the gúnd, forming most precipitous and inaccessible ground intersected by steep valleys. Looking along the axis of the Bhatani range, which abuts against that of Shekh Budín gúnd, the convex curvatures of the bedding lines, in plan, as shown in Dr. Verchere's sketch,[1] are plainly seen, and the view is closed to the west by the massive forms and rugged outlines of the Sulemán trans-frontier ranges.

Northern anticlinal.

Where the main axis of the Níla Roh traverses the northern lobe of the mountain beneath the gúnd, it has, from terminal pressure, assumed an upward curvature,[2] and thus given to the jurassic beds of this portion of the mountain a quaquaversal, ellipsoidal arrangement, enfolded at both ends by the tertiary sandstones, which enter deeply the synclinal trough perfectly coincident with the course of the Hásham tanga.

Paniála bluffs. Anticlinal.

Beyond this valley at its southern side, the same jurassic beds rise steeply on to the Jangla ridge, forming part of a similar, nearly parallel, anticlinal ellipsoid, which has been deeply eaten into and cut back from the plains to the line of the Paniála bluffs. These grand precipices expose a fine but nearly inaccessible section down through the calcareous portion of the jurassic rocks, the variegated group beneath, the underlying triassic beds, and lower still a portion of the carboniferous formation.

I have not observed any of the infra-carboniferous beds in the section,

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[1] Jour. As. Soc., Bengal, 1867, Vol. XXXVI, pt. II, p. 14.

[2] Extremely similar to features of the same kind in the northern ranges of Kach.

but Dr. Verchere mentions "beds of massive gypsum" which are "not extensive" "on the southern side of the hill near its base."[1]

Formations of the anticlinals.

The curves of the two anticlinals flatten, where they coalesce on the col, or 'divide,' between the heads of the Hásham tanga and Thoru-ba-tanga or Khavuri ravines; and the easterly convex declinations of both are well exposed by the excavation of the last named valley and upon the spur nearest to Paniála. In the opposite direction the termination of the northern anticlinal is equally well displayed near the ascent of the main road to the hill station from the Pezu post, but that to the south expands, and its definition in the neighbourhood of Chúnda has been interfered with by the extent of the denudation.

Everywhere about the hill the effect of intense local disturbance, compression, and great denudation are prominently exhibited, the folding of the rocks being accompanied by sharp fractures, placing portions of the crushed groups in complex relations of contact with other members of the series.

General relations.

The rock groups are everywhere conformably disposed, the disturbances communicated to each group are partaken of by the rest, but there is evidence of a considerable break in the series at the base of the tertiary beds. Between these and the jurassic rocks, the whole of the nummulitic limestones and their conformably superimposed lower tertiary sandstones, &c., are absent, and in their place there is only a fugitive representative,—perhaps of the supposed cretaceous sandstones of the Shíngarh and Maidán ranges, perhaps of the transition layers between the nummulitic limestone and the lower tertiary sandstones which rest upon it. This band, occurring at the top of the jurassic beds and at the local base of the tertiaries, is composed of coarse soft whitish-yellow sandstone, lithologically similar to the supra-jurassic band in the Chicháli pass, but sometimes containing pebbles of nummulitic limestone like the lowest tertiary sandstone or uppermost nummulitic layers of the Maidán range at Mitha and elsewhere.

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[1] Jour. As. Soc., 1867, Vol. XXXVI, pt. II, p. 17.

Eocene pebbles in supra-jurassic beds.

The presence of these pebbles shows that eocene rocks were being denuded somewhere in the neighbourhood (probably to the north), while the disturbance which caused this denudation by bringing the parent rocks from a depositing into a denuding region was apparently quite inoperative at this locality. Though no evidence exists to show that any deposition took place here, corresponding to that of a large part of the immediately post-jurassic rocks, the nummulitic group, and the transitional lower tertiary sandstones, &c., the post-jurassic surface appears to have remained flat and submerged in this neighbourhood, till long after it had received the horizontal deposits of the upper tertiary Siwalik period.

Carboniferous.

The carboniferous beds of the Paniála bluffs skirt a portion of their southern base and are cut off to the east by a fault, obliquely crossing the strike, and bringing these rocks into contact with a folded and subsided portion of the overlying jurassic group. The whole formation dips at an angle of 20° or 30° to the north, the lowest beds being about 100 feet of dark micaceous flags and shales, of which 60 feet were exposed and the rest apparently concealed by talus deposits. In the shaly beds I found fragments of grass-like plants and the casts of a mytiloid shell. These shales are succeeded by about 400 feet of light-coloured and gray dolomitic and other limestone, the latter containing the usual *Productæ*, *Spiriferæ*, and *Terebratulæ*, with other carboniferous fossils. At the top of the formation the *Bellerophon* beds are found to occupy their ordinary position.

Trias.

Immediately succeeding the carboniferous rocks are the greenish-gray earthy micaceous and partly gypseous clays and sandy beds of the triassic group, some of them having much the aspect and texture of parts of the Siwalik rocks.

The beds are from 300 to 350 feet in thickness, and in places contain an abundance of *Ceratites*, some of them large like those near Virgal in the Salt Range (one measured over 9 inches in diameter). The group, as in other places, is closely united stratigraphically with the underlying rocks.

Variegated group.

Succeeding the trias with parallel conformity comes at first a group of blackish-purple, thin-bedded sandy rocks and clays, then a set of variegated beds, followed by 200 to 300 feet of dolomite,[1] of the same character as that above the trias at the top and on the north side of the Khasor range at Saiduwáli, and like it overlaid by a white thin-bedded marly and dolomitic band.

These magnesian rocks form a conspicuous zone ranging along the cliffs with increasing thickness to the west, generally rising above a bench occupied by the trias clays, &c., these resting upon the stronger carboniferous group.

The dolomitic band is succeeded by a great mass of the variegated jurassic rocks scarcely less than 1,500 feet in thickness. They include white, pink, ferruginous, and purple, soft and sometimes coarse, gravelly or even pebbly sandstones, alternating repeatedly with pale-gray, or greenish-gray, carbonaceous, coaly and alum shales and clays, bole-like red bands occurring near the top. Many bands of magnesian and dull gray compact and splintery or marly limestone are interstratified, becoming more numerous upwards, and there often filled with marine fossils, while the more flaggy and sandy bands among the clays in the lower portion contain numerous imperfect fragments of plants, a few of which resembled leaflets of ferns.

