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OF THE

GEOLOGICAL SURVEY

OF

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ADDENDA AND CORRIGENDA.

Page 8, line 11 from top, *for* "Mirial" *read* "Miral."
Pages 13 & 14—The notes *a* at foot are transposed.
Page 29, line 6 from top, *insert* "in" after "participated."
„ 30, line 4 from bottom, *for* "Lower" (group) *read* "Raniganj."
„ 37, line 16 from bottom, *insert* "*the*" after "West of."
„ 45, line 2 from top, *insert* "*the*" after "in."
„ 50, line 15 from top, *dele* "as has already been mentioned."
„ 50, note *a*, *for* "*dherbur*" *read* "*dherhur*."
„ 81, line 16 from bottom, *for* "borings" *read* "holings."
„ 82, line 9 from top, *for* "Mariatu" *read* "Masiatu."
„ 111, line 2 from top, *for* "Valatile" *read* "Volatile," and line 11 from top, *for* "Dansi" *read* "Dauri."
„ 112, line 11 from top, *for* "brownish" *read* "brown."
„ 117, line 14 from top, *for* "Chipars" *read* "Chiparo."
„ 125, line 4 from top, *for* "west" *read* "east," and line 11 from top, *for* "Sattarwah" *read* "Sat-Barwah."

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GEOLOGICAL SURVEY OF INDIA.

On the Aurunga and Hutar Coal Fields and the Iron Ores of Palamow and Toree, *by* V. Ball, M.A., F.G.S., *Geological Survey of India.*

INTRODUCTION.

About fifty years have elapsed since attention was first directed by Mr. A. Prinsep to Palamow, the object being to open out the coal fields then known to exist, and so obtain a supply of cheap fuel for the steam navigation of the Ganges. It was urged that an immense saving would accrue to Government by the establishment of a coal depôt at Futwah, only a few miles from Patna, which would feed all the more western stations on the river.

Daltonganj field worked by Bengal Coal Company.

To meet this demand the Daltonganj field was worked by the Bengal Coal Company up to the time of the mutiny, when the works were attacked by the rebels and destroyed. Since then coal has been mined, or rather quarried, to a small extent for the supply of the irrigation headworks at Dehree on the Sone, and for the supply for local purposes of some of the nearer towns in the vicinity of the East Indian Railway. During the past few years operations have, however, been in abeyance, owing to the cessation of these local demands.

Field not worked at present.

Proposed branch line of railway.

The main canal having been completed, the questions have recently arisen, first, whether, by connecting the Palamow fields with the East Indian Railway by means of a branch line, or by a branch line and canal combined, a considerable saving in the price of coal, as compared with the cost of that carried from Karharbari, could not be secured for north-western stations; second, whether the Palamow subdivision does not offer facilities for the manufacture of iron on the European system.

Preliminary information required.

A definite estimate of the probable amount and the quality of the coal available, and an examination of the circumstances under which the iron ores known to exist occur, being preliminary data of great importance in this enquiry, it was determined last year that the geological examination of the area should be resumed, in continuation of Mr. Hughes' work on the Daltonganj field.

Area examined.

The Palamow subdivision with the adjoining parganah of Toree, which geographically and geologically belongs to it, though it does not do so fiscally, occupies an area of about 4,272 square miles. To geologically examine the whole of this tract, with a degree of detail which would be exhaustive and of permanent value, would occupy several working seasons. It was therefore considered advisable to make the examination of the coal fields the principal object of the season's work; while by making long traverses across the main area of metamorphic rocks, the principal iron localities could be visited, and a certain amount of negative, if not of positive, evidence could be obtained regarding the possible existence of hitherto undiscovered basins occupied by sedimentary rocks.

Existence of two distinct fields ascertained.

The result has fully justified this disposition of the available time. The so-called Upper Coal Field[a] has been found to resolve itself into two distinct and separate fields which contain very different qualities of coal; which information,

[a] It is to be hoped that this ambiguous and misleading title will not be again employed by any one who may have to write of these fields.

and that which has been obtained regarding the various iron deposits, will probably be considered sufficient to determine the questions as to the projected establishment of an iron factory and the selection of the best route for connecting the district with the East Indian Railway.

Iron ores.

For reasons that will be given on subsequent pages, the titles Aurunga and Hutár have been adopted to indicate in future these two areas of coal measures and their associated sedimentary rocks.

Titles of fields.

Although it will be necessary to describe each field separately, the preliminary chapters in this account, which refer to previous observers and to the general physical features and geological structure of the surrounding country, will be common to both. This is not merely a matter of convenience, but is rendered necessary from the fact that the existence of two distinct fields was not apparently realised by any one who has hitherto written on the subject. Further, the advantage of describing the physical features in one continuous account is sufficiently obvious. For very much the same reasons, the concluding chapter on the economic resources will refer to both fields and also to the surrounding area of crystalline rocks, since it will thus be easier to treat as a whole the comparative and general aspects of the conditions under which the coal, iron and other minerals occur, their value and availability. It is therefore the purely descriptive geology of the fields alone which it will be necessary to submit to separate treatment and description.

Arrangement of subjects.

CHAPTER I.

PREVIOUS NOTICES.

In Rennell's map of the "Conquered Provinces on the South of Behar" (No. VIII), we find "Cole mine"[a] marked on a spot, which, from its relative position to the Coyle (Koel) river and the villages of Chopere (Chapri) and Coruna (Karunkhora), may confidently be identified with Hutar. This particular map is dated 1779, so that the discovery of the field took place at least a century ago, and long before the fields in many more accessible localities were brought to notice. It is not improbable that the fact of its being in the neighbourhood of the Palamow Fort may have attracted attention to it. Under these circumstances, the propriety of adopting the name of the village Hutar to indicate the coal field will not be disputed.

Rennell, J., F.R.S., Atlas, 1781.

In the year 1830 the Hutar field was visited by Captain Sage, who gives a section of the coal seams and associated rocks which occur at the junction of the Dauri and Ghorasan rivers as follows:—

Sage, Captain, 1830.[b]

	Ft.	In.
Earth, sand and gravel	8	0
Sandstone	6	4
Shale (bituminous)	1	0
Ditto	2	1
Coal	1	1
Shale	1	0
Sandstone	1	4
Coal	3	9
	24	7

[a] This is also marked on Arrowsmith's map for 1804. The locality was visited by Captain Franklin in 1829. See "Gleanings in Science," Vol. I, p. 178, and Vol. II, p. 217.

[b] "Gleanings in Science," Vol. II, pp. 219, 220.

He speaks highly of this coal as being very bituminous and burning with a clear bright flame. It has been supposed that the coal spoken of as being of inferior quality by Mr. Smith (*vide postea*) was the same, but this I do not think to be the case. I shall show on a subsequent page that there are several distinct outcrops of coal in the Dauri section.

Captain Sage also visited the 'coal mine' at Hutar, and in the Burra river close by discovered extensive beds of coal on the left bank. I do not know to which of the streams the name Burra was applied. If it be the one at Hutar, the term *extensive* is certainly applicable to the seams in a sense, as the lateral extension is considerable; but the thickness it will be seen is trifling.

Ironstone is said to be plentiful in the neighbourhood of Alyapur, three miles south, where it is worked. The name Alyapur is unknown to me, but ironstone does occur about three miles south of Hutar. Captain Sage's remarks on the navigability of the Koel I shall again allude to.

In the year 1837 Mr. J. Homfray was deputed by the Coal Committee to report on the coal fields of Palamow. He says[a]:—

Homfray, J., 10th July 1837.

"At a ford near Mungardar Nuddee on the river edge, four or five thin bands of coal, from four to twelve inches in thickness, but no thick vein; near to this place is Hutar, and this is conjectured to be the site of Rennel's 'Cole mine,' since there is no other place in the river for some miles where coal is to be found, until we reach the small nuddee of Barwellia running to the eastward; and at half a mile up that stream there is a fine vein of coal three feet four inches thick. This coal is found also to the westward at Myapore, and indeed for an immense distance southward and westward; it is traceable even down to Singhbhúm and towards Ruttenpur—this I learnt from an intelligent zamindar with whom I was in company for three days—so also to the eastward; and this is what constitutes the Palamow coal field. Within the Barwellia Nuddee this vein of coal is three feet four inches, exclusive of some little adhesive black shale which makes the apparent thickness of the vein to be four feet six inches. Both sides of this Nuddee are very high sandstone hills, and underneath which the coal is traceable to the eastward and northward, continuing to crop out in a vast number of places until

[a] Coal Committee's Report, 1846, p. 159.

we bring it fairly over to the Dauri Nuddee, the upper end of which winds into an extraordinary deep and narrow valley, within which this vein, as well as another smaller one of one foot six inches lying at five fathoms beneath it, is found."

Mr. Homfray after a description of the valley goes on to say that he raised 700 maunds of this coal, and states that—

"It burns with little flame, gives out an intense heat, with very little or scarce any smoke; it retains fire for days together; and to me appears to be a stone coal."

Inaccuracies in the above.

I should have preferred to have given a *résumé* of Mr. Homfray's remarks as a whole, rather than quote the above rambling statement; but I find it quite impossible to follow a large portion of his description. Some of the localities he mentions are quite unknown to me, and on the others the remarks are either vague or inaccurate; particularly, however, is it necessary to call attention to the statement made about the coal extending to Ratanpur and Singhbhúm on the authority of an intelligent native. If for Singhbhúm we read Sirguja, the statement would be consistent with general accuracy. But as Singhbhúm is again referred to by Mr. Homfray, and his statement has been quoted in subsequent publications, it is necessary to point out that a Singhbhúm coal field had its existence only in the imagination of his intelligent friend. Detached areas of coal measures do, however, extend towards Korba and Ratanpur through Sirguja and adjoining territories. In the Committee's Report, Mr. Homfray's estimate of the extent of the field is stated to be fourteen miles by six miles, which would be a fair approximation to the truth; but in his own letter he seems to claim a wider extension "*over an immense extent of country.*"

Koel unsuited for navigation.

He points out very clearly the impossibility of employing the Koel above Chandu as a means of carriage, but somewhat exaggerates the difficulties of the route by road, as the Ghâts he speaks of can be avoided.

Iron.

Regarding iron he writes—

"Ironstone is here found in abundance close to the village of Baumundya in the Dauri Nuddee in veins of three and four inches each; these veins are also found in

the ravines all the way to Pohea Agar (Pootooagur of present map), and at which place there are a number of iron melting furnaces upon the native plan. Iron is here sold generally at Rs. 2-12 to Rs. 3 per maund of 48 sicca-weight seers; it is in lumps of four to five pounds each, and has undergone the process of hammering and re-melting four times at the time of sale."

Mr. Homfray concludes with a mention of the "*extraordinary fact*" that—

"the gigantic reed whose impressions we constantly discover in the carbonaceous strata is here found growing in luxuriance. I have brought some whose roots were actually extended four feet into the coal bed. This is the only example I know of the living reed being found near to coal."

In Dr. McClelland's Report we are told that the specimens were exhibited at a scientific *soirée* at Government House, as belonging to the plant from which coal is derived. Subsequently, they were found to be only a well-known-grass, *Saccharum spontaneum*, which grows very generally throughout Bengal. Possibly to this *exposé* of his discovery may be attributed some of the bitterness of Mr. Homfray's remarks upon the "literary phantasmagoria" of "snail hunters" and "saxoflorists" which appears in his paper on the coal-field of the Damuda Valley[a], where he very properly points out the absurdity of the theories which were current as to the former connection of the Damuda and Sylhet coal fields.

Ravenshaw, E. C. Letter to Secretary, Government of Bengal, dated 6th January 1840[b].

In looking over the past history of discoveries of coal in Palamow, I find several allusions to a reputed discovery of coal at a place called "Chupri, two koss south of the Sone river, before its junction with the Koila Nuddee."

Reputed discovery of coal at Chupri.

Properly speaking, this locality is quite outside the area under description; but owing to the fact of its proximity to the head works of the canal and to the occurrence of quite another place with the same name close to the Hutar field, I think it not altogether inopportune to give here

[a] Journal, As. Soc., Bengal. Vol. XI, p. 724.

[b] Reprinted in Mr. Forbes' Settlement Report of Palamow.—Calcutta, 1872.

the result of my inquiries. As the locality is not given in the coal Committee's Report printed in 1846, it may be that the true history was at that time known to the Committee; but nowhere can I find any published statement of the real facts as given below.

According to Mr. Ravenshaw's letter, the discovery at the above-named locality was communicated to him by Cazi Mahamdee of parganah Jupla—

"The specimen of coal forwarded from this mine appeared precisely similar in quality to that from the Singra mines; but after digging a hundred maunds, the coal is stated to have assumed a more stony character, and the Cazi therefore abandoned the mine and proceeded to the old mines of Singra and Mirial near the banks of the Koila Nuddee."

The remark on this made in Dr. McClelland's Report on the coal fields of India, dated 11th July 1845[a] is as follows—

"If the Cazi's statements regarding the existence of coal so near the Sone be correct, the circumstances under which it occurs ought to be fully investigated."

Although the neighbourhood is included in the Geological Survey Map published in 1869, the position of one village named Chupri being represented as surrounded by alluvium, and although the account of the Cazi's operations was strongly suggestive of deception, it seemed to me all important to thoroughly enquire into the story and, if possible, expose and stamp out the fiction, or establish the fact, as the case might be. Being somewhat pressed for time towards the end of the season, and unable personally to visit the locality, I was fortunate in being able to refer to Mr. Davies of Rotasgurh, from whom I received the following letter, which will probably recall to some readers of this similar stories of reputed coal discoveries in other parts of India. Mr. Davies writes—

Mr. Davies' letter.

"That olden report concerning the discovery of coal at Chupri, not far from Deori was a pure fabrication and got up by the then Cazi of Jupla to try and ingratiate himself with the Bengal Coal Company and benefit by working on their apprehensions. The matter was closely enquired into

[a] Printed by order of the House of Commons, 19th June 1863, and reprinted, in so far as it refers to Palamow, in Mr. Forbes' Settlement Report.

by a gentleman named Sweetland, with whom I was well acquainted. He was on the staff of the very first explorers in India on account of railways, and was practically acquainted with geology. The other Chapri to which you allude is, as you observe, located on alluvium. A report similar to that got up by the Cazi was spread abroad by a *lohar*, or blacksmith, in the vicinage, shortly before Dr. Hooker came to Rotas, and Mr. Williams (Government Geologist), in company with Dr. Hooker, explored the Bhukhi *Kho*, or valley, in consequence fruitlessly. I subsequently discovered that the *lohar* had purposely scattered fragments of Rajharra coal in the dry bed of the Bhukhi *Kho* to give a color to his assertions."

Dr. Hooker in his journal does not make any reference to this in his account of his visit to Rhotas, but alludes to the information and assistance he received from Mr. Davies.

Smith, D., 1856.[a]

In his Report on the coal and iron of Bengal, Mr. Smith, having described the coal field in the neighbourhood of Rajharra, gives an account of his observations made during a rapid trip southwards into the Hutar field. He appears to have met with but one seam, which occurs in the Dearee (Dauri) Nuddee at the foot of a hill named Chenra. It is described as being two feet two inches thick and of very inferior quality. His further remark that—

"the strata here have a 'dip' to the west, which is unusual *and may be taken to indicate a serious disturbance in this coal field*"—

shews a certain want of appreciation of the laws of legitimate geological induction; but otherwise I see nothing to justify a recently-printed criticism of Mr. Smith's Report. On the other hand, in dealing with the question of iron manufacture, his full mastery of his subject is abundantly apparent. What he wrote in 1856 might be read with advantage by promoters of iron works to-day[b]

Ill health prevented further exploration of the area, and the principal coal deposits were not seen by him. But he was fully satisfied that the

---

[a] Report to Government of India on the Coal and Iron Districts of Bengal, dated Nynee Tal, 1856.

[b] A reprint of Mr. Smith's Report will be found in Dr. Oldham's "Return on the Coal Resources and Production of India."—Calcutta, 1867.

heavy cost of transport and the bad quality of the coal—

"deprived this locality of all chance of successful competition with others more favourably circumstanced."

It will be found that the conclusions I have arrived at, even under the somewhat altered conditions of the present day, are in many respects similar.

On his return journey northward, he reports the occurrence near the village of Adur of a—

"deposit of magnetic iron ore of the very richest quality, but so limited in quantity as to be of no importance."

Hughes, T. W. H., 1872.[a]

Appended to his Report on the Daltonganj field, Mr. Hughes gives a note on the sedimentary rocks observed by him at Satbarwah, where he only saw Talchirs, and in the neighbourhood of Latiahar, where he remarked upon the presence of Barakars and Upper Panchets (Mahadevas). He states that there is but little coal, and notes the ferruginous character of the Barakars in some sections.

Forbes, L. R., 1872.[b]

Mr. Forbes' Settlement Report embraces a wider range of topics and contains more interesting information than is to be found in many similar publications. The first chapter on the physical features contains most of the information immediately connected with the present subject, but from several of the other chapters numerous facts bearing upon the future development of the country may be gleaned. The whole cannot fail to be instructive to any one who may be at present, or is likely to become hereafter, connected with the exploitation of the resources of Palamow.

Mr. Forbes describes the general structure of the area, and points out that the forms of the hills are directly due to the character of the rocks of which they are built up. He then enters into some rather

[a] Memoirs, Geological Survey of India, Vol. VIII, p. 22.

[b] "Report on the Ryotwaree Settlement of the Government Farms in Palamow" by L. R. Forbes, Esq., Assistant Commissioner and Settlement Officer.—Calcutta, 1872.

original speculations as to the origin of the crystalline rocks, and attributes, as others have done before him, the splitting-up and fracture of the gneiss, &c., to the sudden transitions in temperature during the winter months. I believe this agency to be wholly incapable of producing the results. Owing to the feeble conducting powers of stone, the temperature of the atmosphere can only affect but a limited superficial layer of rock; moreover, with a sudden fall of temperature, the stone is not immediately cooled, but gradually radiates forth its heat, which process may be continued throughout the greater part of a night, as any one who has camped near bare rocks during the hot weather is likely to have a lively recollection of.

Mr. Forbes shews the accuracy of his powers of observation by pointing out the existence of detached patches of sedimentary rocks at a distance from the main areas.

He then describes the coal-mining operations in the Daltonganj area, and discusses the question of a light railway to connect the field with the East Indian line.

The discovery of copper ore by himself in Daltonganj is recorded, and there is an interesting sketch of the native system of manufacturing iron, to which reference will be made on a future page.

Mr. Forbes alludes to the coal of the Aurunga valley, of which he appears to have been the first discoverer.

In an appendix, the reports on the coal by several of the above authorities are quoted in full, the whole forming a valuable epitome of the information available on the subject up to date.

Samuells, Captain, 1871-72.[a]

In his descriptive accounts of the country surveyed in Districts Hazaribagh and Lohardugga during the season 1871-72, Captain Samuells mentions the seams at Juggulduggа as containing, apparently, the best coal. Several localities

[a] "Report on the Revenue Survey Operations of the Lower Provinces from October 1871 to September 1872.—" Calcutta, 1873.

where coal occurs in parganah Toree are also marked on his maps. The coal of the Amanut and Damuda is alluded to.

The area occupied by the coal fields is roughly estimated at 1,500 square miles. Including the Karanpura fields, this is about double the actual area, but was no doubt arrived at by supposing that the most remote localities formed part of one connected area. An account of some hot springs in Hazaribagh is also given by Captain Samuells.

Memoirs on Branch Line by P. W. D.

Some papers which have been printed by the Public Works Department, in connection with the proposed branch line of railway, contain a *résumé* of the information on the coal fields which is given in some of the reports above quoted. As these documents I believe have not been published, they are not susceptible of criticism here. But what has been said on the previous pages will shew the value of some of the statements which have been thus reproduced.

CHAPTER II.

PHYSICAL FEATURES.

Section 1.—General Structure of the Area.

Limits of area here described.

The portion of Palamow herein described and the parganah of Toree are situated south of the Daltonganj parallel of latitude. To define the tract more exactly, it may be said to coincide with the rectangular area which is bounded by the 83° 45′ and 84° 45′ meridians of east longitude, and the 23° 30′ and 24° parallels of north latitude.

Central valley crossed by a watershed.

In the central part of this area there is a distinct valley which is on the same line of east and west strike as the Damuda valley, but is separated from that line of drainage by a very marked bar of metamorphic rocks which forms a watershed separating the waters which flow northwards, by the Koel and Sone, into the Ganges from those which find their way eastwards by the Damuda into the Hugli and so into the Bay of Bengal.

Disruption of coal fields how produced.

Separated by this barrier at an average distance from each other of six miles, lie the coal fields of Karanpura and Aurunga. That these two areas formed at one time parts of a continuous whole, there can be little doubt; and the relative elevations of the two fields compared with that of the watershed, considered in connection with some other observations, indicate pretty clearly the *modus operandi* by which the disruption was produced. The marginal rocks of the Karanpura field dip away from this watershed at elevations only slightly below its average level, while outlying patches of beds of the same age occur at even higher levels. It does not seem probable, therefore, that the barrier is formed, at least to any great extent, of a locally upheaved ridge[a]. On the other hand, the

[a] Mr. Medlicott found rocks which he considered to be of this age capping the Madagir Hill near Toree.

Aurunga field is at Rampur on the eastern margin 300 feet, and at Latiahar, if the elevation given on the map be correct, more than 600 feet below the watershed at Balumath. But when we find outlying patches of the Barakar rocks at elevations of from 150 to 200 feet higher than the neighbouring parts of the Aurunga field, and other patches which there is good reason to believe exist at still higher elevations in the highlands on the south-east and south,[a] we are compelled to suspect that the Aurunga field has subsided as a whole. That such has actually been the case seems to be incontestibly confirmed by the intense faulting and tilting of the beds in that field, as is indicated on the map, and will be fully described on a future page.

Hutar field let down by faults.

Similarly, the Hutar field shews evidence of having been let down towards the west by faults, which have tended to isolate it and alter the pre-existing general directions of the drainage. There is, however, much less lithological resemblance as regards the lower groups of rocks between the Hutar and the Aurunga fields than there is between the latter and the Karanpura, and there is therefore less ground for assuming an original continuity, though such may possibly have existed.

Without trenching on the subjects which belong strictly to subsequent sections, it is impossible to enter here more fully into this part of the question. But so much, as affording a preliminary view of the origin of the present structure, was necessary to make what follows intelligible.

Central valley originally continuous with the Damuda valley.

This central Palamow valley, then, was probably originally continuous with the Damuda valley separating the Hazaribagh plateau on the north from that of Lohardugga or Chutia Nagpur on the south.[b] Towards the

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[a] The disturbance and tilting of some of the beds on the margin of the Karanpura field perhaps indicates some upheaval, but may, on the other hand, be due to lateral pressure from within.

[b] The origin of the valley as a whole, which is a distinct question from its separation into two, will be treated of on a future page in the section on the rocks of Mahadeva age.

valley of the Koel the former disappears, but the latter is continued by ranges, *pâts* and highlands generally through Sirguja and far away to the west.

Characters of scenery.

As the hills and rivers are described under separate sections below, it only remains to refer to the general aspect of the area. The scenery is very varied, often beautiful, and occasionally grand. Flat plains of wide extent are of rare occurrence. But the forest-clad hills, the bold scarps in the highlands formed of sandstone, the rocky beds and rapids of the principal rivers, and the lofty ranges which bound the view on the south, all combine to produce most pleasing effects. Though tolerably familiar with most parts of the wide area of Chutia Nagpur, I have seldom come across a scene more attractive than that presented to my view as I entered the Aurunga valley in December. Particularly striking were the effects produced by the patches of many-tinted cultivation scattered about through the more uniformly coloured jungle which surrounds the irregularly outlined Juggulduggа and Latiahar sandstone ranges. There were scarcely any bare spots to be seen, and though the previous rainfall had been lamentably insufficient for some of the crops, but little evidence of the drought was to be seen in the greenery and brightness of the jungles at that season.

Aurunga valley.

Section 2.—Hills.

The hills of this area are susceptible of a triple classification which is determined chiefly by the geological structure—

1st.—The oldest and most numerous are those formed of the crystalline or metamorphic rocks.

2nd.—Those formed of sandstones or conglomerates.

3rd.—The *pâts*, or plateaux, which are formed of crystalline rocks, with their summits capped with sandstone trap or laterite.

The 1st class is represented by a great number of hills and ranges, with elevations up to, and sometimes beyond, 3,000 feet. Where not

capped by any of the above-mentioned more recent formations, the outlines presented by these crystalline hills are generally sharply angular, but some of the ridges are flat-topped and continuous at pretty steady elevations for long distances.

Hills of crystalline rocks.

2nd.—The hills of this class are exclusively formed of one or other of two of the subdivisions of the Gondwana sequence, *viz.*, Barakars or Mahadevas. In the Aurunga field the Barakars never rise to form an eminence worthy of the title of hill; but in the Hutar field, east of the Koel river, they form long ranges averaging from 250 to 300 feet above the surrounding country, occasionally having peaks which rise about 200 feet higher. This occurrence of Barakars as hill-formers is unusual and will be again alluded to further on.

Hills of sandstones, &c.

Barakar hills.

Rocks of Mahadeva age occur as hill-formers not only in the Aurunga and Hutar fields, but also in the Karanpura and Tatapani fields. The structural and lithological characters in each case present the closest and most striking points of resemblance. In the Aurunga field there are three distinct groups of these hills, which are situated respectively in the neighbourhoods of the villages of Subano, Juggulduggu and Latiahar. Besides which there are two small outlying hills at Sasung and at Chulta west of Latiahar. These groups consist, for the most part, of flat-topped ridges from 200 to 300 feet above the level of the surrounding country, and have their faces scarped and often eroded into grotesque shapes. Occasionally, where the beds have been tilted, conical peaks rising considerably above the general level of the ridges have been formed, as, for example, the Chiharo peak near Subano, and the Latiahar peak near the village of the same name. The latter hill according to the map is 910 feet high, or 2,051 feet above the level of the sea.

Mahadeva hills.

In the Hutar field there are similar flat-topped ridges with scarped and eroded faces. In this area the Bijka hill is the most prominent peak, being 1,300 feet above the village of the same name, or 2,479 feet

above the sea. In its vicinity are several subordinate peaks, all of which owe their elevation in a measure to the tilting of the beds caused by the faults which bound the field.

Pâts: crystalline hills capped by trap, laterite, &c.

3rd.—Regarding the pâts which occur on the south of the area, what little is known of the details of the caps which give them their peculiar character will be found on a following page. The principal are Neturhat 3,600 feet; Lamti pât 3,777; Gulgul pât, 3,823 feet; Jamira pât, and Mailan pât, 4,024 feet. Besides these pâts, from the contours of some of the hills near Balumath, I think it probable that they will be found to be capped with sandstone. The Madagir hill, near Toree, was found by Mr. Medlicott to be capped with sandstones, which appeared to him to be of Barakar age. North of the Hutar field, near Bansdih, the Chungah hill is capped by a curious arkose bed which forms a small plateau.

Other capped hills.

As to the age of this rock, I am quite uncertain, owing to its very local lithological characters. For the present it must remain unrelegated to its position in the geological sequence.

Section 3.—Rivers.

Rivers afford evidence of great denudation.

The principal rivers of our area are the Koel,[a] the Aurunga, the Sukri and the Kunhur. The most remarkable feature exhibited in common by the Koel and Kunhur is that their courses run north and south, or at right angles to the valleys in which the coal-fields are situated, thus indicating an enormous amount of denudation, since the direction must have been determined when the valleys were filled up to the level of the bounding ridges through which these rivers have cut deep gorges.

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[a] I adopt this mode of spelling the name, as it more nearly, I believe, represents the ordinary native pronunciation than any of the numerous other combinations of letters which have been used by different writers, *e. g.*, Coyle, Koyle, Coil, Koila and even Cél.

The Koel.—This river takes its rise in Burwah, another river of the same name also rising near the same spot, but proceeding southwards, to contribute to the formation of the Brahmini. This northern Koel is from its source to its junction with the Sone about 160 miles long, and since it drains a catchment area of at least 3,500 square miles, it naturally contributes a large supply of water to the Sone during the rains; but at other times the quantity is not sufficient to enable cargo boats of the smallest dimensions to make their way between Daltonganj and the Sone.

Length and size of basin.

At one time it was proposed (by Captain Sage in 1830) to make use of this river as a means of conveying coal from the Hutar field to the Sone. But any one to whom an opportunity had been afforded of actually seeing the rocky bed and rapids which are found between Chandu and Hutar could not have failed to denounce the scheme as an utterly chimerical and impracticable one. In any discussion as to the means which may be employed for bringing the Hutar coals to market, the navigation of the Koel as it now is, or even the canalization of it, may, I think, safely be left out of consideration.

Koel not navigable.

It may be that the construction of a canal, fed by the head waters of the Koel, is possible; but so far as I know the ground, I believe that it would be attended with most serious difficulties, owing to the fact that the only outlet northwards is that of the Koel valley, which is in places so much constricted by impinging ranges of hills, that a low, level canal could scarcely be made so as to be safe from floods.

In many places this river affords scenes of very great beauty and sometimes of grandeur. The rocky bed and the rapids a few miles north of Hutar—the neighbourhood of Sindhorwah, where the river has scarped the hills of Barakar rocks which rise frowning over the channel and the rapids near Purro, beyond the southern boundary of the field—may be quoted as instances in point.

Scenery on Koel.

The Aurunga is the only considerable tributary of the Koel within our limits. It rises near Soheda in the pass descending from Lohardugga into the valley, and pursues a winding course in a north-westerly direction for a distance of about 50 miles. Where it traverses the coal field it affords numerous and instructive sections. Leaving the coal field, its bed rapidly widens, and by the time it reaches Palamow, where the ruins of two considerable forts overlook it, it has attained a considerable size, and, with its channel crowded with huge masses of gneiss, affords some very beautiful scenes. Owing to its rocky bed in this neighbourhood, its navigation would be dangerous during the rains. At other seasons the supply of water is insufficient for even the smallest craft. Its principal tributaries are the Sukri and Ghugree, both of which traverse portions of the field.

The Kunhur.—This river is in many respects similar to the Koel; it is about the same length, and pursues a nearly parallel course, to the Sone. It is likewise, at least in its upper reaches, useless for purposes of navigation. For a considerable portion of its course it constitutes a well-defined boundary between Palamow and Sirguja.

Section 4.—Hot Springs.

In each of the separate areas described in this report, and in direct connection with lines of fracture which it will be shewn have been instrumental in determining the present structure of the coal fields, there are series of hot springs.

Hot spring at Jarum.

The first of these is in close proximity to the Aurunga field; it is situated in the bed of the Tataka River at Jarum, about a mile and a half north-west of Pochra, or in north latitude 23° 49′ and east longitude 84° 32′. Although the water actually finds its way to the surface through joints in some vertical beds of granitic gneiss, which are the only rocks exposed in that part of the bed of the river, the position is in immediate proximity to the continuation of the well-marked east-to-west fault which has cut off the Barakars, &c., at the north-west corner of the Aurunga field. Were there a complete

section exposed, it is almost certain that it would give conclusive evidence of the existence of fracture and distortion in close proximity to the spring. Not improbably the hills at Joreesukhwa, a little further west, will, when examined, mark the line of fault. Reference to the map will, perhaps, render the above description more clear, and justify the probable correctness of the supposition.

Temperature.

The highest temperature of the water of the several outlets did not exceed 132° F. The amount of water poured forth, though not very copious, formed a steady stream. Sulphuretted hydrogen was emitted freely in bubbles, and its odour was apparent for some distance all around.

No peculiar development of vegetable life.

The springs being situated in the sandy bed of a running stream are not accompanied by any unusual development of vegetable life.

My attention was particularly directed to this point since I have, in the basin of the Mahanadi, met with some very interesting instances of considerable modification of the *Flora* in the vicinity of certain hot springs. I hope to obtain further data for the treatment of the subject hereafter.

It will be sufficient to indicate here how, in ancient geological periods, when hot springs were probably more abundant, there may have been local hot-house climates which would serve to explain such difficulties in connection with fossil floras as the occurrence of tropical or sub-tropical plants in the supposed glacial beds of Talchir age.

Hot spring at Thatha.

In the Hutar coal field in the vicinity of the village of Thatha (called Kokraha on the map), when examining the bed of the Thatha river, my attention was attracted by a strong sulphurous odour to a copious outburst of hot water, of the existence of which I had no previous intimation. Here the spring is distinctly connected with a marked disturbance of the Barakar beds, and the occurrence of a strong ridge of pseudomorphic quartz or fault rock, which is coincident with a line of fracture described on another page.

Temperature.

The highest temperature of this spring is 151°F. There is here a strong confervoid growth which forms felt-like masses in the pools warmed by the water, but I did not observe any modification of the herbaceous or arboreal vegetation.

Mr. Forbes in his Settlement Report says that he only knows of one hot spring in Palamow, which is at Mundul in tuppeh *Bari*, and of which the temperature is 180°F. As I understood from him that he had not himself visited the spot, I am inclined to believe that the locality given to him may have been Mundul, otherwise known as Jodah, which is however in tuppeh Durjag, and is not far from Thatha, and that therefore the present spring was meant. There is also a Mundul in tuppeh Bari, and hence perhaps the confusion arose. I think I should most probably have heard, when in that tuppeh, if there had been a distinct hot spring in Bari.

Hot springs at Tatapani.

In the Tatapani field in the Sirguja district west of the Kunhur, the hot springs have given a name to the village, and also to the tuppeh or parganah in which they occur.

They constitute, from their number and their copious outpourings, a very remarkable, and, in this part of India at least, a unique display. They are all arranged with one exception on, or in, the immediate vicinity of a strong ridge of pseudomorphic quartz and breccia, which evidently marks a line of fracture, since a little further west it cuts off and bounds the coal measures, while to the east in the Hutar field the faulted boundary is on exactly the same line of strike; and although in the former case the downthrow is on the north and in the latter on the south, the line of fracture along which the movement of subsidence of the coal measures took place, in both cases respectively, may be identical, but the continuity has not yet been fully established, as the intervening sections have not been examined. This agreement in strike, *vide* map, is probably something more than a mere coincidence, and accordingly attention is here directed to it with a view to future examination.

Number of outlets.

It is not easy to say how many distinct active springs there are at Tatapani, but there were seen by me certainly not less than a score, besides which there are indications of many others whose action has been either temporarily or wholly suspended.

As a rule, these springs rise in small basins with a bottom formed of large-grained quartz sand. Round the edges of these basins there is frequently an encrustation of silicious sinter. A strong odour of sulphuretted hydrogen pervades the atmosphere all round.

Occasionally these springs have given rise to marshy and boggy ground all round, which is most treacherous, as it is generally covered with a thin upper crust which simulates firm ground.

Temperature.

Proceeding from east to west, the Fahrenheit[a] temperatures in the successive basins were as follows: east 185°, 174°, 162°, 130°, 170°, 144°, 168° (166° close to temple) (154°, 184°, 180°, in bed of stream) west. These were all taken in the early forenoon on a day near the end of March, when the sun was hot and there was no perceptible condensation of the vapour. Early on the following morning the position of each spring was distinctly marked by a column of condensed steam. On this occasion the temperatures were somewhat different from what they had been the previous evening. In the bed of the stream one was 190°, while the spring close to the temple was 185°. The highest temperature observed was in a basin off the general line and north of the temple; in it the thermometer registered 196°. I think it probable that this spring is situated on a small branching fault, of the existence of which the neighbouring rocks afford some evidence.

The temple above alluded to was built over what was considered by the natives to be the hottest spring; but that particular outlet being now closed, the temple has been allowed to fall into ruins. I was told

[a] Taken by a Negretti and Zambra's boiling-point thermometer.

that the locality is not regarded as being one of particular sanctity. In any more civilised part of India, it would be assuredly a place of annual resort and the site of a *méla*.

On the same line of strike and at a distance of 24 miles west-south-west of Tatapani, and 8 miles north of Pertabpur, there is another hot spring known to exist. From its name, Ganduáni, its connection with *gandak*, or sulphur, is indicated. That a connection is believed by the natives to exist I learnt from the late Raja of Sirguja, who first told me of the spring in 1871. Its position is marked on the Atlas sheet.

Note.—The names Tataka, Thatha and Tatapani — all indicate the presence of hot springs. I have used the spelling of the maps, as there seemed to be a slightly different pronunciation in the case of Thatha, but the names have, of course, all the same origin and derivation.

CHAPTER III.

MISCELLANEOUS.

Section 1.—Inhabitants.

In connection with the future development of the mineral resources of Palamow, it may be useful to make a few remarks on the leading characteristics of the population.

Palamow being, as Mr. Forbes has pointed out, a sort of border land, is inhabited by both Aryan and non-Aryan peoples. The former, as is usually the case, occupy the open and cultivated parts, which, though smaller in extent, support a larger number of individuals than the wilder regions inhabited by the latter. In the portion of Palamow under description, which includes a large part of these wilder regions, the non-Aryans largely prevail, and as these tribes would most likely furnish the most considerable proportion of the labour, it will be only necessary to describe them, the more particularly as the characters and capabilities of the various castes of Hindus do not, so far as I know, present any local or unusual peculiarities.

Non-Aryan tribes.

Both the principal families of Kols are represented—the Múndás by about a dozen different tribes among which the Chiros, Kherwars, Korewas, Paharias and Agurias are the most numerous; the Oraons by Oraons proper and Kol-lohars.

Múndás.

The Kherwars and Chiros appear to me to be both indolent and wanting in stamina. The villages of the former are generally excessively dirty, and their houses, notwithstanding the fact that building materials are generally abundant, are in a most miserable state of dilapidation. They are not likely to make good labourers; but possibly they might improve somewhat if the weight of indebtedness to the money lenders, which now depresses them, were removed from their shoulders.

Kherwars and Chiros.

Korewas and Paharias.

The Korewas and Paharias are wild and not very numerous tribes in Palamow, but are more abundant in Sirguja. They are not likely to be of much account as labourers.

Aguria iron-smelters.

The Agurias are chiefly iron-smelters, but some have taken to cultivation. Colonel Dalton refers them to the Múndá family, while the Kol-lohars are considered to be Oraons. The statement made by Mr. Justice Phear in a memorandum[a] on the iron of Karanpura, that the Agurias are a low caste of Aryans, therefore is probably incorrect. But there is no doubt that the Loharias proper, or workers in iron, of whom also there are representatives in Palamow, are Hindus. Occasionally, I believe, these latter smelt, as well as refine and work up iron.

All these artificers would be useful and could be easily trained to manipulate iron ores in the European fashion. But for general purposes the Oraons would furnish the best and most abundant labour.

Oraons.

In Palamow the Oraons are found in various parts; those in the more open tracts having lost many of their tribal characteristics. In Toree they appeared to me to be tolerably numerous. From other parts of Chutia Nagpur they could be attracted in large numbers if necessary. At present a steady current of them flows in the direction of Assam and Cachar; the only means of arresting which, and preventing depopulation of wide areas in Chutia Nagpur, will be to give them remunerative occupation nearer their homes.

Section 2.—Roads and Carriage.

This section might almost be written in the words, *mutatis mutandis*, of Aldrovandius' famous chapter concerning the owls of Iceland.

Principal roads.

Of *pucka*-bridged roads there is not a single example in the whole area. The few roads that do exist are little better than mere fair-weather tracks. Of these the

[a] See Appendix F. to a paper read before the Bengal Social Science Association on the 24th July 1876.

principal are from Daltonganj to Ranchi, and from the same place to Dehree on the Sone. But few of the others are practicable for carts, and the remainder can only be used by pack cattle and elephants.

Except in Burkhol, I did not anywhere see any indigenous wheeled vehicles; these too were of the rudest description. Carts find their way along the two above-mentioned roads into Daltonganj; and recently timber has been drawn in carts from Sirguja over a track where carts never passed before. Judging from what I saw, I should say the average rate of progression of these carts was under three miles a day.

Export trade by pack cattle.

The export trade in grain is wholly carried on by means of pack bullocks, which are mostly of a small and weakly breed. The Oraons alone of all the tribes can be induced to carry banghies, the Kherwars and others carrying but half loads on their heads.

Section 3.—Forests and Wild Animals.

The forests of Palamow do not, I believe, contain much valuable timber at present, but the strict conservancy which has been initiated in parts of Bari, Durjag, Barasand, Sima, &c., promises a supply in the future.

Sal timber is by no means generally distributed. I often searched in vain for single examples in mixed jungle. In other places the soil does not seem to be well suited to its free development. However, it is possible that it may be larger and more plentiful in parts of the hills unvisited by me. Most excellent *sal* timber is now being cut in a neighbouring tract of Sirguja.

Teak, as is the case, to the best of my belief, throughout the Chutia Nagpur Division, does not occur.