Jurassic limestones.

To the variegated series succeeds a thick mass of clays, drab or crimson, or in part jet black, with alum shales and coaly layers, and containing, as indeed do many of the earthy bands, plates of selenite. They have in places much the appearance of the shales in the jurassic beds of Kach, show the same kind of yellow powdery partings, are covered here and there with white saline efflorescences, and when broken into, are sometimes crowded in the same way with small broken fragments of plants. At one place in

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[1] If this band of dolomites be identified with that at the extreme northern end of the Khasor range,—and it seems very similar,—the jurassic formation may probably be represented there to some extent; but the identification is not certain, and no jurassic fossils have been found in the lower part of the dolomite or immediately beneath it in either place.

the cliffs where the section was well exposed, but inaccessible for the most part, they have the following arrangement :—

Shaly limestone . . . .
Drab shale 50 feet . . . .
Gray shales with limestone bands . . . . .
Black alum shales 100 feet . . . . . .
Crimson clay or bole . . . .
Shaly limestone with numerous fossils . . . .
} 200 feet.

Above this shaly zone comes the mass of thin-bedded pale or dun-coloured limestone with some intercalated clays or shales which forms the sheer cliffs along these bluffs, and bends round the end of the southern anticlinal.

In these limestone beds which may have a total thickness approaching to 800 or 1,000 feet, there are numerous fossils—*Crinoids, Corals, Chemnitzia* or *Cerithium? Echinus* spines, *Rhynchonellæ, Terebratulæ,* some *Pectens, Goniomya, Ammonites,* and several others besides one of the *Asteridea,* an imperfect impression of which I was unable to remove from the surface of the limestone bed that exposed it.

The absence of *Trigoniæ* in these fossiliferous beds appeared peculiar.

Two groups.

The jurassic beds so far present two strongly marked groups, a variegated sandy and earthy one of great thickness below, succeeded by a calcareous one above of uniform dun or light-yellowish colour. The separation, it will be seen, was already somewhat defined in the Chichâli range (page 45), but here it is much more complete; the limestone layers in the lower group, while they serve to connect both, are insufficient to affect the striking difference of character between these two parts of the formation.[1]

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[1] Dr. Waagen has shown the palæontological correspondence between the jurassic beds of the Salt Range and those of Kach (Geol. Surv. Manual, p. 496). A stratigraphical difference, however, which has been also observed in this formation in the intervening deserts (Records, X, pp. 18-19), exists in the fact that in Kach the arenaceous portion of the whole group overlies the limestones, while here and in the Indian desert the reverse is the case (*cf.* Manual, pp. 253, 263, and 495). The Ranikot group of Sind as described (Manual, p. 451) appears to be strikingly similar in composition to the variegated jurassic beds here.

Uppermost jurassic.

The jurassic limestones mantle round, enfold, and occupy the whole of the anticlinal ellipsoid forming the northern lobe of Shekh Budín. They are in places fossiliferous, and a considerable collection from these beds is in the hands of Dr. Waagen for determination. Among the highest, or forming the very highest layer around the ellipsoid, as well as overlying it in scattered patches to the east, near a tank on the descent from the summit towards Paniála, and again near the Pezu road, between the Gúnd and a summit called Pic-nic hill, there occurs a tough blackish sandy and ferruginous band of 40 to 50 feet or less. This is almost exactly similar to the black band in the Chicháli range on the same horizon containing uncanaliculate *Belemnites* and a neocomian *Ammonite* in its upper part, but enclosing jurassic *Ammonites* and *Belemnites* just beneath.

Blackish zone.

This black band here (if it be quite the same) always contains *Belemnites* with and without canals. *Ammonites* of two or three species have been found in it, but none that have been as yet identified with the neocomian *A.* (*Perisphinctes*) *asterianus* of Chicháli pass: several fossils besides, such as *Rhynchonella*, *Pecten*, *Goniomya*, *Corals*, *Ostrea*, &c., occur, also nodular masses of hard clay full of cavities, apparently made by boring shells.

Not far below this horizon is a band of blue oolite which contains numerous *Retziæ?* some *Pleurotomariæ*, and numbers of *Pholadomyæ*, as well as fragmentary *Ammonites*, &c. One always singularly well preserved tumid *Pecten* ranges from these upper beds down into the variegated series of the Paniála bluffs. The zone is perhaps partly representative of some of the golden oolite layers elsewhere.

Similar rocks.

In some spots, but always isolated, dislocated, or generally without any overlying strata, I have observed exposures of similar dark-coloured rocks to those just described, but not always found them to contain fossils. It is uncertain whether these exposures belong to the topmost jurassic horizon, or may be those of other black bands at no great distance downwards in the series. The

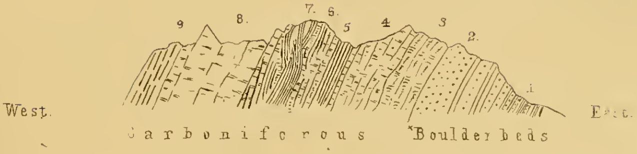

Fig: 8. Junction at Ghulami between Carboniferous and boulder beds (P 66)
(For index, see text.)

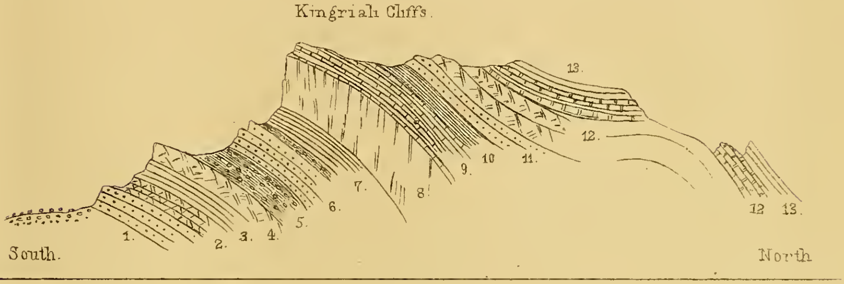

Fig: 9. Section of the Kingriali Cliffs. (P. 70)
Scale: 2. inch = 1. mile Vertical = double Horizontal.