The Forest Department, having been for several years in possession of the Palamow forests, will no doubt be able to state how far a trade in timber is likely to aid the traffic on the proposed line of branch railway. The ordinary jungle products, such as lac, kath or catechu, fibres, &c., need not be described here.

Wild animals.—Palamow has not a good reputation as a place for sport, but I have reason for believing that in certain limited areas wild animals are by no means scarce. Tigers and leopards were chiefly to be heard of in the vicinity of the Koel, where it crosses the Hutar field and thence westward to the Kunhur.

Mr. Forbes speaks of the chetah, or hunting leopard, having been at one time abundant, but the leopards seen by me, whether alive or dead, were all the so-called panther (*Felis pardus*). Bears are rare, as also are wolves. I saw but one pair of the latter near Latiahar. The sambhur and spotted deer are not common in the parts visited by me, but nilgai are abundant in certain tracts, as also are barking deer and the four-horned antelope. The gazelle is frequently seen in the west, and occurs close to Daltonganj. A pair were seen near Latiahar, longitude 84° 35′ E., which is, I believe, the most eastern locality where this animal has as yet been observed. *Gaur,* or bison so-called, are found on the ranges and pâts to the south. Occasionally they appear in the valleys as at Barkhol.

Section 4.—Cultivation.

The scarcity of tanks and *bunds,* and the unwillingness or inability of the people to provide irrigation for themselves—which extends, according to Mr. Forbes, to a disinclination even to repair temporary ruptures in bunds which have in some cases been made by the hired labour of a particular tribe called Nunias—account for the inferiority and uncertain yield of the crops and the generally impoverished state of the country.

Of the grain crops which are raised, no doubt a large proportion is exported, the people being too poor to use them themselves, even when they have not been wholly hypothecated, as they commonly are, to the mahajans on account of advances. The jungle products are the great stand-by, and furnish a means of subsistence to many thousands for several months of each year. The reservation of large tracts of forest has, however, curtailed the areas accessible to the people, and thus in bad seasons the relief to be obtained from these jungle products is less than it was formerly.

Jungle products.

Cotton.

Mr. Forbes seems to think that the cotton crop is the one most likely to flourish and yield a good return under proper cultivation. But for this to be successful a better class of seed should be imported.

The majority of cotton-bearing plants which I saw averaged under a foot in height. Not only is the variety grown a stunted miserable one, but it appears to be particularly subject to the attacks of insects; at least such was the case with the crops grown last season after the short rainfall. In at least 75 per cent. of the cotton fields seen by me, I noticed that the *bols* had not been collected, but had fallen to the ground where they were left to rot, the reason being, as I was informed, that the kernels had been eaten by grubs, and that it was therefore impossible to clear the fibre from the broken fragments of the seed shells in the rude machines (*chirkis*) used for that purpose.

Loss of last year's crops.

The damage done to the kharif crops by drought, to the rabi crops by rain coming too late and by heavy hoar-frosts, and finally to the crop of mhowa flowers by rain, while the collection of a most abundant harvest was going on, all contributed to make up during the last twelve months in Palamow a tale of loss and consequent suffering, without absolute famine, which it is most unpleasant to contemplate.

Crops how raised and exported.

In Mr. Forbes' report and the appendices will be found full information as to the principal crops grown and the amount of exports from which deductions may be drawn as to the probable amount of grain traffic. The immediate result of an increased prosperity among the people would, perhaps, be a diminution in the quantity of grain exported. But with the introduction of capital and improved systems of cultivation, this would be far more than recouped in a very few years.

Section 5.—Climate.

The comparative healthiness of a district in which it is proposed to establish iron-works or other similar undertakings should be no mean

factor in the determination of the preliminaries of the project. So far as my personal experience goes, Palamow is the healthiest part of Chutia Nagpur. The amount of sickness in my camp was most conspicuously less than it has been in other parts of the division.

But the very different amount of sickness which I witnessed and participated in two successive seasons in Sirguja warns me from attempting to generalise on the personal experience of but one season in Palamow. The balance of testimony, however, seems to indicate that the healthiness of Palamow is above the average of similar hilly districts. The highland pâts might be advantageously used as local sanitaria.

Note.—It may, perhaps, be thought by some readers that the topics discussed in this miscellaneous chapter are hardly suitable to the pages of a geological report. But their connection with the question of the development of the mineral resources is not likely to be denied, and no other justification for their appearance here is, perhaps, necessary. There are many other subjects connected with the natural productions, the history and the antiquities and the ethnology which might be dwelt on at some length, but without the above justification. The introduction of all such subjects, therefore, is scrupulously omitted, and the information on the first-mentioned is conveyed in as few and as brief paragraphs as is consistent with a reasonable amount of clearness.

CHAPTER IV.

GENERAL GEOLOGY.

Formations Represented.

At one time it seemed probable that the termination of the series of coal fields in the Damuda valley would be found to be exactly coincident with marked changes in the characters of the Gondwana rock-groups, and that this would at once become apparent as new areas in the country farther west were brought under examination. Already in the Karanpura fields the central groups so well developed in the Raniganj field had been found to be diminished in thickness and modified in character. The result of the examination of the various coal-fields of Palamow has been to confirm the general truth of the view thus entertained, but the change has proved to be not quite so abrupt and is not coincident with the termination of the Damuda valley, but takes place farther west.

Correlation of rock groups not aided by fossils as yet.

Had it been abrupt, the difficulty in correlating the several groups would have been great, as the aid which might have been afforded by the presence of distinguishable fossils has been denied to us for the present. Fossil plants are not indeed wholly absent, as will appear on a future page, but they have not been available for purposes of determining the ages of the rocks in which they occur. The geological formations and sub-division of formations represented within the limits of the area herein described are as follows (in descending order) :—

		Superficial deposits.	
		Laterite.	
		Deccan trap.	
Gondwana system.	Upper	Mahadeva series.	
	Lower	Panchet group.	
		Lower „	Damuda series.
		Barakar „	
		Talchir „	
		Metamorphic series.	

Before proceeding to the detailed account of the above sedimentary formations under the headings of the different fields in which they occur, it will be well, with the aid of the accompanying small-scale map, to indicate generally the extent of their distribution so far as it is known throughout the whole area, and to point out the resemblances and relations which exist between the deposits of identical age in more or less widely-separated localities. But first it will be necessary to give a general sketch of the crystalline or metamorphic rocks which form the floor of the basins or troughs in which the more recent rocks have been deposited.

Section 1.—Metamorphic Series.

A considerable number of observations on these basal rocks have been accumulated during the season, in consequence of its having been necessary to make traverses in various directions, in order to examine deposits of iron ores at a distance from the coal fields, and also for the purpose of searching for outlying areas of sedimentary rocks. Although the observations made under these circumstances are therefore of a somewhat disconnected character, sufficient has been seen to show that the detailed examination of these rocks will not improbably throw much light on the origin of the leading structural features of the country.

So far as is certainly known, the metamorphic rocks of this area belong to but one great series, but there are some marked features in the distribution of the several lithological varieties. In the west, massive granitic rocks with abundant veins of pegmatite and epidotic granite prevail. In association with them there is an enormous thickness of crystalline limestone which will presently be described. The economic importance of this rock will also secure for it some further notice in the proper section.

Distribution of lithological varieties.

Towards the centre of the area, west of Munkah, there is a complete change in the character of the rocks. Hornblendic gneisses are there the most common form met with. Many of these have a markedly trappean aspect, and are sometimes not

Hornblendic rocks.

to be distinguished from trap. In association with these rocks occur all the principal deposits of magnetic iron ore.

Black mica granite.

Farther west, in the neighbourhood of Ramkunda, a black micaceous granite, which is occasionally syenitic, occurs over a considerable tract of country. To the south of this the granitic rocks are chiefly remarkable for including very fine veins of stilbite. Towards the Kunhur the hornblendic gneisses disappear, and among the granitic rocks a coarsely porphyritic variety becomes the most prominent form. Throughout the whole area schistose rocks are rare.

In the country south of our main area rise several lofty ranges of hills which are principally formed of metamorphic rocks, but on some of them deposits of sandstone, trap, or laterite occur, forming distinctly marked caps. The Gulgul and Neturhat pâts belong to this latter class and have bases of highly granitoid gneiss.

Fault rock at Pukree.

Limestone.

To the above general sketch of the distribution it will be well to add some further details. Approaching the Aurunga valley by the road from Balumath, a very distinct ridge of fault rock is met with crossing the road near Pukree and striking thence to west-south-west. A mile farther on, at Olherpât, there is a considerable exposure of limestone. This consists partly of highly calcareous gneiss and partly of vein-like lenticular masses of crystalline limestone. For about a mile and a quarter, or nearly up to the village of Deredag, the road crosses the outcrops of similar rocks, the strike being to about 35° east of north, with varying, but high, dips.

In the Chunhat stream the limestone is clearly seen to be cut off by the fault, whose presence was indicated by the already mentioned fault rock. Close to the village of Chunhat the water charged with lime from this source falls over a step in the gneiss, and the evaporation of the spray and drip, extended over a long period of time, has resulted in the

formation of a very considerable bank of calcareous tuff which is well known to the people[a], though the limestone rock, as such, is not.

Calcareous tuff.

On the low plateau ground to the south of this position the limestones, flung westward by the fault, reappear and are seemingly richer and purer than they are at Olherpât. The following is the result of an examination of a sample from this southern locality by Mr. Mallet:—

Carbonate of lime	91·9
„ magnesia	·2
Oxide of iron and alumina	·7
Insoluble	7·2
	100·0

The small proportion of carbonate of magnesia and the purity in other respects indicate a high value for this limestone as a flux for iron-smelting.

The limestones are covered up on the west by Barakar grits and conglomerates, upon which too, in the neighbourhood of a stream, a tuffaceous deposit is in process of formation. The continuation of the fault is marked near the village of Koorean by a ridge of fault rock which is surrounded on all sides by Barakar beds, those on the north dipping away at high angles. This is to be attributed rather to subsidence along the old line of fracture than to the original fault, which, in all probability, operated before the deposition of the Barakars.

Continuation of fault.

Had it taken place subsequently, its effects, considering the fling it has certainly given to the limestones, should be distinctly traceable in the distortion of the ironstones and carbonaceous shales beyond Lejang, but no such distortion is to be seen.

Along the eastern margin of the field the bounding rocks are chiefly granitic gneisses with veins of quartz and pegmatite. Inside the margin a small inlier of these rocks is exposed one mile north-west of

[a] This is shewn by the name of the village, which is derived from *chuna* (lime).

the village of Seruk. To the north of the field at Balu-naggar there are several hills connected with the higher regions bordering the valley, which are formed chiefly of thin-bedded hornblendic gneisses, with veins of coarsely crystalline pink granite and pegmatite, and capped by Barakar pebble conglomerates, as will be described on a future page. In the valley of the Tataka, to the west of this, the rocks consist chiefly of gneiss with pegmatite and epidote veins, but hornblendic and granitic rocks also occur. The general strike of these rocks is the same as that of the bounding face of the plateau and of the subordinate ranges, being about east-north-east to west-south-west.

Sandstone-like gneiss.

A very peculiar form of gneiss, which I at first mistook for indurated Barakar sandstone, occurs in that portion of the Sukri which lies to the north-west of Toobed. Foliation is obscure, and the face of the rock shews lenticular masses and strings of coarsely granular structure, which closely simulate the irregular texture of certain Barakar sandstones.

Pot-holes.

These rocks are cut into a deep gorge by the Sukri and are in places eroded into pot-holes of considerable dimensions. The rocks which surround the remainder of the western extension of the Aurunga field consist mainly of varieties of granitic and hornblendic gneiss, about which there is nothing of importance to be recorded.

Calcareous gneiss.

On the southern side of the field the metamorphic rocks have a generally similar character. It is noteworthy that in the Aurunga river section, a short distance north of the Daltonganj and Ranchi road near the village of Bhoosor, the gneisses are somewhat calcareous, and that they are on about the position of the south-west continuation of the direction of strike of the above-described limestones of Chunhut.

Inliers.

Besides the inlier already mentioned north-west of Seruk, there are several other localities where metamorphic rocks occur inside the boundary. In the Sukri section

east of Mooroop there is a small exposure of granitic gneiss within the limits of the Barakars.

Near the villages of Bindee and Ledupali gneiss occupies two small areas within the boundary of the Talchir rocks. Reference to the map will shew the position and relative importance of all these.

Hornblendic gneiss.

In the valley of the Aurunga to the north-west of the Aurunga field the metamorphic rocks consist chiefly of hornblendic gneisses, and in some cases, as in the neighbourhood of Kedh and Bansdeeh, of hornblendic rocks with a cannon ball structure which may be really intrusive diorite so far as anything is certainly known to the contrary. In association with these rocks occur all the principal deposits of magnetite as at Lunkah, Rajhera, &c. These will be fully described in the economic chapter.

Limestones near Satbarwah.

In the Maila river section, half a mile east of Satbarwah, there is an exposure of a considerable thickness of limestone, and calcareous gneisses. They do not appear to be nearly so pure or clean as those in the Toree parganah above described. A fair average sample yielded to Mr. Mallet the following percentage composition:—

Carbonate of lime	60·8
„ magnesia	16·0
Alumina and oxide of iron	5·0
Insoluble	18·2
	100·0

This would be a very indifferent flux for iron-smelting, but it is possible some portions may prove to be of better quality.

The hilly ground on both sides of the Koel above its junction with the Aurunga, and thence, up to and beyond Daltonganj, consists of similar rocks, with which granitic varieties are occasionally interpolated. This region has not yet been thoroughly explored; but so far as is at present known, the only sedimentary rocks found there occur as a cap of arkose grit, which forms the plateau of the Chongah hill station.

Labradorite with calc-spar.

On the hill east of the village of Kokaroh there is a vein of white rock consisting partly of calc-spar and partly of a mineral which has been analysed by Mr. Mallet, who regards it as an abnormal form of labradorite.[a]

Passing now to the description of the rocks in the area surrounding the Hutar field, it is found that they present no general characters which would serve to distinguish them from those in the neighbourhood of the Aurunga field, but there are several points about them deserving of notice. At the north-east end of the field they are traversed by clearly defined trap dykes, no similar intrusions having been met with elsewhere.

Trap dykes.

On the south a lofty range which runs east and west, and is continuous with the one forming the southern limit of the Aurunga field, is formed of granitic gneiss, with quartz and granite veins of ordinary character. This ridge is very possibly connected with a line of faulted upheaval.

Neighbourhood of Ramkunda.

North-west of the field in the region surrounding Ramkunda, the metamorphic rocks are much decomposed, and there are wide tracts of raviny, unreclaimed land, covered by sál and bush jungle. The map well illustrates the character of the network of streamlets and ravines abounding in that neighbourhood. Where rock has been conserved, it mostly appears in the shape of bosses and tors of a black syenite-looking rock, some of which is indeed lithologically true syenite, but more commonly the colouring mineral is black mica and not hornblende.

Stilbite.

In this region, south of the village of Manjuri and at the mouth of the stream which, rising in the Bijka peak, joins the Atee river, there occur several veins of stilbite. This mineral, though well known to occur in metamorphic as well as volcanic rocks, has been but rarely met with in India in this association. I am unaware of the existence of any record of its having been found elsewhere in this country in equal profusion and beauty.

[a] It is partially decomposable by HCl. The filtrate contains alumina and lime. It does not gelatinize with acid. It contains no water. Hardness 6·5.

Three distinct veins were observed: the principal one occurs about 80 yards in from the mouth of the stream. It is from half an inch to ten inches wide, with a vertical underlie, and strike of about west-20°-north. Though for the most part the vein lies parallel to the planes of foliation of the pink porphyritic gneiss which encloses it, it does not invariably do so. The mineral has a laminated, somewhat hackly structure, and is of a bright salmon-coloured hue with a pearly lustre. Associated with it, there are plates of quartz pseudo-morphic after micaceous iron.

A second vein occurs close to the mouth of the stream. It is in places one foot wide, and the combination in it of the stilbite with the pseudo-morphic quartz produces a very beautiful structure.

A third smaller vein was noted in the bed of the Atee. Very possibly there may be others also.

Veins of pink pegmatite and epidote occur in some abundance also in the vicinity of the stilbite.

Supahi river sections.

West of Hutar field the sections in the Supahi exhibit a considerable variety of the ordinary forms of gneiss with veins of granite, pegmatite and quartz. Hornblendic rocks are there more rarely represented, but are by no means wholly absent. Towards the valley of the Kunhur coarse porphyritic gneis comes in abundantly often forming considerable ridges.

The pâts.

Traverses made southwards from the region above described to the Neturhat and Gulgul *pâts* or plateaux did not reveal the presence of any metamorphic rocks meriting particular or special notice. It may be stated, however, that the face of Neturhat on the north is principally formed of a massive felspathic granite, in which foliation is either very obscure or wholly non-existent.

Sub-metamorphic series absent.

Rocks referable to the sub-metamorphic series are not represented in this area, but only a few miles off to the south and south-west they are found in the neighbourhood of the Bisrampur coal field in the district of Sirguja.

Section 2.—Talchir Group.

Gondwana System:

The following table indicates the geographical distribution of the Gondwana rock groups in Palamow and the neighbouring portions of the adjoining districts:—

Table showing the distribution of the Gondwana rock groups in the coal fields of Palamow and adjoining areas.

Hazaribagh.[a]			Palamow.			Singhbhum.	
Itkuri.	Chope.	Karanpura.	Aurunga.	Hutar.	Daltongunj.	Tatapani.	Bisrampur.
...	...	Mahadeva ...	Mahadeva ...	Mahadeva	...	Mahadeva	Mahadeva.
...	...	Panchet ...	Panchet.	.....	.....	.....	.....
...	...	Ranigunj ...	Ranigunj.	.....	.....	.....	.....
Barakar ...	Barakar ...	Barakar ...	Barakar ...	Barakar ...	Barakar ...	Barakar ...	Barakar.
Talchir ...	Talchir ...	Talchir ...	Talchir ...	Talchir ...	Talchir ...	Talchir ...	Talchir.

Besides the above there are several isolated areas both in Hazaribagh and Palamow where the Talchir group only is represented.

The Talchir rocks have recently, on account of the characters of their fossil contents, been degraded from their position as a series readily separable from all rocks of the Damuda series to that of a group under the widely-spreading embrace of the Gondwana system. But the very latest examination of their physical relations tends only to confirm the propriety of the earlier classification.

It is believed from the characters of the fossils that the coal measures of Karharbari are really of this age in spite of lithological resemblance to Barakars. On this particular case I offer at present no opinion, but can only say that in the many fields which I have examined the

[a] Only the coal fields of the Hazaribagh district which are the nearest to Palamow are included here.

Talchirs appear to me to be separated by a greater hiatus from the overlying coal measures than is implied by speaking of them respectively as being consecutive groups of the same series.[a]

The Talchir rocks in our area, though nowhere *exposed* over so extensive a tract as they occupy in the Daltonganj field, are still, in all probability, widely spread under the newer deposits.

Their presence is indicated by narrow marginal strips at separated intervals along the boundaries of the Aurunga field, and in more steadily continuous exposures round the limits of the coal measures of the Hutar field. They occur also on the eastern margins of the Tatapani and Bisrampur fields. Several detached outliers in the vicinity of the Aurunga field are partly, or altogether, made up of rocks of this age, and at Satbarwah, in the bed of the Maila (or Mylee) river, they occupy an area of about three square miles, being unaccompanied there by any more recent deposits.

Talchirs at Satbarwah.

As this Satbarwah area is about centrically situated with reference to the three coal fields of Daltonganj, Hutar and Aurunga, it can scarcely be regarded as pertaining more to one than to another. The rocks there occurring may, therefore, most fittingly be described in this place. The fact of their existence has already been noted by Mr. Hughes in his report on the Daltonganj field[b] and by Mr. Forbes in his settlement report.

The area occupied by these beds extends as an irregular strip for nearly five miles along the bed of the Maila, with an average width of about two-thirds of a mile. East of the village of Bari the boundary is concealed by alluvium, and it may be that the Talchir rocks extend for some distance under the cultivated plain in that neighbourhood.

The ordinary varieties of sandstones, shales and boulder conglomerates represent the group in this area; but it is noteworthy that in some of the last-mentioned beds, in addition to rounded boulders of metamor-

[a] This question has many points in common with the difficult one as to the limits of the terms 'genus' and 'species.'

[b] Memoirs, G. S. I., vol. VIII, page 22.

phic rocks, large-sized angular fragments of vein-granite and gneiss occur in some abundance.

Thickness.

In the Daltonganj field Mr. Hughes estimates the thickness of the Talchirs at 500 feet. In the area under description they probably do not exceed a total of 300 feet.

Abnormal rocks.

The members of this group, within the limits of the Aurunga and Hutar fields, possess lithological characters which, as a general rule, may be described as being normal. There are some exceptions to this rule, however, which merit particular notice. In the Aurunga field near Latiahar there are some sandy and fibrous shales, with papery carbonaceous layers, which for reasons given further on I refer to this age. In the Hutar field in some instances there is found to be in the boulder bed a preponderance of red (Vindhyan) quartzite boulders over those derived from the neighbouring metamorphic rocks.

Besides the areas herein described it is not improbable that other detached patches of Talchirs may be found in the hilly broken ground surrounding the coal fields.

Section 3.—Barakar Group.

The lithological characters of the rocks of this group vary very much in the different coal fields of Palamow.

In the Daltonganj field Mr. Hughes found[a] that the typical Barakar sandstone of the eastern fields is replaced by "a false-bedded rock with fine and coarse layers of sand deposited often at an angle of 50° with the plane of the bedding." It is friable, earthy and slightly calcareous and consequently rather resembles a common form of sandstone in the Raniganj group than it does any normal Barakar form previously met with.

Lithological characters of Aurunga Barakars.

In the Aurunga field the rocks of this group may, in general terms, be described as being normal, perhaps even more so than they are in the Karanpura field. The ordi-

[a] Memoirs, G. S. I., vol. VIII, page 333.

nary forms of sandstone grits and conglomerates all occur, and huge seams, consisting largely of carbonaceous shale, are found at various horizons and with most irregular lateral extension. As will be amply exemplified in the detailed sections which are given below, the irregularity in the deposition of the various Barakar beds was extreme. Internal overlap exists on a large scale being very clearly shewn in certain closely adjacent sections, where beds are seen to thin out or expand, as the case may be, with extraordinary rapidity. The bottom beds are usually conglomerates, with small rounded pebbles of white quartz. Occasionally, however, these are replaced by what would be more properly denominated as *breccias*, the fragments of quartz being sharply angular and quite unworn, in this respect resembling some of the coal-measure conglomerates of the Karharbari field. In the eastern parts of the field these lowest beds are often covered by white and pinkish, somewhat clunchy, clays. Occasionally, too, there are dark-red clays at about the same horizon, but sometimes these last occur at the very base, in which cases they might very probably be taken as belonging to the Talchir group, from which however they must, I think, be separated.

Above this lower zone comes one of variable thickness, consisting of sandstones, carbonaceous shales and ironstones, which extends up to the base of the Raniganj group. In the sandstones next adjacent to the conglomerates concretionary masses of brown or red hæmatites occur in considerable abundance. These are covered by an irregular sequence of carbonaceous shales (with coal), ironstones and sandstones, which in some instances, as at Toobed on the north, and in some of the sections of the Aurunga and Ghugree on the south, have completely overlapped both the iron-bearing sandtones and the conglomerates of the lower zone, and rest directly and naturally on the metamorphic rocks.

Internal overlap.

In the neighbourbood of Latiahar this upper zone has a very much diminished thickness, and west of the Aurunga has wholly disappeared, for we find there that the Mahadevas rest directly on the lower conglomerates. How far this

Thinning out to west.

is attributable to original limitation of the area of deposit, how far to denudation, is uncertain; but that some denudation took place is probable, though there are no very clear sections showing unconformable superposition.

Thickness.

The maximum thickness of Barakar beds in the Aurunga field is about 1,500 feet.

Coal inferior.

As a coal-bearing group the rocks of this field take but low rank; for although the quantity of coaly matter is great, the quality is markedly inferior to that of the coal in the other fields.

Disturbance.

Although the Barakar beds in certain tracts throughout the field do not show signs of much disturbance, great local tilting is of common occurrence. This is particularly found to be the case along the *natural* boundaries, and appears to be attributable to lateral thrust and compression, produced in connection with several considerable main lines of fault.

In many of the sections a vertical contact between the bottom beds of the Barakars and the metamorphic rocks has been thus established.

Lithological characters of Barakars in Hutar field.

In the Hutar field, although its position is so closely adjacent to that of Aurunga, the coal measures present many points of striking contrast to those just described. In the east of the field the Talchirs are overlaid by sandstones and conglomerates, which form hills and plateaux having a stronger structural resemblance to those formed of Mahadevas than have the hillocks and ridges which usually characterise areas where Barakar rocks are found.

In the Dauri river section, and thence westwards to the extreme limits of the field, a basal zone of sandstones and conglomerates with coal seams first appears,—no trace of coal being seen in the scarps of the hills and sections which are passed before that river is reached.

To this basal zone the whole of the coal is confined, and not only is there this contrast with the state of things just described, but the coal seams are themselves of a completely different character. Instead of the thick irregular seams, which consist largely of carbonaceous shales as above described, we here meet with seams which are generally thin, sometimes lenticular, and consisting of a more compact and uniform material which is sometimes a high class fuel. These seams are parted from each other by massive beds of sandstone, the whole being contained in a zone, very possibly not exceeding 200 feet in thickness, which exists as a margin, internal to the Talchirs, all round the western portion of the field, except at those points where it has been cut off by faults.

Coal zone.

On the right or eastern side of the Koel river the high ground is formed of sandstone grits and conglomerates, which, as has been above stated, overlap on to the Talchirs at the eastern end of the area. At one time I was inclined to suppose that some ferruginous beds which occur near and at the top of the rocks forming these highlands might possibly belong to the Mahadeva series, but I was afterwards compelled to class them all as Barakars.

The thickness of the group as now existing in this portion of the field is probably under 600 feet. West of the Koel a curious change takes place, the upper overlapping zone of sandstones and conglomerates thins out and no longer forms hills and plateaux. In the extreme west it is represented by but a narrow zone of sandstones and conglomerates which overlies the coal-bearing zone, and is overlaid by a considerable but varying thickness of beds forming a synclinal basin, and of which the determination of the age and affinities has been a considerable source of doubt and difficulty. Though in places somewhat resembling true Barakars, their more constant lithological characters may be described as being unique. They consist of coarse grits and conglomerates, the latter containing not unfrequently fragments of metamorphic rocks, and not being composed

Thickness west of Koel.

Top beds west of Koel abnormal.

exclusively of rounded or angular white quartz pebbles, as is commonly the case with normal Barakars. Associated with them there are green, somewhat clunchy, clays, and occasionally soft yellowish sandstones. This group is overlaid by Mahadevas, which are precisely similar in lithological and structural characters to the rocks of the same age in the Aurunga and Karanpura fields. How far the superposition by these Mahadevas is strictly conformable, it is difficult to say; but that the thickness overlaid varies very considerably in different places is sufficiently obvious, as will be seen by reference to the map.

From their position the rocks of this zone might be taken to represent the Raniganj group, but the lithological characters of the grits and conglomerates are a bar in the way of this supposition, normal Raniganj rocks being strongly characterised by the fineness and uniformity of their texture. To the grits which occasionally occur in the Panchets (Lower Panchets of old classification), they present a certain but not sufficiently close resemblance for satisfactory correlation.

Correlation.

The alternative left is to regard them as a local sub-group of Barakars with special characters. In favour of the adoption of this view, there is the fact that irregularities produced by thinning out being excepted, they rest with perfect uniformity on the beds of the lower zone, and that a few cases were met with where green clunchy beds appeared to occupy a position within the limits of the lower zone, thus preceding, and as it were anticipating, the coming more general change.

Tatapani field.

In the Tatapani field west of the Kunhur, so far as my brief examination of it enabled me to form an opinion, similar rocks occupy the position of the intermediate sandstone and conglomerate zone which has there died out, and rest directly on a thin bottom zone of sandstones, carbonaceous shales and coal.

On the map the limits of this sub-group in that portion of the Hutar field which lies west of the Koel is indicated by a dotted line. I have not thought it to be advisable to distinguish it by a separate colour at present.

Including this sub-group with the lower rocks of undoubted Barakar age, there is a total maximum continuous thickness of 2,750 feet in Hutar field, the line of section being measured in the valley of the Supahi from Toleh or Tiharo to the foot of the Doothoo Hills.

Section 4.—Raniganj Group.

Since within our area representatives of this group are alone found in the Aurunga field, it will be better, as avoiding unnecessary reiteration, to refer to section 3 of Chapter V for a description of them. The maximum thickness I estimate at from 900 feet to 1,000.

Section 5.—Panchet Group.

The above remark applies to the rocks of this group also. An account of the Aurunga field Panchets will be found in section 4 of Chapter V. The maximum thickness does not exceed 700 feet and is possibly less.

Section 6.—Mahadeva Series.

In the table given on page 38 it will be seen that this series is represented in all the fields from Karanpura to Tatapani which lie on the same line of strike. Not only is the correlation fully established by the identity of lithological characters, but the physical features of the successive plateaux or groups of hills occur with an extraordinary repetition of minutiæ. The conclusion from these facts, that these now detached areas are the remnant of a once continuous deposit seems to be unavoidable.

Deposits of the several fields once continuous.

The lithological characters which are thus constant for the distance mentioned are somewhat different from those of the deposits in the more eastern fields of Bokaroh and Raniganj. Notable in this respect is the scarcity of conglomerates and the absence of that form to which the name of pudding stone might be applied. On the other hand, there is a very considerable resemblance between these rocks both structurally and lithologically, and those of the Hingir field, whose fossil

Lithological characters.

Resemblance to Hingir Kamthis.

contents have determined their age as belonging to the Kamthi-Raniganj groups. This lithological resemblance is even strikingly apparent in the hand specimens placed side by side in the Museum. But for the existence of representatives of the Raniganj and Panchet groups in the Aurunga field and the obvious identity of these highest rocks with those in the Karanpura field, I should have been at first inclined to regard these rocks as being identical with the Hingir rocks. The reflection suggested is that either the Hingir rocks are separable into two groups, or that they indicate a coalescence or blending of the characteristics of two groups which in this area are separated by a distinct interval. The geological history of other countries furnishes us with cases parallel to the latter. The fact indicates the difficulties which will be experienced in relegating these often unfossiliferous rocks which occur in the wide region to the west and south-west to their proper positions in the geological sequence.

Elevation of top beds of Mahadevas.

Along this central line of distribution there can be little doubt that the general surface of the Mahadevas before being denuded stood at a pretty continuous and equable level of rather more than 2,000 feet, *i.e.*, at the same level as that of the bounding plateaux.

Age of hill capping sandstones unascertained.

The correlation of certain sandstones which occur as caps on some of the hill tops and ridges in the neighbourhood of the fields, more particularly on those south of the Aurunga, has not yet been finally accomplished, and it is to be regretted that there has as yet been no time for doing so. *Primâ facie*, it might justly be anticipated that, wherever in the vicinity of the coal fields sandstones occur at elevations of, and over 2,000 feet, they would prove to belong to the Mahadeva series. But the result of examination hitherto has been to demonstrate that, while the Damudas are represented by widely-separated deposits which occur at various elevations[a], the Mahadevas are restricted within very narrow

[a] *e. g.* in the Daltonganj, Chope, Itkuri and Karharbari fields.

and easily defined north and south limits. Rocks which it is believed belong to the same age do, indeed, occur in the Rajmahal hills and in the Bisrampur field in Sirguja, but these are localities so far removed from the tract of country under consideration that they may for the moment be disregarded. The fact then to be accounted for is the occurrence of these Mahadevas along a zone of country 240 miles long and from 3 to 12 miles wide, this maximum width being attained in but one place in the Karanpura field, which occupies about the centre of the whole length. Otherwise, the distribution may be indicated by saying that, excepting the areas in the Raniganj field, which are slightly to the south, it is confined within the 23° 40′ and 23° 50′ parallels of north latitude.

Limits of zone of distribution.

We have evidence, afforded by the present varied elevations of the coal measure deposits, and the frequent recurrence of great lines of east and west faulting in the Damuda valley and more western coal fields, that great disruption of the originally much more extensive and continuous deposits took place;[a] and that while the broken and disturbed areas raised to the higher elevation have been much denuded, the principal coal fields have been preserved in consequence of their being protected in a trough produced perhaps by a fold in conjunction with the faulting.

Cause of the limitation.

In this trough or valley a huge sluggish river, with little power for excavating, may have flowed and gradually deposited the sand and gravel which has formed the Mahadeva rocks.

The past history of the Panchet group has not been alluded to, but it seems probable that it is the same as that of the older groups, though both it and the Raniganj and Ironstone Shale group have this in common with the Mahadevas, that their distribution is restricted to a definite zone. There is, however, a

Past history of the Panchets.

[a] On a first glance at the map the clear definition of the valleys in which the Aurunga and Hutar fields respectively lie suggests that these were the original limits of deposition, but examination rather tends in the direction of showing that these bounding highlands are due to subsequent upheaval.

much more marked unconformity between the Mahadevas and the underlying Panchets than there is between the other groups respectively.

Scarcity of collateral evidence of disturbance.

The absence, in the eastern fields, of clearly marked unconformable junctions showing disturbance is no doubt a difficulty in connection with this theory, as some evidence of the kind might reasonably be expected; but if it be remembered that the disturbance need not have been very marked along the central axis of the subsided rocks[a], and that the scour of the supposed river could not be very great, as the average gradient throughout the 240 miles can scarcely have exceeded three feet per mile[b], the difficulty is considerably lessened.

Possible denudation of groups to west of Aurunga field.

Moreover, it may be that the absence of the normal sequence of beds between the Barakars and Mahadevas in the west may really be due to denudation. Thus to the west of Latiahar in the Aurunga field, and in the Hutar and Tatapani fields, the Mahadevas rest directly on the Barakars without the intervention of representatives of the groups found to the east.

Thickness.

The maximum thickness of these beds is probably not less than 800 feet, and may be nearer to 1,000. In the detailed accounts below I give measurements. With Mr. Hughes' estimate of the thickness of these rocks in the Karanpura field I cannot agree. "Three or, perhaps, two hundred feet," he writes, "would probably be its maximum development." But in some of the scarps wholly formed of these rocks in the Karanpura field, a thickness of 500 feet is frequently exposed, and in the Maudih hill the total thickness must be several hundred feet more.

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[a] On the *margins* of the fields in those cases where there are no main bounding faults, there are often evidences in the tilted beds of great lateral crushing and pressure.

[b] The Balumath watershed (*vide* p. 13) was very possibly formed after the deposition of the Mahadevas. If it existed before, the beds in the Karanpura and Aurunga fields, although the scarps are so similar, could not have been continuous.

Section 7.—Deccan Trap and Laterite.

In the localities where Deccan trap and laterite occur their relations are so intimate that it will be most convenient to describe them together. Neither are found within the limits of the coal fields. Indeed, low-level laterite seems to be wholly absent in this area,[a] and the only trap which has as yet been met with occurs in the form of dykes which traverse the metamorphics and in places the Talchirs along the northern margin of the Hutar field, and belongs very possibly to an earlier period than the Deccan trap, but which must, however, have been subsequent to the Talchir period.

Low-level laterite absent.

So far then as our present knowledge goes, these rocks are confined to the highest elevations on the south of the subdivision and the neighbouring tracts of Lohardugga proper. It is possible that they may hereafter be found at lower elevations; but so far as they have hitherto been examined, the base of the trap does not occur in this region below elevations of about 3,000 feet above the sea. The *pâts*, or plateaux which have been visited by members of the Geological Survey so far are known by the following names: Neturhat, 3,356 feet; Lamtipât, 3,777 feet; Gulgulpât, 3,823 feet, Mailampât, 4,024.

Occur only at high elevations.

Neturhat.—The ascent of this plateau was made on the north side from the village of Pindra, which is situated south of Simah. The base is formed of a massive felspathic granite, which is exposed to within about 420 feet of the top. Laterite, fallen and to some extent reconsolidated, then appears, but it is doubtful whether it occurs there in original contact with the gneiss, since boulders of trap were found about 240 feet higher up or within 180 feet from the summit, after which laterite only was seen. No trap was actually observed *in situ* near this line of ascent. Possibly

Section.

[a] Detailed examination of the northern portion of the district, not yet visited, may perhaps reveal some.

near some of the other routes there may be clearer sections of the scarped sides of the plateau.

Lithological character of laterite.

The laterite varies much in character. Sometimes it is pisolitic and argillaceous, containing but a small quantity of iron. Occasionally, it is cellular with a larger percentage of ferruginous matter, passing thence into a remarkably rich brown ore (limonite),[a] which contains 45·5 per cent. of iron, and is smelted by the Neturhat Aguriahs.

Summit of plateau.

The Neturhat plateau is about 4 miles long by 2½ broad, but this is likely to give an exaggerated idea of its area, which does not exceed about 7 square miles. The central southern portion forms a basin traversed by a perennial stream, which runs from south to north. The laterite within this basin is covered by about a foot or so of soil, and the locality has already attracted two tea companies, as has already been mentioned.

Lamtipât is in close proximity to the Gulgulpât about to be described. The thicknesses of the trap and laterite respectively have not yet been ascertained, but both are believed to occur there.

Sections.

Gulgulpât.—On this hill, which is a long ridge, capped at its centre by a steep-sided mass of laterite and trap, gneiss was found exposed up to a point about 260 feet below the summit, or in other words at an elevation of 3,563 feet above the sea. Fallen laterite then conceals the section; but trap boulders were noted at least 90 feet higher, though no trap was seen *in situ*.

The crowning layer of laterite is, perhaps, 60 feet thick and is much split and crevassed. The huge blocks so separated have, in some cases, fallen away from the mass and present a strange appearance, which is in some cases intensified by the creepers and luxuriant jungle which in part conceal their Titanic dimensions. Much of the laterite is pisolitic and similar in character to that of Neturhat, but I did not

[a] This I believe to be the ore called *dherbur* by the natives.

meet with any ore of iron equal in quality to the Neturhat stone. So far as I know, none is worked. The only inhabitants on the slopes are semi-wild Korewahs, whose very extensive hill clearances have laid low considerable tracts of forests.

Mailampât.—This plateau, which has a considerable extent of flat ground on the top, has not as yet had its trap-laterite cap measured. Other well-known plateaux of considerable extent, but situated beyond our present limits, are those known as Jamira and Main pâts.

Laterite a natural water reservoir.

The important part played by these laterite caps as reservoirs for water from which a perennial supply finds its way into the valleys cannot be over-estimated. On Neturhat, as stated above, the quantity is sufficient to form a running stream, which traverses the centre of the basin. On Gulgulpât there is a spring coincident with the boulders of trap abovementioned, or 170 feet below the summit. It is not improbable that it marks the line of junction between the permeable laterite and impermeable trap.

The occurrence of water on these pâts will give them great value as sites for tea plantations when the country is opened up and becomes more accessible.

Section 8.—Superficial Deposits.

On the accompanying maps the positions of the principal deposits of alluvial character, which conceal the underlying rocks, have been indicated in writing. The thickness of these deposits in the basin of the Koel is inconsiderable, but in the vicinity of the Kunhur there are deposits of some magnitude, both as regards their vertical and horizontal dimensions.

Kunkur.

Kunkur occurs abundantly in a few localities, which are principally, though not exclusively, on, or in close proximity to, rocks of Talchir age. But the amount available cannot be compared in abundance to the extraordinary rich deposits

which occur in the neighbourhood of the Daltonganj field, and which have been remarked on by Mr. Hughes.

Calcareous tuff.

The occurrence of calcareous tuff at Chunhut, on the east of the Aurunga field, has already been alluded to when describing the crystalline limestones which have supplied the material of which it is formed. A similar deposit is found in the river Mungurdaha at the foot of a waterfall near Kokaroh. Limestones were also found in that neighbourhood.

Perched tabular blocks.

The principal, or at least the most noteworthy, deposit of diluvial origin in our area is a red sandy clay, which is directly derived from the Mahadeva sandstones, and forms a belt of unculturable land, much intersected by ravines and surrounding the base of the Mahadeva hills. Fallen tabular masses of the ferruginous sandstone occur sometimes enveloped in this deposit; but more commonly, the result of erosion has been to isolate these masses and leave them perched on columns of stiff clay which often stand out at heights of ten feet or more above the general level of the country. The tabular blocks are frequently from 200 to 300 cubic feet in solid content, and when seen thus perched up above the low brush jungle present a very striking appearance.

Section 9.—Faults.