1. Purple sandstone 2. Dolomite 3 Gypsum. 4. Dolomite (gypsum group.) 5. Purple boulder beds 6. Purple sandstone. 7. Clays. 8. Carboniferous limestone. 9. Bellerophon beds. 10. Ceratite beds. 11. Trias sandstone. 12. Dolomite (? Triassic) 13. Jurassic marly limestone and sandstone.

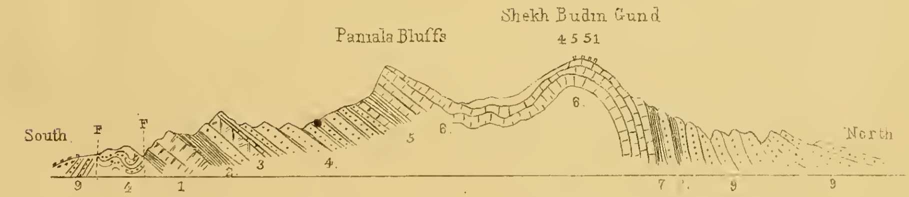

Fig. 10. Section over Shekh Budin.
Scale. 1. inch - 1. mile Vertical scarcely exagerated (P. 79.)

1. Carboniferous. 2 Trias 3. Dolomitic band. 4. Variegated Jurassic. 5 Shale zone 6 Limestone Jurassic 7 Black zone Jurassic 8. Sandstone, cretaceous ? in part. 9. Siwalik sandstones F Fault

most probable case I observed of an inferior position for these beds occurs in the Hásham tanga, on its north side, south-west of the station; even here it was not certain that slipping of a portion of the higher rocks had not taken place.

Sandstones above jurassic beds.

Nearly always in contact with this black zone on external parts of the hill are to be found the whitish or light-coloured sands and sandstones of the, perhaps, partly cretaceous and partly post-eocene or even upper eocene band which intervenes between the jurassic and tertiary formations; they sometimes appear either not to have been deposited or else to have been squeezed out of place in the sections, and they vary somewhat, both in thickness and character. Not unfrequently sharp checks, faults and omissions of the group, are to be found, probably resulting from the intense crushing at the contact of rock masses having so great a difference in hardness as the jurassic limestones possess compared with the Siwalik rocks.

Siwalik beds.

Succeeding the sandstone band (No. 8) of this section comes the enormous mass of the Siwalik sandstones of the Níla Roh and Bhatani ranges, almost entirely without the frequent alternations of clays to be found in other districts, until the uppermost part of the group is reached. Here a comparatively narrow band of the usual drab clays seen at the top of the upper Siwalik beds in the Indus section closes the series as exposed. A section over Shekh Budín is given in figure 10 at page 78.

This being one of the most, if not the most, interesting portion of the trans-Indus extension of the Salt Range, as well as the farthest point in this direction at which the relations of the palæozoic, mesozoic, and tertiary rocks are known, I append a coloured reduction from the recently completed frontier survey of the locality, on the scale of one inch to a mile, four times as large as that of the map to accompany this paper.

Faulted tertiary junction.

The tertiary sandstones in the neighbourhood of the spurs nearest to the Paniála staging bungalow are seen to be in several places faulted against the jurassic rocks, and on the south-western side of the Khavuri tanga, near its mouth, there is a mass of the variegated group with portions of the uppermost black zone brought into crushed and faulted contact with both the Siwaliks and the calcareous jurassic beds. How this mass was originally placed it is difficult even to conjecture with probability, but its presence may be connected with the intense folding and distortion of the rocks where the Paniála bluffs turn sharply to the north, and are traversed by the bridle path used to convey water from the last-named village to the hill station.

East cliffs.

The cliffs in the limestone group at this place were estimated, partly by the aid of aneroid readings, at from 800 to 1,000 feet in height, most of this being a sheer vertical precipice, through beds not only presenting a very focus of plication, but so intensely faulted and crushed that a portion of the Siwalik rocks, once caught apparently in a minor oblique synclinal on the northern side of the main Níla Roh and Shekh Budín anticlinal axis, has been wedged into a position along the upper part of the Khavuri ravine actually underlying the jurassic rocks on both sides of the stream.

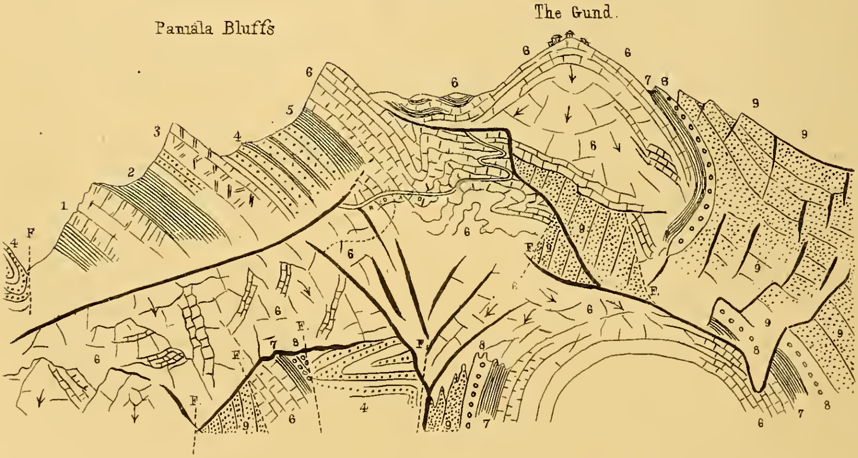

Fig. 11. Diagram east end of Shekh Budín hill.

Diagram.

The annexed diagram may assist in the comprehension of the way in which the rocks here are arranged. The outlines approaching an observer are drawn thicker than those more distant; the figures are the same as in the section across the hill, previously given; lines of fracture are marked with the letter F, and the large surfaces upon which the limestone (sectional) character is omitted are convex towards the spectator.

Supra-jurassic sandstone to east.