The great lines of fracture in our area, of which the faulted junctions afford evidence, are by their compass-bearings resolvable into three groups or systems. This arrangement, as will be seen, does not necessarily imply synchronism. So classified, they would stand as follows:—

1. East to west faults.
2. North of east to south of west faults.
3. North of west to south of east faults.

1. East and west system.

Of east and west faults three have been clearly discriminated by their effects in the Aurunga field, and two in the Hutar field. The effect of the southern pair in the Aurunga field has been to lower the Mahadevas to the level of the Barákars, cutting out all but small remnants of the two

intermediate groups (Raniganj and Panchet). They have in conjunction with the great north-west south-east fault facilitated the upheaval of the wedge-shaped areas of metamorphic rocks which give to the field, as mapped, an appearance which, at first sight, might be thought to be due to a huge fling and distortion of the field by the agency of the north-west south-east fault alone. Owing to the fact that where the more southern, east and west fault intercepts the north-west south-east one, and similarly where the more northern of the pair intercepts the Latiahar and Putkee fault, no lateral displacement in either case is discernible, the question of relative ages becomes one of some difficulty. The balance of probability, however, seems in favor of the north-west to south-east fracture having taken place first, and that the rocks were simply vertically upheaved in the angles when the east and west faulting took place. The other east-west fault of the Aurunga field is that which forms a portion of the northern boundary where it cuts off several patches of Barakars and is connected with the hot spring at Jarum.

Relative ages.

In the Hutar field one east and west fault has cut off the Barakars at Morwaie, from whence westwards up to the Koel its course is indicated by fault rock and the hot spring at Thatha. West of the Koel its existence is somewhat doubtful, but its line of strike coincides with the base of the scarp of the Doothoo hills, and its existence there would help to account for a diminished thickness of the Barakars south, as compared with those north of the hills.

Hutar field faults.

The other east and west fault of this field is well marked near Binda, where it has cut off the small patch of Talchirs and Barakars. Apparently it is older than the neighbouring fault of the north of west to south of east system.

2. North of east to south of west system.

The first example of this system to be mentioned is the one which has flung the limestones described in section 1 of this chapter. Its course from Pukree to Korean strikes 15° north of east to 15° south of west.

I have already given my reasons for believing that the fracture took place before the deposition of the Barakar rocks.

The next example of this system runs between Putkee and Antekhita, forming the boundary at the extreme north-west prolongation of the field. The fractured junctions between the Barakars and gneiss in the Aurunga section clearly indicate the faulted character of this boundary. The strike is 20° north of east to 20° south of west.

The last representative of this system which has yet been proved forms the north-west boundary of the Hutar field, and is, it is believed, continuous with the line of fracture marked by fault rock, wherefrom the Tatapani hot springs take their rise. Where it forms the boundary of the field its faulted character is clearly indicated by the fractured junctions and cut-off patches in a series of cross-sections which are yielded by streams; its strike falls from 25° to 21°, north of east and south of west. There is nothing to indicate its relative age.

3. North of west to south of east system.

The first example of this system is the already described fault which bisects the Aurunga field. Its strike between Obur and Rukhant is from 47° north of west to 47° south of east. At Obur it is deflected about 17°, so that the direction between Jarum and Obur is from 30° north of west to 30° east of south.

The next of this system is the one which runs from Putkee to Latiahar; at several points it touches the bends of the Aurunga tangentially, and its faulted character is clearly apparent; its strike is 27° to 22°, north of west and south of east.

The last fault of this system is the well-marked one which forms the terminal western boundary of the Hutar field. Its strike is unusual, being 60° north of west and south of east. Properly speaking, perhaps, it ought to be classed by itself. From what I have seen of the metamorphic rocks I fully anticipate that their detailed examination will result in the discovery of other lines of fracture, having strikes referable to the above systems.

CHAPTER V.

AURUNGA COAL FIELD.

Stratigraphical Details.

What has been stated on previous pages, when read with the aid of the accompanying map, will probably be found sufficient to convey all necessary information as to the general form and surroundings of this field. There remain to be described, therefore, only the stratigraphical details of the several rock groups which are represented.

The area of the field inclusive of outliers is exactly 97 square miles, the different rock goups being exposed in the following proportions :—

Mahadeva series	14·8	square miles.
Panchet group	10·3	„ „
Raniganj „	8·8	„ „
Barakar „	58·5	„ „
Talchir „	4·5	„ „
	97·0	

Section I.—Talchir Group.

As has already been stated, rocks belonging to the Talchir group are but sparingly represented in the Aurunga field. Except in the few instances about to be noted, the Barakars, where the boundary is natural, rest directly on the gneiss, having completely overlapped the Talchirs, which, it is to be presumed however, occupy the central and deeper part of the basin.

Talchirs south of Balunaggar.

Commencing examination on the east, the first deposit of rocks of this age is exposed south of the village of Balunaggar near the road-crossing of the Sukri. The section discloses a false-bedded Talchir conglomerate with some red shales, the latter being perhaps of somewhat doubtful affinities. They are immediately covered on the southern bank by typical Barakar grits and pebble beds with white and pinkish clays.

To the west of this there are two short exposures of Talchir shales in the bed of the river, which are interrupted by gneiss and partly overlapped by Barakars, which, farther on, completely conceal them. To the east of the road-crossing after an interval in the bed of the Sukri where no rocks are exposed, and at the junction of the three streams which combine to form that river, Talchir shales are again seen. In the first of these streams a section of about 200 yards long is exposed. The beds consist chiefly of yellow sandstones, but there are also some shales; they rest naturally on gneiss, and are covered up in the next three reaches of the southernmost tributary by sandstones, which gradually assume a Barakar-like aspect. Gneiss then occupies the section for about a quarter of a mile, after which the section discloses a narrow strip of Talchirs, consisting of liver-coloured shales and grey sandstones, with which a boulder bed of limited extent is associated.

The total area of the Talchirs, at this north-east corner of the field which are not concealed by overlapping Barakars probably does not exceed a quarter of a square mile. The precise extent is uncertain, owing to the boundary south of Balu-naggar being concealed by alluvium. The maximum thickness of Talchirs exposed in the above sections nowhere amounts to 100 feet.

Red clays at base of Barakars.

Proceeding round the eastern edge of the field, in the Bagh Digwa section north of Rampur, and at several of the points of junction in the Ghugree, north-west of Bhurla, there are red clays which may represent Talchirs; but they seem to be very intimately connected with the Barakar grits and sandstones, and are practically inseparable from them. On the south boundary narrow marginal strips of Talchir shales and boulder bed occur at the base of the sections to east and west of Mungur. Similar, but less distinctly seen, exposures occur in the bed of the Aurunga between Hurkha and Bishunpur.

On the northern boundary of the field between Latiahar and Nowadih, outside the east to west fault, there is a triangular-shaped area

occupied by beds of somewhat anomalous character, and the determination of the age of which was a source of considerable uncertainty to me.

Abnormal Talchirs at Latiahar.

The lithological characters are so unusual and peculiar that, until I met with some rather similar rocks among the Talchir beds in the narrow strip at the extreme end of the field, near Hosir, I was unable to bring myself to believe that they should be relegated to that age.

At the base of the section near Nowadih there are yellow sandstones exposed in the bed of the stream; these are overlaid by greyish yellow shales with some gritty beds, including one which is calcareous and contains small fragments of metamorphic rocks. With these shales there are thin papery carbonaceous layers, which confer a most un-Talchir aspect to the beds. The shales differ from ordinary Talchirs in being more fibrous and in seldom shewing the characteristic concentric structure and splintery fracture. In some respects they resemble more nearly certain beds which, in this area, have been referred to the Raniganj group, but the stratigraphical relations are such as to render it impossible to refer them to any group younger than Barakars.

They rest directly on the gneiss and dip steadily southwards towards the fault, the Barakars having the same general direction, modified by anticlinal rolls on the other side of it.

The occurrence of distinctly visible carbonaceous matter in rocks of Talchir age is not unprecedented, as I have already recorded a case which I met with in Sirguja, where there was actually a thin layer of coal of very inferior quality.

On the whole, it seems impossible to classify these rocks otherwise than as being Talchirs. The existence or non-existence of a fault does not materially affect the case, as from the dips the beds on the north must be older than those on the south.

South of the indicated line of fault which probably had a very slight downthrow here, the rocks, up to the foot of the hills, are much obscured by alluvium. This is particularly unfortunate, as the neighbourhood of

Latiahar is one where the relations of the beds is very intricate, and where a few really clear and unmistakable sections would be of great importance.

Talchirs at Bindee.

The last area of Talchirs in direct contact with the field forms a marginal strip of varying width, which extends along the south-west border of the field for about 9 miles from Godinan to beyond Hosir. Within its limits at Ledopali and Bindee there are two inliers of metamorphic rocks whose boundaries, though not very clearly exposed, owing to superficial deposits, cannot be very widely different from those indicated on the map. North of Bindee the Barakars appear to rest directly on gneiss without the intervention of any Talchirs. The Talchirs throughout this strip consist principally of shales and boulder beds, sandstones being less common.

Talchirs at Hosir.

At Hosir, as already mentioned, occur the sandy and fibrous shales already alluded to as being similar to the anomalous rocks at Latiahar. Here they occur on the same line of strike and in intimate association with distinct Talchir shales and boulder bed, leaving no doubt as to the horizon to which they should be referred. There is a good deal of disturbance all along the line of junction with the gneiss, the shales often dipping at angles of from 60° to 90°. I failed to detect any faulted contacts, and it seems most probable that this disturbance should be referred to the effects of the lateral crush which would naturally follow from the faulting of the Barakars on the north boundary of the field.

At the same time it is possible that there may be a continuation of the northern of the Latiahar pair of east and west faults in the gneiss of this neighbourhood.

Outliers.—Detached from the main area of the field, but in its immediate vicinity, there are two outliers, in which representatives of the Talchir group occur.

Outlier beyond Hosir.

The first of these consists of a narrow belt in broken continuation with the abovementioned marginal strip which is prolonged beyond the Barakars at Hosir. This

belt strikes in a south-westerly direction from Oopag for about 2½ miles towards Huratu. It is well exposed in section in the Jelma river, and consists of shales, sandstones and a strongly-developed boulder bed.

These in places are a good deal disturbed and crushed, but I saw no clear indication of any faulting having taken place.

Outlier north of Nowagarh.

The second outlier is situated to the north of Nowagarh. The character of the Talchirs here is best seen in a section which is exposed for about half a mile in the bed of the Sotapani between the villages of Kotilwa and Heslah. The rocks chiefly consist of soft yellow sandstones, which rather closely resemble those of Raniganj-age, and yellow shales. At Topo, and thence eastwards, they are covered up by the pebble conglomerates, and are overlapped by them, as they do not reappear along any other part of the boundaries of this outlier.

Section 2.—Barakar Group.

The rocks of Barakar age within the limits of the Aurunga field occupy several practically detached areas (the intervals being covered by younger rocks) which can be most conveniently described separately. These areas, therefore, will be taken up as they occur from east to west, or as they would be encountered by any one entering the valley of the Aurunga from Balumath. The shape of the first of these, which lies on the north-east, and from which a prolongation margins the field on the north, is too irregular to be intelligibly described, but with the accompanying map before the reader any such explanation is scarcely necessary.

Section in northern branch of Sukri.

The first section to be described is that which is exposed in the northern branch of the Sukri south of Balunaggar. Already the character of the beds seen at the road-crossing has been alluded to in describing the Talchirs. The conglomerates and white and pinkish clays extend thence eastward into the highlands where, in the neighbourhood of the already-described ridge of fault rock at Korean, they are locally much disturbed, dipping

at an angle of 40° to north. Farther east they rest on the limestones and other crystalline rocks. To the west of the road crossing, at a distance of rather more than half a mile, the section in the Sukri discloses a lenticular mass of decomposed coaly shale resting on about four feet of blue, pink and yellow shales, and covered by twenty feet of fine white sandstone.

At thickest, the coaly shale is 2 feet 4 inches, with a rolling dip.

Section east of Mooroop.

Beyond this the section alternately discloses Barakars, Talchirs and gneiss up to the point where the stream crosses the boundary, and does not re-enter the coal measures again until a point east of Mooroop is reached, where there is a section as follows :—

Gneiss.
Grits with quartz pebbles, dip 15° S. W.
Inside the boundary, on the east side of the river, gneiss is exposed for 30 yards or so, and the contact is clearly natural.
Overlying these bottom beds there are white and grey clays, dip 25° south.
Interval.
Sandstones, dip 20° S.

The map is here wanting in detail, as it does not represent a very decided loop bend in the river, in which flaggy, somewhat ferruginous, shales are exposed.

These beds possibly represent the Kolherwan ironstone zone to be presently described. Although the imperfection of the section prevents its being traced, it is most probable that close by here runs the continuation of an east to west fault, which is well seen in the west. And it is possible that to the cutting out by this fault may be attributed the absence in this section of the Rajbar coaly zone, which is described below.

Coaly zone cut out by fault.

The flaggy beds are followed by sandstones with their carbonaceous shales. These, east of Mungra, are covered by soft fine-grained yellow sandstones, which must be referred to the Raniganj group.

Raniganj beds.

In the neighbourhood of Kolherwan occurs the above-alluded to zone of shales and ironstones. The latter are disseminated rather sparsely in beds 2 to 3 inches thick, through perhaps 30 feet of grey sandy shales which rest on blue concretionary shales. Such is the section seen south of Patratu beyond which the extension is obscure, possibly the ironstones die out. At Lejang there are ripple-marked sandstones forming a small hill, dip 20° S.-W. Throughout a considerable portion of this neighbourhood, concretionary nodules of iron, weathered out from the sandstones and grits, strew the surface in great abundance.

Ironstones at Kolherwan.

In the southern branch of the Sukri[a] at Pukrar, the junction of the Raniganjes with the Barakars appears to indicate internal overlap in the former. In the north to south reach near the village the yellow sandstones dip steadily south at angles rising to 40°. Suddenly then at the village there is a roll which brings up Barakar sandstones with carbonaceous shale, the base of which is slightly coaly. There is no sign of any faulting, and the peculiarity of the section seems to be due to the topmost beds of the yellow (Raniganj) sandstone overlapping all below, thus resting directly on the Barakars. About half a mile east of Pukrar the section discloses some light-coloured sandstones and shaly beds, which are, I think, referable to the Raniganj group; they rest detached in a distinct synclinal of Barakar beds, and therefore constitute an out-lier. Proceeding eastwards, grits and sandstones with dip of 5° are underlaid by shales with poorly developed ironstone, which may possibly represent the Kolherwan zone. In the next reach south-west of Lejang, we meet the following section:—

Internal overlap of Raniganjes.

Raniganj outlier.

Section, descending, dip W. and W.-S.-W.

Grit	4′	6″
Grey shales	4′	0″
	8′	6″

[a] Whether there exist distinctive names for all the different streams which combine to form the Sukri I cannot say; it is most probable that there are, but the guides with me certainly applied the name Sukri both to the one south of Balu-naggar and that under description.

Brought forward	8′	6″
Flaky sandstone	1′	4″
Grey shales	1′	6″
Sandstone		10″
Grey shales	3′	0″
Sandstone		3″
Blue and black shale coaly towards base	4′	0″
Sandy shale		3″
Blue shale	2′	6″
Sandstone		8″
Grey shales	1′	4″

Seam—

Coal, decomposed		3″	
Parting		1″	
Coal, decomposed	1′	0″	
Grey and blue shales	3′	0″	
Coal		2″	
Carbonaceous shale, coaly		6″	
Grey shale		2″	
Carbonaceous shale, coal		10″	
Blue shale		8″	
Coal		3″	
Carbonaceous shale, coaly	1′		
	7′	11″	
	32′	1″	

Below this there are four bands of carbonaceous shale ranging from one to two feet in thickness. The lowest includes about one foot of poor flaky coal. Another lower seam includes about six inches of coal. In the next reach the beds locally bend round by south to east, and some of the carbonaceous shales are repeated. This seam, or, to speak more correctly, this zone of seams and carbonaceous shales, is again exposed north of Rajbar, whence it follows much the same course as the bed of the stream. By interpolation it here so increased in dimensions that it is nearly a mile wide south of Kolherwan.

The following is the section of the beds measured in the reaches east of Rajbar :—

Section, descending, dip rolling S. W. 7°

South bank of river.

Surface soil.

Synclinal—

1. Thin sandstone and sandy shale	6′	0″
2. Carbonaceous shale, coaly		2″
3. Same as No. 1	3′	8″
4. Blue and grey concretionary shale	2′	8″
5. *Coal*		1″
6. Same as 4, but more carbonaceous in places	2′	4″
7. Sandy bed, lenticular, maximum	1′	8″
8. Same as 4	3′	0″
9. Sandy concretionary bed with ironstone	3′	0″
10. *Seam*—		
Consisting of carbonaceous shales, 72 feet at 10°	12′	6″
11. Sandstones with concretionary ironstones	5′	0″
12. *Seam*—		
(a), Carbonaceous shales, much concealed, 23 feet at 10°	4′	0″
(b). *Coal*, good		4″
(c). Similar to (*a*) with sandstone interpolations, 26 at 10°	4′	6″
(d). *Coal*, lower part very ferruginous	1′	0″

North bank of river—

13. Sandstone, with ironstone, about	5′	0″
14. *Seam*—		
Carbonaceous shales with occasional layers of good coal up to 4″, and of inferior flaky coal up to 1′— 195′ at 25°	83′	0″
15. Sandstones with shales alternating, dip. 25° falling to 15°, say 58′ at 20°	19′	9″
16. *Seam*—		
Coaly shale . . . . . 1′ 9″		
Flaky coal, decomposed. . . 6″		
Sandy and concretionary shale . 2′ 4″		
Coal, poor . . . . 1′ 1″		
Concretionary shale . . . 1′		
Coal . . . . . 2″		
6′ 10″		
	164′	6″

	Brought forward	164′	6″
17.	Shales	7′	
18.	Sandstone, say	12′	
[a] 19.	*Seam*, badly seen— Upper half apparently fair coal, 50′ at 15° . .	12′	10″
South bank—			
20.	Sandstones	3′	
[b] 21.	*Seam* similar to No. 14, 80′ at 15° W.-S.-W . .	21′	2″
22.	Sandstone	1′	
23.	*Seam*, also similar to No. 14, 70′ at 10° . . .	12′	2″
24.	Sandstone		8″
25.	Carbonaceous shales passing into blue shales . .	6′	
26.	Sandstones and carbonaceous shales about 40′ at 10″ .	6′	10°
[b] 27.	*Seam*— Contains thin bands of coal alternating with shale 140′ at 10°	24′	6″
		271′	8″

Strong interpolations of sandstones modify the character of this last seam in its further extension towards Burwa toleh. The contrasts afforded by it as seen in section on either side of the river are very striking. Along the same line of strike to south-east I could find no further trace of these carbonaceous beds, and it seems probable that they die out.

Coal zone dies out to south-east.

Before reviewing the above, it will be well to give an account of the sections which flank this zone. North of Rajbar in the Bunora stream there is a broken section of some of the above as well also as of some lower measures. Being seen dry, instead of sodden with water, as is the case in the Sukri section, it is easier to form an opinion as to the quality of the seams. Coal is only seen in rare bands, the thickest of which does not exceed one foot.

In the Seruk stream which runs south of Rajbar and which joins the Sukri beyond Jorean, the section exposes at the base, resting on gneiss, sandstones and white shales, with a dip of 20° to west. These are

[a] A sample from this seam contained only 22·3 per cent. of fixed carbon, with 50·3 of ash.

[b] *Vide* Table of Assays.

overlaid by grits, sandstones, and blue and grey shales. At Hureyakur, ironstones, of which we shall have more to say presently, are seen in the banks of the stream. Soon, by interpolation, the highest beds of the carbonaceous zone make their appearance, and steadily increase in dimensions, and vary in character as we proceed down stream in a north-west direction. There are, at least, three distinct seams near Jornean with low rolling dip to south-west. To the north-west of Jornean again there are two more, the position of which with regard to the ironstones about to be described is uncertain, owing to the complications of the stratigraphical sequence arising from extensive interpolation.

Seams at Jornean.

Overlying the carbonaceous zone is a band of shales, with ironstones, which form a very marked north-west to south-east ridge for a distance of nearly two miles. From a section afforded by a stream south of the ridge, I am inclined to believe that, as a maximum, the ironstones are about 10 per cent. of the whole thickness of this zone. The actual thickness of the zone is somewhat doubtful, but as the average dip of the shales is about 5°, 200 feet is, I think, a fair estimate, so that where thickest there is probably a total of 20 feet of ironstones. At first sight, owing to the fact that the conservation of the ridge has been due to the presence of the ironstones, and that fragments of ironstone strew the surface in great abundance, it might be thought that the above was an under estimate, but I believe it to be a most liberal one. Now, as to lateral extension: towards the south-east the ironstones, like the carbonaceous shales, appear to die out rapidly. To the north-west at Jornean the ironstones are locally elevated into an anticlinal; their further prolongation is doubtful; a sharp turn to north of Jornean would bring them into connection with the zone at Kolherwan, but the occurrence of the seams north-west of Jornean renders it probable that these are continued and die out in the direction of Timkee, and that therefore the two zones are really distinct, being interpolated at slightly different horizons.

Ironstones south of Rajbar.

Altogether it may be confidently asserted that there is a plentiful supply of ore in this neighbourhood, which, as the dip is only 5° and less, might be easily worked. The quality of the ore too is satisfactory, a fair sample having yielded on assay 49·2 per cent. of metallic iron. So similar in appearance are these ironstone shales to the group of that name in the eastern fields, that it might easily be supposed that they are of the same age. The occurrence of Barakar sandstones, &c., however, higher in the sequence, indicates their true position beyond a doubt. Somewhat similar ironstones occur with the Barakars on the east of the Karanpura field. The true Ironstone Shale group I believe to be wholly unrepresented in the Aurunga field and its outliers. In one of the latter, as will be shewn, these Barakar ironstones are likewise strongly developed, forming a very important deposit.

Quality and quantity of the ironstone.

Ironstone Shale group absent.

We have then in tolerably close proximity to Rajbar coal, ironstone, and limestone (*vide* map). The quality of the two latter has already been described. Regarding the coal it will be necessary here to say a few words in anticipation of the fuller account which will be found in the chapter on the economic resources. The extent of the carbonaceous deposits here exposed could scarcely fail to attract the notice of a passer-by, and a vast supply of coal might be thought to exist; close examination soon reveals the poverty of the seams, and the assays which I have made of some of the best looking bands of coal have fully confirmed the unfavorable opinion which I formed in the field. At the same time I do not wholly despair of the existence of tolerable coal in workable thicknesses; but that coal suitable for iron-smelting will ever be found in this neighbourhood is, I regret to say, scarcely to be hoped for.

Coal of inferior quality.

A pit near the river bank east of Rajbar might easily be sunk to test these seams thoroughly. It is to be hoped that such may be done before any final conclusion is arrived at.

Trial pit.

Between Goortoor and Dunria, along the eastern boundary, the rocks are chiefly hill-forming conglomerates, with angular quartz, a small inlier of gneiss being surrounded by these beds. Ironstone concretions, weathered out on the surface, are here likewise very abundant. At Dunria the position of the boundary is somewhat doubtful. Between Dunria and Renchee I saw no sign of the carbonaceous zone. South of Renchee at the road-crossing, we have on the east Barakar grits, and on the west soft sandy beds of uncertain character, probably Raniganjes; beyond them come in grits which probably belong to the Panchets, but the position of the Raniganj-Panchet boundary is here somewhat uncertain.

Rocks on eastern margin of field.

In the neighbourhood of Rampur a series of streams afford a number of sections which throw much light on the geology. South of the village there is a well-marked faulted junction between the gneiss and some grits and shales which dip north at 20.° In the bed of a tank the beds appear to be nearly vertical. The fault strikes nearly due west from hence towards the Juggulduggа hills, and with the aid of a north-west to south-east fault, has cut a wedge-shaped area out of the field. The sole evidence of the former existence of the Barakars is afforded by a small outlying patch at Reharee which rests on the upheaved gneiss.

Sections at Rampur.

In the Bagh-digwa stream north of Rampur the bottom bed is a red arkose, upon which rest sandstone, grits and shales with dip of 35° to south-west. Following this stream westwards Barakar, sandstones are met with dipping in various directions. As the village of Hoochloo is reached, a tolerably continuous section is exposed, carbonaceous shales with portions slightly coaly dip south-west at 40°. Above these are sandstones and a few thin bands of ironstones, the quality of which is probably equal to that of the Rajbar ironstones. These are soon covered by rocks which must be referred to the Raniganj group, and are thus separated from the area of Barakars exposed to the south-east of Juggulduggа. We pass therefore again to the northern boundary, to describe the sections near Toobed, before entering upon an account of the Barakars on the south of the field

Section at Toobed.

North-west of Toobed, in the bed of the Sukri, there are the already mentioned sandy gneisses striking east-north-east, and 35° north of east; these have been cut into a deep gorge by the river, close to the mouth of which they are overlaid by red and white shales, after which follow a number of seams with dip to east. If not cut off by the east and west fault as is represented, we should here have evidence of great unconformity between these beds and the Raniganjes, but the fault, as will presently be shown, is very distinctly marked. The following descending section was measured in the reaches of the Sukri to east and north of the village of Toobed; though extending from the sandstones of Raniganj age to the gneiss, it is of no use as an absolute measure of thickness, as some beds of the Barakar sequence have certainly been cut out by the fault:—

Descending Section in the Sukri at Toobed.

	Sandstones (Raniganj).		
	Interval, wherein the fault probably occurs.		
North bank	Blue and carbonaceous shales with sandstones, perhaps 150′ in all, but rolling and, where repeated, dip-E.-S.-E. 10°.		
	Section—		
	1. Grit sandstone	4′	
	2. Blue shales and sandstones, very variable . .	10′	
	3. *Coal*		3″
South bank, opposite mouth of stream.	4. Same as No. 2, about	15′	
	5. *Seam*, shaly coal, dip S.-E. 10° < 15° . . .	10′	
	6. Sandstones and shales	8′	6″
	7. *Seam*, 850′ at say 5° = ...	77′	0″
	This seam, nearly flat in places, certainly contains some fair coal, but owing to its sodden decomposed condition it is impossible to give details. Dip changes from S.-E. to E.-S.-E.		
North bank	8. Shales	4′	
	9. *Seam*, covered, about 100′ at 5° = ...	8′	8″
	10. Yellow and white shales	5′	

North of 2nd stream.

11. *Seam*, 8′ vertical, 110′ at 15° E. = 36′ 6″
contains about ¼th of burnable coal, separated in bands, none of which exceeds one foot in thickness.
12. Blue and white shales, 150′ at 8° = . . . 20′ 10″
13. Red and yellow shales resting naturally on . . 4′
Gneiss, vertical, strike 35° north of east.

Samples of the coal in Nos. 5 and 11 have yielded on assay but poor results, the percentages of ash being respectively 34·6 and 25·6.[a]

In the streams to the north of this section the beds are somewhat better seen, and the poor shaly character of the seams is more clearly apparent than where they are sodden with water in the bed of the Sukri. Here too I am forced to state my belief that there is not much prospect of a really good quality of coal being found in sufficient quantity to be mined with profit. Proceeding westwards along the bed of the Sukri, the section passes abruptly from the above-mentioned gneissose rocks into a narrow zone of intensely tilted ripple-marked sandstones with carbonaceous shales, which are seen tobe in vertical faulted contact with the gneiss in several junctions exhibited in the small tributary streams. In the Sukri itself the ripple-marked beds dip 55° to south and south-south-west, and are covered up immediately by yellow sandstones and some blue, slightly carbonaceous shales belonging to the Raniganj group. Just beyond the village of Bandudag the Barakars are completely cut out by a fault, but immediately reappear with some Raniganjes in a cut-off patch, to the north of the fault,—*vide* map.

Disturbed section west of Toobed.

The section of this cut-off patch west of Bandudag is particularly well seen in the Sukri, and exhibits a peculiarly interesting piece of geological structure. Underlying the yellow Raniganj beds, there is in the first section a very narrow belt of nearly vertical grits with red clays in *natural* contact with the gneiss. These are, therefore, the bottom beds and represent, in this particular spot, the whole thickness of Barakur

Section in Sukri west of Bandudag.

[a] Vide Table of Assays in chapter VII.

beds, which, it is needless to observe, have very much thinned out. Passing the loop bend occupied by metamorphic rocks, the next section of the Barakars is in the vicinity of the mouth of the Katari, where there is a seam, not very well seen, which is overlaid by sandstones and grits, and these, within a short distance, by the yellow sandstones of the Raniganj group. Under this seam are some red beds which, in one spot on the south bank, rest on decomposed gneiss, and for a short distance the junctions with the gneiss are very irregular, the sections of the bottom beds on either bank of the river exhibiting striking contrasts.

In the next reach, from south to north, the following section is met with :—

Section in loop bend of Sukri north of Manjhar, dip to south, and 10° east of south (descending).

(1).	White shales and grit with one 4-inch band of coal about centre	10′	0″
(2).	*Seam*—		
	Does not appear to contain any good coal, but is much decomposed, dip 30°	15′	0″
(3).	Blue and white shales, 70′ at 30° = ...	35′	0″
(4).	*Seam*—		
	Consists of alternating thicknesses of concretionary shale and papery coal of from 2″ to 8″, the latter about one-third of the whole thickness, 18′ at 30° = ...	9′	0″
(5).	Mottled and concretionary shales, portions passing into grit, 17′ at 30° = ...	8′	6″
(6).	Blue (carbonaceous), white and mottled pink, concretionary shales, 83′ at 17° = ...	24′	2″
(7).	Similar beds, more carbonaceous in places, 100′ at 20°=	34′	2″
	There is a transverse slip in the above beds which does not, however, affect the above measurement.		
(8).	Mottled grits passing into shales, 32′ at 25° = . .	13′	6″
(9).	Carbonaceous shale, seen	2′	0″
(10).	Interval 120′ at 25° = ...	50′	7″

(11). Same as 8	10	0″
(12). Red (liver-coloured) and greenish shales, 100′ at 25° .	88′	7″
Gneiss		
	300′	6″

If 50 feet are added to the above, the total, 350 feet, will give as near as possible the *maximum* thickness of Barakars cut off north of the fault. The *minimum* thickness probably does not exceed 20 feet.

It may be that these liver-coloured clays, No. 12 of section, represent Talchirs. Though occurring at most of the natural junctions, they are nowhere so well developed as in this section. In some cases they occur not actually as bottom beds, but are underlaid by sandstones or grits, which seem properly referable to Barakars. Though it is true they are somewhat an unusual form of rock to meet with in Barakars, they differ from Talchirs both in texture and mode of fracture.

Section at intersection of faults.

The last section of these rocks which is seen in the Sukri, though short, is a very interesting one, as it affords evidence of the intersection of the two faults at the precise spot where from their directions further east it was concluded that they would meet. In the angle included between them, the Raniganjes are let down in a V-shaped trough, a seam of carbonaceous shale, which is clearly seen on the south side of the V, is cut out by the east to west fault on the north, and the edges of the beds brought into contact with those of the cut-off Barakars.

Areas south-east of Pochra.

The next areas of Barakars to be described are those which occur to the south-east of Pochra, and are included in the angle formed between the northern of the pair of Latiahar east-west faults, and the great north-west south-east fault. The rocks mainly consist of coarse grits with a large amount of concretionary ironstones. In the raviney ground south of Subano, the streams shew indications of the existence of a patch of Raniganjes cut off by the fault. As near as possible the limits of this patch are given on the map, but the relations are not very clear. The

faulted junction is clearly seen in the streams south-west of Subano, where the coarse grits are in contact with the greenish Panchet sandstones. The general form and position of these areas will be best understood by reference to the map.

Section in Ghugri.

Resuming description close to where the Barakars were described as being covered up by the higher groups near Hochloo, in the region lying to the south-east of Jugguldugga, the first section to be mentioned is that afforded by the Ghugri. In this river between Rukhunt and a point south of Sukri the rocks are, for the most part, concealed by alluvium, and the precise position of the boundaries is somewhat uncertain in consequence, but they cannot be very different from what is represented. South of Kurmahi the effects of the great north-west south-east fault are marked by the steep and abrupt tilting away from it of some sandstones, grits and shales which dip at angles of 50° to 70° to south and south-south west.

Gorge north of west of Bhurla.

A little to the west of north of Bhurla the river has cut a deep gorge through massive sandstones and grits which dip to north-east and north-north-east at angles of from 20° to 30°. A little farther on, north of Nowatolah, the boundary strikes a loop bend tangentially, and a section is disclosed shewing a massive pebbly grit resting with original contact on the face of thin purple sandy gneiss. After this the river runs with the line of junction of contorted gneiss with south-east dip, exposed on the south bank, and sandstones dipping away on the north.

Beyond this about seven bands of carbonaceous shales appear by interpolation. They do not include any coal. Several very pretty natural junctions which have been affected by lateral thrust are then met with at intervals, but the detailed description of which would occupy too much space here. It must suffice to allude to one only. This is where the boundary crosses the Aurunga river north of its junction with the Ghugri.

Section in Aurunga.

The difficulty about this section is to ascertain sharply the line of junction between the decomposed metamorphic beds and the sandstones, &c., which are largely formed of gneissose materials. On the right of the section a massive pebble bed rests on the edges of the disturbed and decomposed gneiss, while on the left red clays and white and ferruginous grits with much false bedding occur next the gneiss.

In the next reach we meet with the following well exposed section, the dip throughout being *q. p.* north :—

Ascending section in Aurunga River, south-east of Juggulduga.

(Gneiss partly epidotic and decomposed; might be mistaken for Talchirs.)

1.	Coarse grits, with shales, strike east-west q. p.	100′	0″
2.	Decomposed carbonaceous shale (details not seen), 50′ at 65°=	45′	3″
3.	Shales and thin sandstones, with some carbonaceous shale, much covered, 100′ at 65° > 35°=	76′	7″
4.	Sandstones and grits, 120′ at 35° < 55°=	84′	9″
5.	Decomposed carbonaceous shale, say	3′	0″
6.	Grits, 60′ at 45°=	42′	5″
7.	Interval, 40′ at 50°=	30′	6″
8.	Decomposed carbonaceous shale, 33′ at 55°=	27′	3″
9.	Thin false-bedded sandstones, with blue shales, 50′ at 57°=	39′	7″
10.	Coarse grits, with interbedded shaly sandstones, 25′ at 60°=	21′	5″
11.	Sandstones, 44′ at 60° > 50°=	31′	1″
12.	Same as No. 9, 71′ at 60°=	61′	4″
13.	Decomposed carbonaceous shale, 23′ at 60°=	19′	10″
14.	Interval, bed of river, 120′ at 60° > 50°=	98′	3″
15.	Sandstone and grit	6′	0″
16.	*Seam*, including 1′ 6″ of *coal*	8′	0″
17.	Shales and sandstones, 100 at 60° =	86′	7″
18.	Thin sandstone with carbonaceous and blue shales alternating, 150′ at 50°=	114′	10″
19.	*Seam*, includes thin layers of *coal*	8′	0″
20.	Similar to 18, but less carbonaceous, 200′ at 50°=	153′	2″

21. Interval in bed of river, 100′ at 50° > 35° =	.	68′ 0″
22. White sandstones and grits, with blue shales, say	.	50′ 0″
Total	. . . .	1,195′ 10″

Maximum thickness of Barakars.

The beds included in No. 22 might pass for Raniganjes, but in the high ground north of river there are grits and ironstones, higher in the sequence, which are, I think, clearly of Barakar age. If we add for these higher beds 300 feet, a most liberal allowance, the total thickness would amount to something under 1,500 feet.

Thickness in other sections.

In succeeding sections of the narrowing Barakar zone there is clearly no room for the full thickness above given, and here there is no trace of the overlying yellow beds, which may overlap in the sections measured below; but this would not account for the fact that between these beds (No. 22), where last seen, and the gneiss, there is not room for more than 200 feet as against about 1,000. This indicates great thinning out and internal overlap; in fact, in the succeeding sections the carbonaceous zone is scarcely represented. But the sections below measure 256′ 7″, rising to 559′ 4″ as we proceed eastward, and shew a decided tendency in the beds to recover this lost thickness. The thinning out of the carbonaceous zone here resembles its disappearance south-east of Rajbar.

Some of the decomposed seams may contain coal, but their appearance is not promising, and as their dip averages 60°, their economic importance is slight.

The sections above alluded to are as follows:—

Section in west reach of loop, south-west of Juggúldugga.

(Gneiss seen on south bank of river.)

1. Bed of river, rocks concealed, say	. . . .	70′ 0″
2. Sandstones, shales and grits, 125′ at 70° =	. .	117′ 6″
3. Massive grit, dip 65°	. . . . .	9′ 0″
4. Seam, decomposed	. . . . .	10′ 0″
5. Grits and shales, 60′ at 65° > 50° =	. . . .	50′ 1″
Total	. . . .	256′ 7″

Resting on the above are soft white sandstones with shales and grit. These seem to belong to the upper group (Raniganj). Their junction is disturbed by a roll.
Thickness, say . . . . . 30′

Section in reach north of Jaloom (Zalim.).

Gneiss, dip 70° . . . . . .

Barakars.	1. Massive grit, 1 foot arkose at the base, 90′ at 45° N.-N.-W.=	63′	7″
	2. Grits, with blue shales, 80′ at 45°=	56′	6″
	3. Same, 100′ at 65°=	90′	7″
	4. Grits, with sandstones and fine shales, 250′ at 55°=	204′	8″
	5. Concealed, 300′ at 30°=	150′	0″
	6. Grits	20′	0″
	Total	559′	4″
Probably Raniganjes.	7. Yellow sandstones, false-bedded, 280′ at 20°= . .	95′	8″
	8. Yellow sandstones, with lenticular calcareous sandstones and carbonaceous shale at base, 300′ at 30°=	150′	
	9. Sandstones and carbonaceous shales . . .	12′	10″
	10. *Coal*		3″
	11. Same as 9	12′	10″
	12. Concealed, 350′ at 15°=	90′	7″
	Fault (?)		
	13. Grit 10° N.-N.-W.	15′	0″
	Total	377′	2″

Section in Bagh Digwa River, east of Juggulddugga Hills.

Red and green clays and white sandstones; Dip, 25° south-west (Panchets).
Yellow massive grit sandstone; Dip, 20° south (Mahadevas).
Fault, no junction seen.

Barakars (descending).

1. Thin sandstones and blue shales, N.-N.-W. 15° . . 35′ 0″
2. *Seam*—
   (*a*). Blue shales . . . . . 1′ 0″
   (*b*). Papery coal . . . . . 3″

(*c*). Blue shales	3′	4″
(*d*). Papery coal		2″
(*e*). Blue shales	2′	4″
(*f*). *Coal*		6″
(*g*). Carbonaceous shale		10″
(*h*). Blue shale, with coaly layers	6′	0″
	14′	5″
3. Sandstone, ferruginous at top	2′	6″
4. Blue shales and white sandstones, base concealed, dip N.-W., 15°, say	7′	0″
Total	58′	11″

In the next reach the above beds, modified in character and relative thickness, are again seen. The coaly portions, which are better exposed, are in mere strings.

In the reach again next following there is further modification. No. 4, is reduced to about 4′ 6″, and consists chiefly of blue shales and coal, alternating every 3 or 4 inches.

Brought forward	58′	11″
Grits, dip W. N. W. 15°	6′	0″
Blue sands and carbonaceous grit	2′	0″
Total	66′	11″

In next reach we find the junction with the Borasukwa stream where Nos. 1 and 2 are repeated, No. 1 being thicker and more varied in character, including massive sandstones and thin layers of carbonaceous shale, and No. 2 slightly more coaly, dip 10° to 30° west of north.

In the reach next beyond the junction these shales include one band of coal 1′ 6″;[a] besides this there are several thinner seams with varying thickness of coal.

[a] Table of Assays of Coal in chapter VII.

So great is the difference in appearance in this part of the section, that it is difficult to regard it as representing the same horizon as that to which Nos. 1 and 2 belong. As No. 1 is not really the highest bed, but only apparently so in consequence of the faulted junction with the Mahadevas, it follows that we get higher beds to the dip.

The section of these in the next reach, dip, 15°, to 30° west of north, is, (*ascending*)—

(a).	Carbonaceous shales, with coaly layers . . .	30′	0″
(b).	Sandstone, parting	1′	6″
(c).	Same as (*a*)	18′	0″
(d).	White sandstones	25′	0″

The descending section is again resumed in the reach beyond the junction with the Sukri stream: sandstones, N.-N.-W. at 60°. These correspond to No. 10 of the Aurunga section on p. 73, so that the modifying effects produced by interpolation receive further illustration here by comparison of the beds in the two sections which have been measured above that horizon.

Last exposure of carbonaceous zone.

Although I shall have to mention some seams which occur in the country further west, this is the last strong development of the carboniferous zone in the Aurunga field. It does not, I am sorry to say, give any better, indeed not even so good a promise, as did the Rajbar section, of including any valuable seams.

Area west of Zalim.