Round the eastern margin of the jurassic limestones in the valley of the Khavuri tanga, the sandstones between these beds and the Siwalik group are as well exposed perhaps as anywhere else about the hill. Due east of the point where the Paniála road crosses the bluffs, in the valley far below, they are quite vertical, adjoining the dark uppermost jurassic band on one side and soft Siwalik sandstones upon the other, and they contain two small conglomeratic bands enclosing pebbles of alveolina-limestone. A little way along the strike, up the course of the algad, they appear to have gained in thickness, and dip with the curving beds of the anticlinal at a lower angle, the contact with the beds adjoining taking place thus—

SIWALIK ...	4. Gray soft sandstone with scattered pebbles: part of a great thickness of similar rocks.	?
SUPRA-JURASSIC	3. Soft whitish sandstone alternating with gray and dark-brown rusty clays and conglomerate layers below. One minute *Terebratula* found.	120 feet.
	2. Black sandy earthy zone with *Belemnites;* a few rusty layers:—50 feet, and less.	
JURASSIC ...	1. Hard thin-bedded limestone with thin shale partings; *Rhynchonella, Gervillia,* and large *Belemnites* in topmost layer. Upper part of the jurassic limestones. Thick.	

The conglomeratic bands do not appear to be everywhere present in the sandstone No. 3, but were distinctly seen just above the black zone No. 2, where the rocks are tilted upon edge near this.

Further on towards the axis of the anticlinal the soft white sandstone zone seems even thicker, still overlying the dark earthy band, but being in two or three places totally and sharply interrupted by cross-faults, probably more the result of partial landslips in consequence of the torrential action of the stream than anything else.

There are some patches of the dark uppermost jurassic zone, apparently left by the weathering and denudation of the ground, scattered over the arched surface of the anticlinal here, and a similar sort of exposure occurs near a fine tank on the small plateau above the cliffs, traversed by the Pariála road. This is one of the fossil localities of the hill.

Cliffs.

To the westward along the line of the Chunda bluffs the cliffs on the south of the ridge are very fine. They are formed at the crest and for many hundred feet downwards by the jurassic limestones. Their height must be great, particularly beneath the peak called Gúgu-ka-Chúka, to judge from the time occupied in the descent of the cliff by a large herd of Markhor going at full speed and jumping from ledge to ledge; some of the latter are 30 to 50 feet apart, and the rocky wall so perpendicular that no other kind of four-footed animal could have attempted to descend. No heights for these commanding points are marked upon the maps.

Beyond this towards Chunda the path is very difficult. One must either follow the very crest of the ridge formed by the limestones, here dipping at nearly 40° into the Hásham ravine, or descend into the ravine itself, for at the place called the Jangla the cliffs are inaccessible and the whole northern side of the mountain is formed for long distances of the surface of a single sloping bed of rock too smooth and too steep to afford a foothold except to the Markhor and Oorial, nearly always to be found there.

South of the Jangla ridge.

Supra-jurassic beds at Pezu ascent.

To the south of the ridge here the variegated group is well exposed upon the spurs in the Wazirwal tanga or kas; while to the north of the ridge the 150 to 170 feet of soft sandstones interposed between the jurassic and Siwalik rocks are to be seen following the strike of both of these formations, but interrupted in a singular manner in the ravine just south of the lower part of the steep zigzag ascent from Pezu. The section here is as follows :—

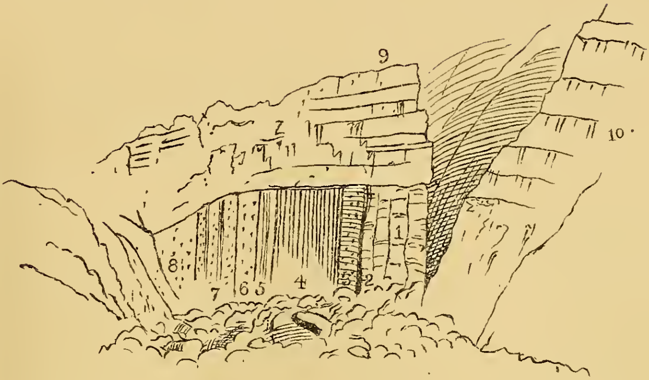

Fig. 12. Diagram of a small section near the Pezu ascent to Shekh Budín. (References given in the following paragraph).

Just at the mouth of the ravine some soft whitish sandstones are visible, and following it upwards for a few chains, to where a small elbow occurs, the uppermost beds of the jurassic group and those of the intervening zone between these and the Siwaliks are found in the abnormally crushed, faulted, and overslipped position seen in the sketch. The mass to the right (No. 10) is of gray strong limestone, similar to that of the rest of the jurassic formation adjacent. The subsided mass No. 9 is of similar limestone also, and fully 50 feet, or more, in thickness or height, passing into shattered rubble to the left:—

	Feet.
No. 8. Massive, soft, milk-white sandstone	39
—underlying grayer sandy beds imperfectly seen, and overlying—	
„ 7. Rusty and white sandstone, thin-bedded and alternating with gray saline clays	20
„ 6. Red sandstone	10
„ 5. Gray thin-bedded shale	10
Carried over .	79

	Feet.
Brought forward .	79
No. 4. Black shale, gypseous and containing *Belemnites* . .	45
„ 3. Dark greenish-olive concretionary and sandy rock . .	18
(Nos. 3 and 4 equal the black band at top of the jurassic formation).	
„ 2. A thin layer of black gypseous clay.	
„ 1. Dark rugged limestone with tracks on surfaces and partings of clear gypsum (selenite).	
TOTAL . , . .	140

North of the hill.

At a little distance to the north, the main road crosses the sandstone band where it is in its proper place, and the white sandstones seem much thicker. The band is vertical and at least 150 feet in thickness, apparently increasing considerably to the eastward. The junction with the perfectly parallel Siwalik beds is thus—

	Feet.
Siwalik.—4. Thick gray sands or incoherent sandstones passing downwards into thick sandy clay.	
3. Green clay . . , ...	15 to 20
2. Rusty sandstone passing down into	
1. Thick white sandstone band: more than	130

This sandstone band is traceable to the eastward among the vertically bedded rocks on the northern side of the Gúnd anticlinal, but the ground is here so precipitous and impassable in places that the junction which occurs high up among the cliffs cannot always be closely inspected: here and there the zone, if present, was certainly not prominently in view from above.

The following provisional determinations of fossils collected at Shekh Budín have been kindly supplied by Dr. Feistmantel:—

TERTIARY.

LAMELLIBRANCHIATA.

Lucina gigantea, Desh.—Karundi.

GASTEROPODA.

Nerita schmideliana, Chemn.—Karundi, Soh Mts.

ECHINODERMATA.

Conoclypeus (comp.) *flemingi*, d'Arch.—Kálabágh, Karundi.

CORALS.

Trochosmilia, sp.
Leptoria, sp.
Latimæandra, sp.
Actinacis, sp.
East-north-east of Thal.

FORAMINIFERA.

Nummulites, sp.—Sherkot, hills behind Hanga, road to Udi.
Alveolina, sp.—Hills behind Hanga.

KALABAGH.

CARBONIFEROUS.

GASTEROPODA.

Bellerophon decipiens, deKon.

BRACHIOPODA.

Terebratula biplicata, Brocchi, var. *problematica*.
„ *himalayensis*, deKon.
Streptorhynchus pectiniformis, Dav.
Athyris subtilita, Hall.
„ *royssi*, L'Ev.
Productus costatus, Sow.
„ *purdoni*, Dav.
Camarophoria purdoni, Dav.

KAFIR KOT.

CARBONIFEROUS.

GASTEROPODA.

Bellerophon decipiens, deKon.
Anomia lawrenciana, Flem.

BRACHIOPODA.

Streptorhynchus crenistria.
„ *pectiniformis*, Dav.
Spirifera octoplicata, Sow.
Athyris subtilita, Hall.
Productus costatus, Sow.
„ *cora*, d'Orb.
„ *semireticulatus*, Sow.
„ *humboldti*, d'Orb.

CORALS.

Michelina, sp.

OMAR KHEL.

CARBONIFEROUS.

GASTEROPODA.

Anomia lawrenciana, Flemg.

BRACHIOPODA.

Streptorhynchus pectiniformis, Dav.
Productus costatus, Sow.
Pr. semireticulatus, Sow.
Productus, sp.
Orthis, sp.

BRYOZOA.

Phyllopora comp. *haimeana*, de Kon.

CORALS.

Lithostrontion.

FORAMINIFERA.

Fusulina comp. *cylindrica*, Fisch.

GULAMI.

CARBONIFEROUS.

Spirifera striata, Mart.
Athyris royssi, L'Ev.

PARANGA KAS.

CARBONIFEROUS.

BRACHIOPODA.

Athyris subtilita, Hall.
Athyr. royssi, L'Ev
Productus costatus, Sow.

BRYOZOA.

Retepora ? lepida, de Kon.

BILOT.

CARBONIFEROUS.

VERTEBRATA.

Xystracanthus, major Waag.
Fish teeth.

CEPHALOPODA.

Ceratites, sp.

GASTEROPODA.

Macrocheilus avelanoides, de Kon.
Dentalium herculeum, de Kon.
Bellerophon decipiens, de Kon.

BRACHIOPODA.

Streptorhynchus crenistria, Phil.
,, *pectiniformis*, Dav.
Rhynchonella, sp.
Productus cora, d'Orb.
Prod. humboldti, d'Orb.

CRINOIDEA.

Philocrinus cometa, de Kon.

CORALS.

Lithostrontion, sp.

SHEIK BUDIN.

CARBONIFEROUS.

BRACHIOPODA.

Spirifera moosakhailensis, Dav.
Athyris subtilita, Hall.
Productus costatus, Sow.
Prod. cora, d'Orb.
Prod. semireticulatus, Sow.

CORALS.

Lithostrontion, sp.

TRIASSIC.

Ceratites planulatus, de Kon.
„ *davidsonianus*, de Kon.

JURASSIC.

CEPHALOPODA.

Ammonites biplex, Sow. (Verchère enumerates four more species).
Ammonites communis, Sow.
Ammonites—several other species.
Belemnites gerardi, Opp.
Belemnites tibeticus, Stol. (Verchère names two more species).
Belemnites comp. *hastatus*.

GASTEROPODA.

Pleurotomaria, sp.
Pleurotomaria—another species.
Natica, sp.
Ancillaria, sp.
Turritella, sp.

LAMELLIBRANCHIATA.

Pecten, sp.
Lima, sp.
Homomya, sp.
Pholadomya deltoidea, Sow.
Pholadomya comp. *media*, Ag.
Pholadomya comp. *murchisoni*, Sow.
Pholadomya, sp.
Mactromya, sp.
Ceromya, sp.
Ostræa, sp. (Several other species are named by Verchère).

BRACHIOPODA.

Terebratula biplicata, Sow. (Verchère names several other species).
Terebratula sella, Sow.
Terebratula.—several other species.
Rhynchonella comp. *dimidiata*, Sow.
Rhynchonella—several other species.

CORALS.

Fungia, sp.

PLANTS.

Ptilophyllum acutifolium, Morr.
Podozamites, sp.

Siwalik beds.

But little remains to be said of the tertiary rocks of this neighbourhood. The whole series possesses an almost monotonous sameness of character with an endless diversity of form. The dips uniformly correspond to the ovoid dome-shaped mass of the older rocks, and the bedding lines in these thick, soft, homogeneous sandstones are frequently so subordinate that the deep erosion which produced the many ramifying spurs, disregarding the bedding, has tended to produce vertical surfaces, whether the stratification be itself vertical or inclined. So readily has the mass yielded to the wasting agencies that one can penetrate with scarcely perceptible ascent, until close to the backbone of the hills, by following any of the numerous flat-bottomed dry sandy gorges. Further to the eastward it becomes apparent that the stratification has, notwithstanding, exerted a modifying influence upon the large scale, for this backbone of the Níla Roh does not coincide closely with the anticlinal axis of the range, but lies adjacent to this axis at a little distance to the north, leaving the steep inclinations of the rocks to the south, and tending to form a scarp along the outcrop of the more gently sloping strata in the opposite direction. From the space occupied, the height of the range, and the angles of inclination, it is estimated that the Siwalik beds of the Níla Roh are more than 4,700 feet thick, the uppermost 500 to 700 feet being chiefly clay.

Fossils.

Siwalik fossils have long been known to occur in these beds, but all that were readily procurable seem to have been already collected by visitors to Shekh Budín, Dr.

Costello and others. Still there can scarcely be any doubt that a regularly organised search for fossils, with sufficient time at disposal, would be successful. The few specimens I was able to obtain during the short time I was in the neighbourhood were scarcely worth carriage.

SECTION VI.—THE BHATTANI HILLS.

Anticlinal.

This is a much lower range than the Níla Roh, formed of exactly the same beds, likewise having an anticlinal arrangement, but the inclination on each side is at low angles and the curve more open and uniform. The axis starts obliquely from that of Shekh Budín Gúnd, and the curves of both anticlinals almost insensibly pass into one another among the hills near of Pezu post. The convex curves, in plan, or "semi-theatres," of Dr. Verchere, are doubtless due to horizontal undulations of the main axis of curvature.