The next area to be described is that which lies west of Jaloom or Zalim, and is traversed in part by the Gowa and Aurunga rivers. The section in the Gowa river is not very perfect; there are a number of seams of carbonaceous shales parted by sandstones; some of these contain coaly layers, but none are clearly exposed. One fragment of loose coal 3 inches thick was bright and of excellent quality, but I failed to find the source. The dips of these seams average 10° to north, but in places they roll a good deal.

They are not likely to include a workable thickness of coal, but should it ever be desired to test them, a boring or trial pit west of the village of Gowa would prove their quality.

Seams probably of no value.

In the Ghotwa river some thin carbonaceous shales occur, resting immediately on a narrow marginal zone of Talchirs.

At Hurkha there is a local development of ironstones of no great extent.

The bed of the Aurunga up to Dhudwa is frequently traversed by the boundary. In several cases the lowest beds are yellowish sandstones, apparently Talchirs. The sections of Barakar sandstones offer no particular points for note, save that anticlinal and synclinal rolls are very abundant. The map will serve to explain the nature of the faulted junction, shewing how the Mahadevas have been let down into contact with the three older groups respectively at different points along the line.

Section in Aurunga.

In the neighbourhood of Latiahar and thence westward the Panchet and Raniganj groups have disappeared, and the thickness now existing of the Barakars is certainly very much less than in the east. How far this is to be attributed to original limitation of deposit, how far to subsequent denudation, it is not easy to say. It is quite probable that the upper groups never were deposited so far west; and, on the other hand, it seems not unlikely that some portion of the Barakar sequence has been denuded away, though it may be difficult to prove the same. Be this as it may, it is certain that an outlier of Mahadevas rests directly on sandstones and conglomerates, whose lithological characters resemble those of the rocks forming the lowest zone in the east of the field. The Barakar rocks near Latiahar, so far as they are seen, shew signs of considerable disturbance, due no doubt to the proximity of three lines of fracture, *viz.*, a pair of east and west faults, and a cross-fault which bounds the field up to Putkee.

Barakars at, and west of, Latiahar diminished in thickness.

From Dudwah westward the Aurunga winds to and fro across the boundary, so yielding interrupted sections of sandstones and carbonaceous shales, which for the most part dip at high angles northwards. No coal is seen in this portion of the Aurunga or its tributaries. In the succeeding reaches of the Aurunga up to Putkee, sandstones, with rare carbonaceous shales, are the only rocks seen. At the three points, *vide* map, where the boundary strikes the river tangentially, the sandstones are either vertical or dip away at high angles. In the section west of Putkee the junction is undoubtedly faulted, and some pebble-beds shew signs of partial vitrification. Half a mile further on the river enters an oval tract occupied by an outlying basin of Mahadevas, presently to be described; where it again passes into Barakars, it discloses a narrow zone consisting of sandstones and conglomerates, with one band of carbonaceous shale, which dip S.-S.-E. at angles rising from 25°, to the vertical. Although it is clear that both here and on the southern margin of this basin the thickness of the Barakars is reduced to 200 feet or so at the utmost, none of the sections give distinct evidence of unconformity. In each stream, on the other hand, there seems to be a steady sequence upwards from the Barakar grits to the red Mahadeva sandstones. In the extreme western extension of the field, white pebble conglomerates, without any very distinct bedding, and forming series of low hills, prevail over every other form of rock. There still remain to be described the Barakar rocks of several outliers in the vicinity of this field.

Aurunga section continued.

No distinct evidence of unconformity.

Outliers.—Four detached deposits which include Barakar rocks are known to exist in the vicinity of the Aurunga field. By far the most extensive, and in other respects the most important of these, is situated beyond the north-east end of the field, and at an elevation which must average 200 feet above the level of the neighbouring portions of the field south of Balu-naggar. A very complete section of this area is afforded by the stream which, starting from Buruhmoria, runs round

Outlier at north-east end of field.

by Palee and Dudhuria to Khuriadih. The bottom beds, seen in the section, south of the first-named locality, consist of a ferruginous conglomerate, with angular fragments of quartz, dip 20° west, covered by clunchy white and grey shales, ironstones and carbonaceous shales. The principal bed of the latter includes some coaly layers, but only a thickness of about one foot is exposed. Close by this section, in the high ground east of Sirka, there is a low range about 50 feet high, half a mile long, which is made up of ironstones, including a fair proportion of excellent quality. The whole surface of this range is honeycombed with holes, made for the purpose of extracting the ore. Resuming the section in the stream south of Sirka, there are sandstones, with white beds and ironstones; gneiss then interrupts the continuity, after which there is a much disturbed section of white and grey shales, with carbonaceous layers and ironstones in abundance, some of which are 5 inches thick, and have yielded on assay 45·3 of metallic iron. West of this there is another break in which gneiss occurs; the stream then traverses sandstones with low dips to west and north-west, changing further on to the east. After an interval, the next rock exposed near Dudhuria is a seam consisting chiefly of carbonaceous shale of uncertain thickness; it is followed by another, and then they are repeated, and a third exposed, by a dome-like roll of the beds. The descending section of this dome, taken on west side, is as follows:—

Ironstones at Sirka.

Ironstones in river section.

Seams of carbonaceous shales.

Seam, very shaly *coal*, includes thin band of ironstone, 50′ at 20° W. =	17′	1″
Interval.		
Seam, 130′ at 20° W.-S.-W. =	44′	4″
Sandstones, with carbonaceous shales.		
Seam, 160′ at 15° W.-N.-W. =	41′	4″

The details of these seams are not clearly seen, but I do not think it probable that there is any workable thickness of good coal; however, as the occurrence of good coal in this vicinity, owing to the proximity of

the ironstones, would be of considerable importance, it would be advisable to sink a couple of trial pits in order to thoroughly test the seams. Higher in the sequence than the beds forming this dome, there are carbonaceous shales with ironstones; these are well exposed in the face of the river bank, where, in a thickness of about 30 feet, 10 per cent. consists of layers of ironstone, which are never more than 6 inches thick. The individual layers have not a wide extension, being of lenticular shape; but as they die out and reappear by rapid interpolations, the total thickness at any particular spot is pretty constant. A specimen of black-band ore from this locality yielded 33·7 per cent. of metallic iron. From this northwards up to Koriadih the section is much interrupted, occasional outcrops of sandstone only being seen.

Ironstone at Dudhuria.

Black-band.

To the west of this line of section there is at Ghotam a low range about a mile long, which, like the one at Sirka, is chiefly formed of ironstone. A specimen of Ghotam ore yielded 39·4 per cent. of iron; but the richest ore was obtained from some borings half a mile west of Kurmahie, the yield of iron being 56·6. Various other sections of these rocks were examined on the edge of the scarp near Ghotam and Dudhuria, which it is useless to describe in detail here; but it should be mentioned that there are caps of sandstones and conglomerates on the semi-detached hills near Balu-naggar.

Ironstone at Ghotam.

Ironstone at Kurmahie.

There is so much irregularity of stratification, that it is difficult to assign a definite thickness to this deposit, but where greatest it may be 300 feet.

The general ascending sequence appears to be—

General sequence.

Angular conglomerate.
White and grey clays.
Carbonaceous shales.
Ironstones.
Sandstones.

These sandstones I believe to be of Barakar age, and the ironstones, like those of Rajbar, must therefore be referred to the same group. No

traces of Talchirs were met in this area. The prospect of the seams of carbonaceous shales being found to contain good coal is very slender. This is the more to be regretted since ironstone of good quality is in great abundance, and the crystalline limestone is close by. The area of this ironstone field is about 4 square miles.

Outlier north of Mariatu.

The next outlier to be mentioned is found north of Masiatu, and consists of clays, sandstones and conglomerates, which occupy an area of less than half a square mile. These are perched on a very irregular pedestal of metamorphic rocks, the elevation of the lowest beds varying within 100 feet in different sections. This deposit offers no particular points for further notice.

Outlier north of Nowagarh.

The third outlier is situated beyond the southern boundary of the field near Nowagarh. It occupies about 2 square miles, in about half of which Talchir rocks are found. These are only exposed on the west, being overlapped on all the other sides. The Barakar beds consist of sandstones and conglomerates similar in character to those of the adjoining parts of the field. There are only traces of carbonaceous shales, and the rocks generally present no particular points of interest.

The last outlier occurs just outside the boundary north of Toobed; the rocks are red shales, and occupy a very small area.

Section 3.—Raniganj Group.

There are few clear sections of these rocks exposed, and as they shew a departure from the normal lithological characters of the group in a comparative scarcity of calcareous bands, and a prevalence of soft yellow sandstones not unlike those occurring in the next succeeding Panchet group, it has not always been easy to discriminate them.[a] The boundaries which have been drawn therefore must be understood to be, to a great extent, arbitrary.

[a] Some of these yellow beds particularly reminded me of the Panchet sandstones of the Damuda section in the Raniganj field at Deoli, where the reptilian fossils were found.

No fossils have been discovered in them, and the correlation is therefore wholly established by geological position and lithological resemblance to beds in the adjoining Karanpura field.

No fossils. Correlation by lithological and geological characters.

In the Sukri, west of Mungra, the Barakar beds are covered up by soft yellow false-bedded sandstones, with rare bands of calcareous sandstones. The transition to the Panchets is not well marked, and the position of the boundary consequently doubtful. In fact, when first examined I thought I had but one group to deal with. The dip of these yellow beds averages 15°, and the thickness I estimate here at from 900 to 1,000 feet. In all other sections it is probably less.

Boundaries doubtful.

Thickness.

In the southern branch of the Sukri occurs the already described junction near Pukrar, which appears to indicate internal overlap in the Raniganjes. Another section of these beds is afforded by the Sukri near Toobed. Resting on the Barakars there are fine sandstones with a dip of 8°, to east-south-east; these are followed by yellow sandstones which dip 15° to south-east, and soon becoming flat are covered by alluvium, so that the topmost beds of the sequence, underlying the Mahadevas, are not seen. It is possible that the beds so covered are Panchets, but immediately south of the village the Mahadevas come so close that these highest beds must be overlapped. The next section is in the Sukri west of Toobed, where, resting on the previously described highly tilted ripple-marked Barakar sandstones and carbonaceous shales, there are yellow sandstones, with carbonaceous shales, having the same dip of about 55°. These are succeeded by fine yellow sandstones and sandy shales, with dips falling from west-south-west 42°, to west 15° and west 5°, upon which rests a bed of gritty sandstone that should probably be regarded as the base bed of the Panchets; resting upon it there are gently rolling greenish and

Section near Toobed.

Panchets overlapped by Mahadevas.

Sections west of Toobed.

purple clays of typical Panchet character, after which we pass again on to yellow sandstone, of which numerous sections are afforded in the streams near Bundodag, where, owing to the vicinity of the fault, they dip at angles of 50°, and even 70°. In the small area cut off by the fault, bluish carbonaceous shales, as in the previous section, are associated with the yellow beds, which appear to be generally conformable to the underlying Barakars, to which however they present the strongest contrast in lithological characters. At the extreme end of this portion of the field, where the two faults (*vide* map) intersect, these beds have been squeezed into a V-shaped trough, on the southern side of which a portion of the beds have been cut out by the east-west fault, as it is only on the south side of the V that a seam of carbonaceous shale is seen, measuring 9′ 6″, dip 50°. There is undoubtedly a zone of Panchet beds round the Sasung hill, but the sections are not very clear.

Section in Bagh Digwa, west of Hoochloo.

We now pass to the section in the Bagh Digwa near Hoochloo. Overlying the Barakar section there, a series of steeply inclined sandstones apparently belong to this group. These are soon covered by coarse gritty beds, which I should be inclined rather to refer to the Panchets, but it is not clear how they can be so, as further west there are, at an apparently higher horizon, calcareous sandstones of the well-known Raniganj type. It is possible that some of the beds higher in the sequence may mark a tongue of Panchets along the line of fault, but as the plotting of the river is very defective, I have not attempted to indicate this. On the other side of this fault there is a narrow strip of red clays belonging to the Panchets, which are soon covered by Mahadevas.

Sections near Juggul-dugga.

To the west of this, surrounding Jugguldugga, there is a patch of Panchets cut off by the fault, which are themselves surrounded by a narrow marginal zone of Raniganjes. These are of typical character, and include calcareous bands in the section seen in a small stream south-east of the village. In the loop bend of the Aurunga south-west of the village there is a small section of rolling sandstones of this group which rest on the much

diminished zone of Barakars. In the next loop bend of the Aurunga to the west there are similar sandstones, and with them some carbonaceous shales. Those at the north end of the reach are in crushed contact with a peculiar massive white grit which has some resemblance to Barakars, but must from its position, I believe, be referred to the Panchets.

Raniganjes thin out.

In the Aurunga west of Gowa the Raniganj beds are not clearly seen, but they must have thinned out considerably, since they are restricted to a very narrow zone between the purple Panchet clays and certain grits, which must, I think be regarded as Barakars. These sections and the one above described in the Sukri where the faults intersect are the most western points where rocks exhibiting the standard Raniganj lithological characters have been met with. It seems most probable that, where rocks of this age are met with further west, they will be found to have assumed the lithological character which distinguishes the Kamthis.

It is singular that the change should be found so distinctly to the west of the watershed of the Damuda. I have already endeavoured to explain this on a previous page.

Areas north of Jugguldugga.

There still remain two small areas of these rocks to be described; they are situated in the raviney ground north of the Jugguldugga hills which is drained by the Subano river. The limits owing to the nature of the ground and the want of striking contrast between some of the beds of the two groups are often very obscure. The most noteworthy fact is that they include the only seam of real Raniganj coal met with in this field. The seam is only 1′ 6″ thick, dip 25°. The quality of the coal is indicated in the table of assays. It turns out to be a worse fuel than I had expected from its appearance and lightness. There are other minor seams close by. The principal associated rocks are dense, micaceous, calcareous, fine-grained sandstones and loose soft sandy shales, some of them not very distinctly separable from the rocks which occur in the region between Udipura and the Jugguldugga hills, and which I have referred to the Panchet group.

Coal seam.

Section 4.—Panchet Group.

In the previous section the indication of the limits of the Raniganj group has involved frequent allusion to these rocks, the distribution of the two being very similar and co-terminous. The generality of the sections tend to shew that the two groups are conformable in most cases, but there are several which make it doubtful that this conformity is universal, notably the two sections just described in the Sukri west of Juggulduggа; and if the soft greenish beds, which at Deobar underlie the eastern end of the Mahadeva outlier beyond the Aurunga, are Panchets, there is evidence of very complete overlap, as there is no trace of the Raniganjes in that section. There are several leading lithological types among the rocks which go to make this group. Of these, the highest are the purple and green clays and associated shales. These are somewhat local in their distribution, being only found in the Sukri section near Kaima in the Bagh Digwa, west of Hoohloo, and in the Aurunga north of Kaima.

Conformity to Raniganjes.

Lithological types.

The next types are grits, of which there are several varieties, some loose and ferruginous, others soft, greenish and friable, and still others which are white and felspathic, and are not easily distinguishable from Barakar rocks. At first I thought that the generally undecomposed condition of the felspar furnished a means for distinguishing these from Barakars, in which the felspar is usually in a decomposed condition and more generally disseminated. This does not always hold good, as Barakar grits, including angular fragments of undecomposed felspar, were subsequently met with. Rocks of either of the above types are not likely to be mistaken for Raniganj beds, but there is still another type, or rather class, exemplified by greenish micaceous sandstones, occasionally calcareous. To distinguish these from very similar beds in the Raniganj group is by no means easy, and this the more especially as they occur at the base. To this cause is to be attributed much of the doubt which must always attach to the determination of the precise position of the Raniganj-Panchet boundary.

In one place only in the Sukri section near Semuria did I meet with any case of the occurrence of carbonaceous matter in these rocks; the traces of it were very slight, being little more than black stains. A constant outlook for fossils in these beds did not result in the discovery of a single fragment. Some of the thin micaceous shaly sandstones resemble the *Estheria* beds of the Raniganj area, but I found in them no trace of any organic remains.

Carbonaceous matter.

Fossils.

From the varying width of the zone of these rocks found surrounding the base of the Mahadeva hills, the probability that they are in places overlapped is very great. Indeed, at Toobed, this seems certainly to be the case; but besides this overlap unconformity there is, I believe, in the sections afforded by the streams in the valley between Hurdee and Chehora hill, south-east of Subano, evidence of regular disturbance unconformity: there is a steady dip southwards of a thickness of several hundred feet of the Panchets, almost up to the very foot of the Mahadeva scarp. There is certainly not interval sufficient for this whole thickness to be turned over so as to dip normally under the Mahadevas.

Overlap by Mahadevas.

Disturbance unconformity.

Since, as I have shewn when treating of the Mahadevas generally, there is great probability of a considerable break in conditions of deposition, if not of time, between the Mahadevas and all preceding groups, the wonder is that there should not be more numerous cases of unconformable superposition to be enumerated.

The estimated thickness of the Panchet group in this area is 700 feet.

Section 5.—Mahadeva Series.

The principal area in the Aurunga field, occupied by these essentially hill-forming rocks, is a raised tract, extending in a north-west south-east direction for a distance of over six miles from Kaima to Hurdee. The beds dip inwards from the opposing scarps at angles of 20° and under, so forming a synclinal trough, at the centre of which the beds are for the most part horizontal.

The maximum thickness does not exceed 500 feet in all probability,

Thickness.

The rocks, as seen in the sections near Subano, consist primarily of dark reddish-brown, ferruginous sandstone, with extremely sparse strings of iron-stained quartz pebbles, and occasional thin partings of dense red clays; there are also white loose-textured grits, from which the iron has been segregated into dense ferruginous plates.

Lithological characters.

The physical characters of these rocks have been sufficiently indicated in the general sketch, and the overlap of the Panchets at Toobed, and the unconformable superposition on the same rocks to south-east of Subano have also been described. To the north-west of this hilly tract there is an outlying low hill near Sasung formed of these rocks. The beds rest upon Panchets, and are cut off by the fault on the south-west. The thickness is inconsiderable, probably under 100 feet.

Physical characters.

The next area occupied by rocks of this age is situated near Juggul-dugga, and is about one square mile in extent. It is partly included between two of the main faults of the area, and the lowest beds are in consequence in contact with the edges of beds belonging to several different groups. These relations will be best understood by reference to the map. The rocks are precisely similar to those just described; the thickness of the beds is at present perhaps about 450 feet; they form a synclinal basin, and, as is almost invariably the case with the Mahadevas, they are most efficient water storers. Perennial streams are almost invariably to be found in their vicinity. This I also remarked upon in reference to the Kamthi rocks of Hingir.

Area near Juggul-dugga.

Thickness.

Perennial streams.

The next area is situated to the west of the Jugguldugga hills, extending thence to Latiahar. A good section is obtained in the deep-cut gorge between Satodeeh

Area east of Latiahar.

and Keenamand. The straightness of the boundaries, together with the varying nature of the contact beds, sufficiently prove the existence of a pair of bounding faults.

Bounded by faults.

This is further evidenced by the high inclinations of the beds, dipping from the faults on both sides, which thus form a very decided synclinal trough. I have already spoken of the obscurity of the relations near Latiahar. The rocks near the base of the hills are completely concealed by alluvium, but if I am right in relegating the anomalous beds to Talchirs, I think the relations represented must be correct, and that the Mahadevas rest here upon Barakars, the Panchets and Raniganjes having died out.

Rocks concealed near Latiahar.

The beds forming the Latiahar hill are, in part at least, highly tilted, rising to an elevation of about 900 feet above the village. The thickness cannot be less here than about 700 feet.

Thickness.

At the foot of the hills south-east of Panripura I found some red shales of limited extension containing fossil plants. This was in immediate proximity to the line of fault, and it was not possible to determine to which group they belonged. They are overlaid by whitish sandstones of somewhat doubtful character, but higher on the slope are very similar red shales belonging to the Mahadevas. The fossils include species of *Glossopteris*, *Vertebraria*, *Pecopteris* and conifer seeds. It would be dangerous, under the circumstances, to refer them to any definite horizon.

Fossils.

About three miles to the west of Latiahar there is a small hill formed of these rocks, which is perhaps about 120 feet high. The beds here rest directly on Barakars. From an observation I made in the hot weather, when the jungle was bare and the lines of stratification visible in profile from a long distance off, I am inclined to believe that the beds have been faulted on the north, since it was then apparent that the lower beds of the southern scarp were cut out on the north.

Outlier west of Latiahar.