The state of the country was too disturbed when I visited it for any examination to be permitted towards the Baindarra, &c.; indeed the town of Tánk in the vicinity was just then raided and burned by the hill-men, and the Pezu post itself was threatened with a night attack.

Upper Siwalik.

The structure of the range was, however, clearly seen from Shekh Budín, and the section through the Pezu pass showed the rocks to be the same upper Siwalik beds as those of the Níla Roh.

SUMMARY.

From the foregoing descriptions it will appear that the Salt Range, both orographically and geologically, is continued through the trans-Indus of the Bannu and Deraját districts to the Sulemáni system of mountains at the termination of the Bhattani ridge. It will be observed that the general sections in both the cis-Indus and trans-Indus portions of the range include, with many variations, palæozoic, mesozoic, and cainozoic formations.

Among these, the groups of least certain age are more numerous cis-Indus in the Eastern Salt Range than to the west, while beyond the Indus they are reduced to the infra-carboniferous salt marl, purple sandstone, gypseous and boulder, groups—the supra-jurassic zone being at least partly cretaceous. But of the four infra-carboniferous groups of doubtful age two are common to the whole range, and known to be not newer than silurian,[1] so far as at present ascertained.

It may be assumed that in early palæozoic times a considerable uniformity of conditions prevailed, giving rise to the formation, over an extensive area, of a curiously unstratified soft earthy rock, largely impregnated with iron and soluble salts, the latter frequently taking the shape of chemically formed layers, probably within more or less circumscribed limits.

Immediately succeeding this early period, more or less adjacent, old, metamorphosed rocks were within the reach of denudation, of coast or river action, and their debris carried here to be deposited in the boulder group. Up to this point, there is no evidence in any part of the range trans-Indus whether the palæozoic deposits succeeding the salt-bearing series were marine or fresh-water or estuarine, but after this they became decidedly marine.

In the eastern Salt Range marine deposits were certainly formed in pre-carboniferous times; here, in the west, they continued to accumulate without interruption till the close of the triassic epoch.

At this time disturbance, not proved with certainty, may have taken place quite locally. The northern end of the Khasor range may then, or shortly after the lowest jurassic layers were deposited, have become an area of suspended accumulation, if not one of actual denudation.

In other places the jurassic deposits continued to succeed the earlier mesozoic ones, but during the period of the variegated series this may have been formed in shallower waters, perhaps no longer entirely salt;

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[1] This is still unsettled, see Manual, p. 488, and Palæontologia Indica, Ser. XIII, Vol. I, p. 6.

at least adjacent land is indicated by woody plant remains, sometimes converted into lignite, and by carbonaceous or even coaly layers.

Later, in the upper jurassic group of this country, marine conditions certainly prevailed till the first traces of the succeeding upper mesozoic and lowest cretaceous epoch had become recorded in what is stratigraphically the topmost layer of the jurassic rocks.

After this, coarse sandstones were formed, perhaps not far from land, and though there is neither great variety nor enormous thickness of rocks to mark the duration of the cretaceous period, its representative here passed either insensibly or with but local interruption within the limits of eocene or post-eocene times.

At the close of the period during which the partly cretaceous rocks were being deposited, notwithstanding there is no local evidence of the presence of a land surface, some cause intervened to arrest the accumulation of the eocene rocks over parts of this region, though so largely developed in others; for they can scarcely have been deposited and removed again without having left strong traces of the denuding agency; and if local elevation of part of the depositing area were the cause of their absence, marked unconformity, entirely undetected, might be expected to have resulted.

Whatever the arresting cause may have been, whether cessation of deposition or otherwise, its influence was first displayed to the west and south; and it extended thence north-eastwards, passing on through the later or post-eocene period of the lower tertiary deposits; so that until the date of the upper tertiary Siwalik strata there are but traces (and westwards very slight ones only) of any beds to represent the great accumulation of pre-Siwalik lower tertiary sandstones and clays found in neighbouring regions.

This capricious distribution of well marked cainozoic groups, it appears to me, must be attributed mainly to changes of level in early tertiary times, and probably largely also to the bank-like method of accumulation usual in sub-torrential deposits; the detritus wherewith they were constructed being traceable to the atmospheric destruction of anciently existing elevated regions lying between India and the rest of the Asiatic continent.

Looking further back, it will be seen that laterally changing sections (changing more by reason of the presence of groups elsewhere absent and the converse of this arrangement, than by gradual internal changes of the groups themselves) is a feature characteristic of the whole Salt Range region and its trans-Indus extension. But the observation may be extended even beyond these limits, for the frontier sections next known to the southwards, although comprising geological representatives of part of the general series here, differ quite as much as they resemble those of this country in the character of the groups displayed.[1] Further still, to the southward, in Sind, the sections,[2] embracing only mesozoic and eocene representatives, are even more unlike those of this country than the intermediate ones; for marine tertiary groups, entirely unknown in this part of the Punjab, form a considerable portion of the Sind series.

When such differences as occur in the development of the Punjab sections can have taken place within the limits of this province, it follows that close identity with greatly more distant areas should not be anticipated; particularly when all the regions capable of comparison are situated along the margin of an extended continental region of disturbances, some of which may have originated at very early periods.

ECONOMIC RESOURCES.

The valuable mineral productions of this region are almost exclusively limited to the salt of Kálabágh and the Lún nala, the alum of Kálabágh and Chicháli pass, the coal or lignite collected in small quantities at times from the jurassic beds of the Kálabágh hills, and the gold washed from the Indus gravel.

The salt and its sources have already been described in the Salt Range Memoir (Mem. Geol. Surv. India, Vol. XIV, page 274) and in the

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[1] Ball, on the country of the Luni Pathans: Records Geol. Surv. India, Vol. VII, p. 145.

[2] Blanford, Geology of Sind: Records, Vol. IX, p. 8: Manual Vol. II, chap. XIX, and Part 1 of the present Vol. of the Memoirs.

SHEKH BUDIN HILLS.

Alluvium (sand, &c.)
Siwalik (upper)
Cretaceous, in part?
Jurassic limestone
Jurassic sandstone &c.
Trias Ceratite beds
Carboniferous

Faults - - - - Fossil localities *

PHOTOLITHOGRAPHED AT THE SURVEYOR GENERAL'S OFFICE CALCUTTA AUGUST 1879

foregoing pages. It all belongs to the same horizon as that of the Salt Range.

The gypsum of Kálabágh and the Khasor range is not as yet utilised in this country. It does not appear to be in any way connected with that of the Kohát district; and how far it may be representative in either of these regions of that occurring to the west in Afghanistan, it is at present impossible to say.[1]

The alum is manufactured from the pyritous shales of the jurassic and eocene formations. This industry seems to have greatly fallen off. At Chicháli, when the place was visited last season, only one batti (kiln) was at work, and no alum was being made at Kálabágh. Dr. Fleming fully described the manufacture in his paper to the Asiatic Society, Bengal, July 1849, page 685, as follows:—

"The alum is prepared from a black, highly bituminous shale called *Rol*, containing a quantity of iron pyrites, and which is brought from Chita, about 2 miles distant, and several other localities in the hills around Kálabágh. This shale is coarsely powdered and deposited in layers about a foot thick, between each of which a thin stratum of brushwood, grass, or other combustible material is placed. These layers being piled up to a height of 20 or 30 feet are set fire to, and the whole allowed to burn slowly, water being from time to time sprinkled on the mass, to facilitate the re-action of the ingredients in the kiln on each other. When the combustion is completed, which occupies six or eight months, according to the size of the kiln, the shale has assumed a brick-red colour, and its surface is encrusted with a coating of alum mixed with sulphate of iron. This burnt kiln affords the materials for the alum preparations, and portions of it are deposited in a baked earthen vat, which is constructed close to the kiln, and a little below the level of its base, and in it are lixiviated with water. When this is saturated with the crude alum, it is run off, by an opening in the lower part of the vat, into another one of the same dimensions and character, when any muddy particles are allowed to settle. After being allowed to rest in the second vat for six or eight hours, it is then slowly run off into another smaller one at a lower level, and close to a large evaporating iron pan, into which the alum liquid is conveyed, and when boiling mixed with a brownish earth which is here called *jumsau*, and appears identical with the saline incrustation abundant in all jungles in the North-Western Provinces

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[1] Vigne mentions that Ghazni is built at the foot of a long narrow ridge of gypsum, beyond which towards Kabul limestone and granite (of the Safed Koh?) occur. (*Vigne's Caubul, p. 126.*)

called *Reh,* and which is a mixture of sulphate with carbonate of soda. When a proper quantity of this has been added, which is judged of from the appearance of the liquid, the whole is allowed to settle, and the clear liquid then removed into smaller earthen vats, where it is allowed slowly to crystallize for several days. By this means, crystals of alum are separated of a small size and pinkish colour from the brown impure mother liquor, from which they are removed, and allowed to dry for a short time. These crystals are then fused in their own water of crystallization in an iron pan, and when in a fluid state are removed into gurrahs [earthen globose vessels,] where for eight or ten days they are allowed to crystallize. The solid mass of alum in the interior of the gurrah is then pierced with a pick and the gurrah inverted so as to allow any uncrystallized alum liquor to escape. The gurrah is then broken, and the alum moulded to its form removed to the depôt for sale or exportation. It is generally of a light brown colour, and evidently contains iron and other impurities.

"A kind of alum called *Kaee* (Kai) is prepared for dyers from a light gray shale containing crystals of what appear to be sub-sulphate of alumina. This shale is coarsely powdered and dipped in the liquor separated from the small crystals of alum. It is then removed and dried in irregular-shaped masses of about a seer weight each, which are of a brownish colour. When dry these get a second dip in the same alum liquor and are again dried, becoming of a tawny yellow colour, in which state they are sold to dyers at 8 annas per maund.

"The shale from which this variety of alum is manufactured is found associated with the other alum shales around, but in moderate quantity."

Since the above passage was published, it does not seem to have ever been accurately ascertained what the *jamsau* above mentioned really is, and the natives appear to make somewhat of a secret of the matter. Large quantities of saltpetre are imported into Kálabágh ostensibly for use in the alum factories, and it appears more probable that *jamsau* is crude saltpetre rather than the ordinary *reh* or *kalar* (sulphate and carbonate of soda) which is made use of in the production of the alum.

A sample of the Kálabágh alum was kindly examined at my request by Mr. Mallet at the Survey laboratory and found to contain—

Sulphate of alumina	36·20	per cent.
Sulphate of potash (with trace of sulphate of soda)	18·43	

"This composition is almost identical with the calculated quantities of the above salts contained in pure crystallized potash alum."

The lignite of Kálabágh and Kotli is referred to by Dr. Oldham in his report to Government on the mineral resources of the Salt Range, &c. (*ante* page 4), from which extracts are given in the Salt Range Memoir (Mem. Geol. Surv., Vol. XIV, pages 293, 296); and several analyses of the lignite of this district are appended to a paper by Dr. Verchere in the Journal of the Asiatic Society, Bengal, Vol. XXXIV, pages 44, &c.

All these lignites occur either in the variegated group of the jurassic rocks or in the alum shale portion of the eocene rocks. They occur at intervals from Kálabágh round the curve of the mountains to Mitha, but the layers themselves are of little value as sources of fuel; in most cases at least, the largest quantity of the mineral is obtained by picking and turning over the disintegrating alum shales of the mountain, some distance north of Kálabágh, at the head of the Pakli ravine.

Stream gold is washed in the Indus, and platinum has been stated to occur with it (*see* Salt Range Memoir, page 27), but this has not been supported by any recent observations. Gold is also said to be washed for in the Kuram river.

The building stones of the country occur in considerable variety. Even rock-salt is used for the purpose at Kálabágh, and the various limestones of the carboniferous, jurassic, and nummulitic formations would each furnish good building materials, but the sandstones of the jurassic and Siwalik beds are mostly soft and very perishable.

In concluding these observations I have to express acknowledgments for assistance received from the District Officers, Major Macaulay of Dera Ismail Khan and Mr. Udny of Bannu, as well as to the Reverend Mr. Meyer, for considerable additions to the fossil collection from Shekh Budín.

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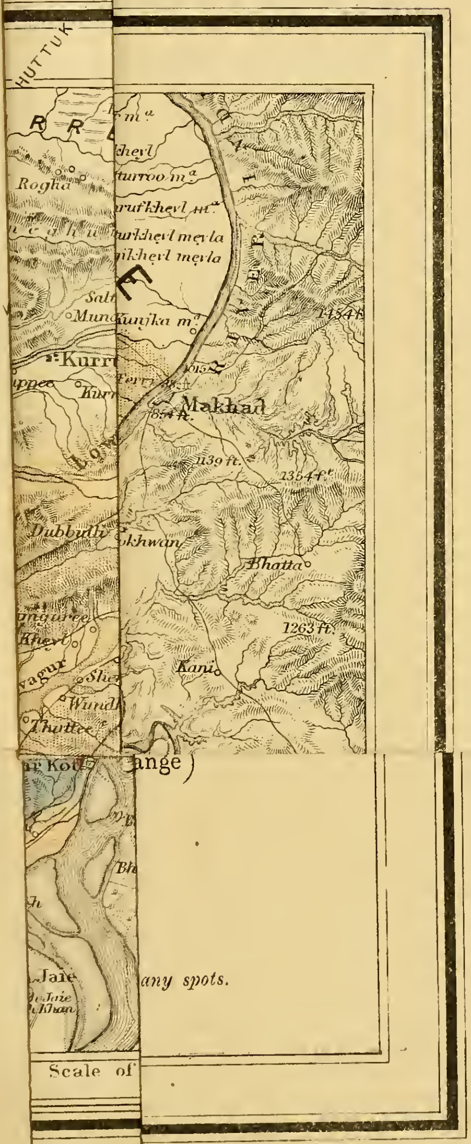

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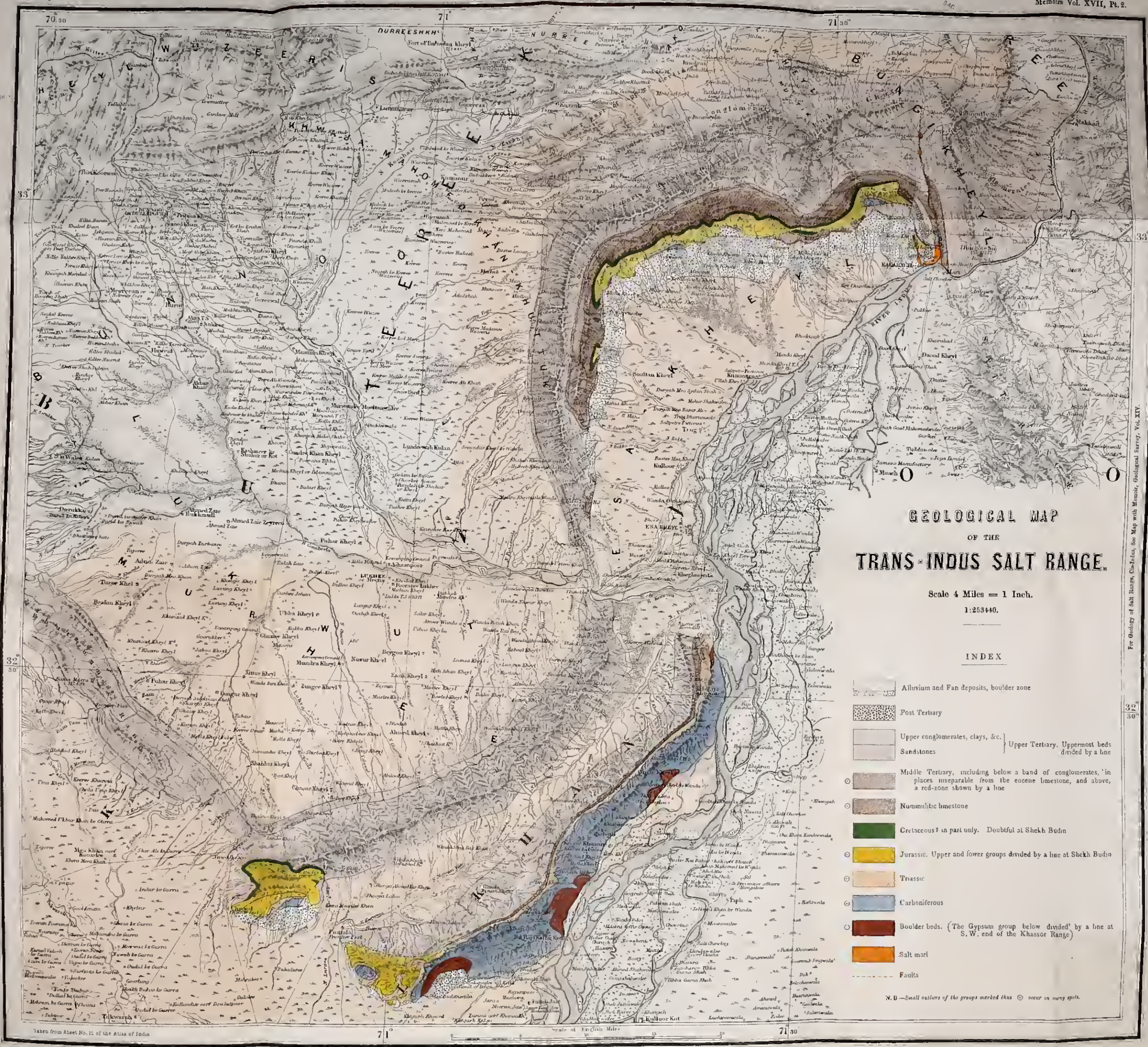

GEOLOGICAL MAP
OF THE
TRANS-INDUS SALT RANGE.

Scale 4 Miles = 1 Inch.

1:253440.

INDEX

▨	Alluvium and Fan deposits, boulder zone
▨	Post Tertiary
▭	Upper conglomerates, clays, &c. } Upper Tertiary. Uppermost beds divided by a line
▭	Sandstones
⊙ ▨	Middle Tertiary, including below a band of conglomerates, in places inseparable from the eocene limestone, and above, a red-zone shown by a line
⊙ ▨	Nummulitic limestone
🟩	Cretaceous? in part only. Doubtful at Shekh Budin
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🟧	Salt marl
- - - -	Faults

N.B.—Small outliers of the groups marked thus ⊙ occur in many spots.

DEHRA ISHMAEE

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Calcutta March 1880