The last area occupied by these rocks is in the bed of the Aurunga, at Deobar. Close to that village there is a section of some fine-grained greenish beds, which are possibly referable to the Panchets, as has been stated on a previous page; these are covered up by a set of bright-red sandstones and shales, which have some local peculiarities, but may, I think, safely be referred to the Mahadevas. Towards the base there are grits, which are not readily distinguishable from Barakars, but nothing could be stronger than the contrast afforded by the warm brick-red and purple hues of the topmost beds, to the cold, stone greys and dirty whites of the Barakar beds. In their physical characteristics these beds differ from normal Mahadevas in that they do not rise to form hills, but the Aurunga discloses long scarps, 20 to 30 feet above the bed of the river.

Outlier at Deobar.

Lithological characteristics.

Physical characteristics.

They form a shallow synclinal resting with apparent conformity on a very much thinned deposit of Barakars. The total thickness was not accurately ascertained, but may perhaps be about 250 feet.

Thickness.

From the occurrence of ferruginous platy beds at the base of the section north of Nowagudha, which more closely resemble some of the beds of the eastern localities than do the higher members of the sequence, I think it possible that the latter belong to the very highest zone in the whole area.

CHAPTER VI.

THE HUTAR FIELD.

The remarks made on previous pages with reference to the general physical structure of this field and its surroundings render it unnecessary to preface the following stratigraphical details with any further description of them. The area of the field is 78·6 square miles. The different formations being exposed in the following proportions:—

Area.

Mahadeva Series	14·1	square miles.
Barakar Group	57·0	„ „
Talchir „	7·5	„ „
	78·6	square miles.

Section I.—Talchir Group.

At the extreme eastern end of the Hutar field rocks belonging to the Talchir group occur at the base of the hills formed of Barakars, and occupy a marginal zone of varying width and thickness. Immediately under the Kande hill the deposit consists chiefly of boulder bed, which, together with some associated shales and sandstones, attains a thickness of about 200 feet. These are directly overlaid by from 250 to 300 feet of Barakar sandstones and conglomerates. From hence, in a south-westerly direction, the marginal zone can be traced only with great difficulty owing to the covering of talus and dense vegetation.

Although I have represented it on the map as being continuous up to the Dauri river, I am doubtful about its being really so, as in several places the gneiss appeared to interrupt it, occurring up to elevations of about 100 feet on the slopes and being apparently directly covered by Barakars; but a distant view of the hill face stretching from Kande to the Dauri, obtained when the jungle had, for the most part, put on its yellow and brown tints, leads me to suppose that the Talchirs may

really be continuous. A well marked line of green trees was seen to stretch westwards, with a slope of about 5°, from a point apparently at the level of the top beds of the Talchirs in the Kande hill, down to the level of the Dauri valley. This line of green trees evidently marked the position of an impervious stratum which arrested moisture—in all probability a Talchir shale.

Dauri section.

In the Dauri section from 80 to 100 feet of Talchirs are seen resting naturally on the gneiss, a small outlying patch also occurring south of the main boundary. The bed immediately overlying the Talchirs in this section consists of a highly ferruginous sandstone which one might hesitate to include with Barakars were it not that it is associated with some small coal seams and other normal Barakar rocks.

Overlap.

Beyond the Dauri the Talchirs are traceable for about a mile, after which they are overlapped, for it does not seem probable that the boundary which strikes south-south-west past Morwaie is a faulted one.

Northern boundary.

From Kande westwards, along the northern boundary of the field, the marginal zone is traceable as a narrow strip, with perhaps one short interval, up to Ookamand. Beyond the village it spreads out suddenly, and the shales, which there thicken considerably, are spread over about half a square mile of ground. Again it narrows, and at Lohoor is overlapped completely. In this neighbourhood there is a trap dyke which traverses the metamorphics with an irregular course. In the sections of this dyke which are exposed in the Teorohee Nadi at Kochilah and Ledgain small patches of Talchir shales are seen, which have been conserved from erosion by the protecting influence of the trap.

Trap dyke.

Thickness.

West of Lohoor the zone spreads abruptly to a width of a mile, and in the Dauri there is a considerable section in which a thickness of possibly 300 feet is exposed.

Towards the base the shales are traversed by a strong dyke of trap which in the river section is nearly 50 yards wide. Close to the top of the section there is a boulder bed, in which there are polished granite boulders up to 2 feet in diameter; besides which there are well rounded masses of a dense red quartzite, which are apparently lithologically identical with a well known form of Vindhyan rock. In Sirguja I met with a similar deposit,[a] where, since there are no Vindhyan rocks within the present existing watershed, it seemed to be necessary to invoke the agency of ice, as affording the only possible means of transport from the Sone valley. It should be stated that there are Vindhyan quartzites of precisely similar character in the Mahanadi valley, but owing to the nature of the intervening country in each case, it is perhaps more likely that the boulders were carried from the Sone.

Trap dyke.

Boulders of Vindhyan rock.

Similarly here, the Vindhyan rocks, though nearer, occur northwards, in which direction the present lines of drainage run. The supposed upheaval of the Palamow highlands, which is elsewhere discussed, would help in this case to support the view, that the boulders may have been transported southwards from the Sone valley by rivers running in an exactly opposite direction to the drainage system at present existing; but that such a fall to the south ever existed is scarcely likely, and in the Sirguja case most improbable. It may be urged, on the other hand, that Vindhyan rocks possibly existed *in situ* in both localities during the Talchir period, and were subsequently completely denuded away. In reply, it can only be said that there is not a particle of evidence to justify such an assumption.

I am anxious to give some prominence to these remarkable cases. Since, subsequently to the publication of the Sirguja instance, an early opinion of mine[b] as to the possible origin of the boulder bed has been

[a] Records, 1873, Vol. VI page 28, note.

[b] Memoirs, Geological Survey of India, Vol. vi, p. 116.

cited[a] in support of the non-glacial origin. These cases of transported Vindhyan boulders appear, however, to indicate a glacial period, quite as strongly as do the polished and striated boulders which have elsewhere been found.

Koel River section.

In the Dauri section west of the last-named locality, and at the corner of the loop bend east of Hurilong, there are pearly grey and lavender-coloured, much false-bedded sandstones, which are the highest bed of this section. They present an extraordinary resemblance to Panchet beds. West of this section the Talchirs are indistinctly traceable through Chercha up to the Koel, where they occupy a much narrowed zone, and are only seen on the western bank of the river near Hutar.

Sections west of Hutar.

Through Hutar and westwards they are found cropping out under the edge of the Barakars[b], till the vicinity of the Cheinpur road is reached south of Nowadih. Here again they are traversed by trap, and in the streams from Banulat there is a somewhat complicated section in which Talchirs, Barakars, gneiss, and then again Talchirs are met with. This section can only be explained by supposing the Talchirs and Barakars to be cut off, as is represented on the map, by the main bounding fault. A section of a similarly cut-off patch is obscurely exposed in the streams and raviney ground south of Chupatsi. The marginal zone is further traceable in a number of sections up to the Atee river near Bijka. In the Sutgurhea, the shales in contact with the gneiss are permeated by veins of pseudomorphic quartz; elsewhere along the boundary, there are indications of induration and crushing; and the distorted junction exposed in the Atee section clearly proves the existence of a fault, which is continued to the south-west past Bijka hill, where the Barakars

Boundary faulted.

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[a] Proceedings, Geological Society, London, 1877, Vol. xxxiii, p. 8.

[b] In one or two sections there seemed to be overlap of the Barakars on to the gneiss; but from the broken nature of the ground, these sections are obscure, and their exact positions difficult to determine.

and Talchirs are completely cut out, and the Mahadevas lowered to the level of the gneiss.

At the western extremity of the field a very pretty confirmation of the existence of a fault, which is otherwise pretty evident, is afforded by the occurrence of a small patch of Talchir boulder bed in the Supahi river, at the foot of the Mahadeva scarp. The full force of this will be better appreciated by a reference to the map than by any description.

Talchirs at Binda.

On the south boundary of the field there still remain some Talchir deposits to be noted. The first of these is at Binda, where the rocks consist chiefly of sandstones and shales underlying a small area of Barakars, which is cut off by a fault, gneiss being thrust up in the angle formed by it with the terminal fault just mentioned.

Talchirs at Purro.

Talchirs are again seen at the base of the section in the Supahi, north-west of Purro, where the lowest bed appears to graduate off into a decomposed gneiss. Hence eastwards they are more or less distinctly traceable up to the Purro stream, where a boulder bed rests naturally on the gneiss.

Talchirs between Mundul and Hetlee.

Further east, though not exposed in the Koel section, Talchirs probably occur underneath the sandstone, as they are well developed in the streams near Mundul, where liver-coloured shales are more abundant than elsewhere. There is also a considerable boulder bed which constitutes the principal thickness in a zone which laps round the base of the Mundul range, from hence eastwards up to Hetlee, where the boundary is faulted and the Talchirs cut out.

Section 2.—Barakar Group.

Physical characters unusual.

At the eastern end of the field in the Kande hill station there is a thickness of about 300 feet of sandstones and conglomerates which spread thence westward, forming flat-topped ridges of a character most unlike that normally

exhibited by Barakars. Certain sandy ironstones and highly ferruginous slightly conglomeratic grits, which are seen in the sections of these ridges on the slopes near Ookamand and Lohoor, made me for a time suppose that these highlands were in part formed of Mahadevas. Finding, however, that these ferruginous beds in some cases occur near the bottom of the sections, being covered by typical Barakar conglomerates, I have been compelled to class all the rocks which occur above the Talchirs on the east side of the Koel as Barakars. The first regular cross-section of these beds is obtained in the Dauri, where the lowest Barakar bed at the southern end is a highly ferruginous sandstone which rests upon the Talchirs north of Saidope, as has been already indicated on a previous page when describing the Talchir section. To it succeed normal Barakar sandstones and grits, many of them, both here and in the Ghorassan river, being eroded so as to form a great variety of fantastically shaped pot-holes, which sometimes, by the breaking down of the parting walls, have coalesced to form large reservoirs, in which fish abound. In the north to south reach above the Talchirs there occur, associated with the sandstones, four seams of coal and one of carbonaceous shale, which average only from 4″ to 6″ in thickness. In the next reach there is a larger seam of about 2′ 6″; locally this dips to south-west, but that is merely due to a roll, the general dip of the rocks being northwards.

Dauri section.

Coal seams.

At the junction of the Ghorassan with the Dauri occurs the section measured by Captain Sage (*vide* p. 4). The seam, which contains some good coal[a], measures about 3′ 6″. Apparently it is exposed for some distance on the hills flanking the Ghorassan valley, since fragments from it are found in the bed of that river some distance up, though the seam is not itself exposed. The dip is 5°, to west. Soon afterwards the beds turn round to a southerly direction, and if they were more constant in character and thickness, we should find a repetition of the just described section on this, the other,

Seam.

[a] See table of assays in Economic chapter.

side of the synclinal. It is impossible, however, to recognize the foregoing section in that which follows. At the bend north-east of Badhunyah there is a seam which includes 15 inches of bright streaked but dense coal[a] dipping at 10°, to south-east. Apparently a continuation of the same seam occurs in the next reach, with dip to south-west; and in the north to south reach north of Badhunyah and south-east of Hurilong, there is a seam which measures about 40 feet horizontally, with a dip of 10°, to south, representing a thickness of nearly 8 feet. The coal is highly bituminous, the most so of any specimen examined. Its small proportion of fixed carbon (*vide* assay) would render it deficient in heating power. From its thickness, and being more easy of access than any of the others, it might prove to be of value, which the others certainly are not. In the wide hilly tract included between the Dauri and the Koel, from Hutar up to its junction with the Thatha river, I failed to find any trace of carbonaceous matter in any of the numerous streams. Close to Badhunyah, there is a sandstone which is remarkable for containing numerous marble-like concretions.

Seam.

Seam.

In the neighbourhood of Morwaie the sandstones are often highly ferruginous, and ironstones and red clays are of frequent occurrence; but the former, though furnishing an ample supply for the native furnaces, are, to the best of my belief, neither here nor anywhere else within the Hutar field in sufficient abundance to justify the belief that they could be employed profitably in the manufacture of iron on the European system, but to this subject I shall return again in the Economic chapter. South of Morwaie the Barakars are cut off by a well-marked fault. On the line of fracture associated with the fault rock I found some magnetite, partially altered into red hæmatite.

Ironstones at Morwaie.

I shall now describe the sections in the Koel and its tributaries, from north to south. First I must allude to the previous notices. Captain Sage's Burra river appears

Sections in Koel and its tributaries.

[a] I have not included the assay of this specimen in the table, as it would, being a useless coal as regards thickness, unfairly depreciate the average. The composition is, moisture 7·6, volatile 30·6, carbon 38·2, ash 23·6.

to be the same as the one called the Mungurdar by Mr. Homfray, as both speak of the near proximity of Hutar. Unfortunately I find that when on the spot I omitted to enquire the names of the two branches of the river at Hutar. The true Mungurdar river, however, joins the Koel nearly four miles north of the coal-field at Hutar, and to the best of my belief does not traverse any outlying patch of measures, but I have not examined its course throughout. What river Mr. Homfray indicates by the name Barwellia, which he speaks of as 'running to the eastward,' *i.e.*, coming from the west, unless it be the Supahi, I do not know. I have already commented on some other of Mr. Homfray's statements.

Previous notices.

In the Koel, Talchirs are seen under the west bank up to within a short distance of the Hutar river. Barakars then supervene, and the following section is found in the southern, Nowadih, branch of the river close to the lower tolehs of the village. Resting on sandstone there is a seam about 5 feet thick, of which the bottom, 1 foot, consists of coal, dip 15°, to south. Above this there are shales very like Talchirs in lithological characters, followed by an irregular seam about 10 feet thick, including 1 foot of bad coal at top and 1′ 4″ of good coal at base (*vide* assay). This seam is traceable westwards for about a mile. Although it varies somewhat in character, the thickness of the included coal remains pretty constant. The Nowadih hill to the south is composed of sandstones and conglomerates, with which there are some ironstones, which are smelted by the Aguriahs of several neighbouring hamlets. This neighbourhood, as a site of iron manufacture, was mentioned by Captain Sage in 1830, and from the great abundance of slag, it is evident that there have been furnaces here for a long period.

Seams at Hutar.

Ironstones at Nowadih.

From the mouth of the Hutar river to that of the Supahi, the Koel exhibits a broken section of sandstones with southerly dip. In the Supahi from its mouth up to the point where it leaves the Doothoo hills, which are formed of Mahadevas, there is a more or less interrupted section of grits, sandstones, and conglomerates, with dips of from 10° to 15°, to south.

Supahi section.

Abnormal top beds.

At a short distance on either side of the Daltonganj road-crossing, there are carbonaceous shales, those on the west including 6″ of coal. From the occurrence in other sections of certain peculiar beds towards the top, it at one time seemed probable that these were representatives of a group or sub-group between the true Barakars and the Mahadevas in the portion of the Hutar field which lies west of the Koel. In this particular section, however, the beds seem to be normal Barakars. Owing to the steadiness of the dip, this section and that of the neighbouring Hurtah river afford unusual opportunities for measuring the thickness of beds intervening between the top of the Talchirs and the bottom of the Mahadevas. Estimating the average dip at 12° and the horizontal distance 2½ miles, the thickness would be about 2,750 feet. This is the maximum thickness at the centre of the basin, and it is much in excess of that found elsewhere.

Thickness.

Section in Hurtah.

The most important of the Supahi tributaries is the one which rises in the Hurtah or Hudur hill, and bears the same name. The section which commences near Titaro (Toleh of map), a small Aguriah hamlet, is as follows:—

Talchir shales.

Grits and shales of uncertain thickness.

1.	Flaggy shales, rolling, say 800′ at 5° =	70′	0″
2.	Sandstones, 400′ at 5° =	34′	9″
3.	Sandstone and sandy shale, part concealed, 220′ at 10° =	38′	2″
4.	*Seam*, dip 10°	3′	0″
5.	Sandstones	17′	4″
6.	*Seam*—		
	a. Stony carbonaceous shale 2′ 2″		
	b. *Coal* 1′ 2″		
	c. Carbonaceous shale 0′ 10″		
	d. *Coal* 1′ 0″		
		5′	2″
7.	Sandstones and grit, 27′ at 15° =	6′	10″
8.	*Coal*	0′	2″
9.	Grit	5′	0″

Here there is a slip and repetition of section—

Seam—			This illustrates the rapid changes in character of beds which so frequently take place.
Coal, seen	1′	6″	
Sandstones	17′	5″	
Coal	0′	2″	
Grit	10′	0″	

10. Interval, 50′ at 10° =	8′	8″
11. Sandstones, 32′ at 10° =	5′	6″
12. Sandstone with irregular band of coal, mostly stony	3′	6″
13. Grit with scattered pebbles, 280′ at 8° =	38′	10″
14. Interval, in which some thin carbonaceous layers occur, 50′ at 15° =	12′	10″
15. Sandstones, 92′ at 10° =	5′	6″
16. *Coal*	0′	8″
17. Sandstones, 18′ at 10° =	3′	1″
18. *Coal*	0′	4″
19. Carbonaceous shales, with thin layers of coal and sandstones, 165′ at 120° =	34′	2″
20. Grits, 95′ at 15° =	24′	7″
21. Carbonaceous shales, layers of *coal* 6″ thick towards top and bottom, 60′ at 12° =	12′	5″
[Beds here distorted and repeated.]		
22. Sandstones and grit	8′	0″
23. Interval, in which some carbonaceous shales are seen to occur, 50′ at 10 =	8′	8″
24. Sandstones and grits, including 4″ band of *coal* at centre, 110′ at 10° =	19′	0″
25. *Coal*, shaly-impure.		
26. Thin sandstones, and carbonaceous shales, 150′ at 8° =	20′	8″
27. Sandstones and grits, with irregular nests and layers of carbonaceous matter, 150′ at 8° =	20′	0″
28. Sandy and carbonaceous shales, 50′ at 10° =	8′	7″
29. Carbonaceous sandstone	3′	6″
30. *Seam*—		
Appears to consist mainly of a dense, rather dull coal, but portions with bright layers, flaky towards base, dip 8°	8′	0″
31. Sandstones 100′ at 8° =	13′	10″
32. *Seam*—		
Carbonaceous shale 0′ 4″		
Shaly *coal* 2′ 0″	2′	4″
33. Sandstones and grits cut into gorge, 300′ at 10° =	52′	2″
34. *Seam*—		
Coal with sandstone, possibly ⅓rd coal, 50′ at 8° =	6′	10″
35. Sandstones and grits with conglomerates	60′	0″
36. *Seam*—		
Quality inferior, but part concealed, 100′ at 10°	17′	5″

Beyond this, up to the junction with Supahi, there are no more seams exposed. The rocks are grits and conglomerates with rare carbonaceous layers. Among the above the seam of real value appears to be No. 30. The average composition of two specimens is good,[a] and the thickness and dip both favourable to working.

Section in Chupatsi river.

To the north and north-west of this line of section small patches of Barakars have been cut out by the main bounding fault. The first is tolerably clearly seen, but the second seems to be complicated by the occurrence of some small slips parallel to the main bounding fault. In the Chupatsi stream there is a section of the carbonaceous zone shewing a diminution in the number and thickness of the seams. There are here in all about six, the coal being in bands from 6″ up to 2′ 6″ in thickness.

Section in Satghoria river.

In the Satghoria river there is another cross-section of this zone. The highest seam varies, within the limits of the width of the stream, from 1′ to nearly 4′. Below it come a series of seams whose average thicknesses are as follows—3′, 2′, 1′, 1′, 1′. These occur in alternation with massive beds of grits and sandstones of from 12 to 20 feet in thickness. There is no workable thickness of coal exposed in either of these last sections. In the almost entire absence of shales, they contrast with the section seen near Hutar, but very closely resemble the sections near Purro on the south of the field which will be described further on.

Section in Atee.

The last tributary of the Supahi in this part of the field whose section remains to be described, is the Atee. At the point south-west of Bijka, where the Atee river leaves the hills, there are Barakar grits and pebble beds with a narrow border of Talchirs. The dips fall rapidly from 50° to 20°. The lowest beds are much indurated and crushed by faulting, which is further indicated by the presence of a ridge of fault rock which strikes hence towards the Bijka hill. Among the broken fragments close to the line of fracture there are some pieces of coal which are derived from

[a] *Vide* Table of Assays.

a seam now concealed. In the river section south-west of the village there are, resting on the typical Barakar grits and pebble beds, some fine sandy shales and green silty Talchir-like clays which, taken in connection with other like exposures, suggested the possibility, as I have already stated, of there being in this field a group of beds separable alike from Barakars and Mahadevas. This view I have been obliged to relinquish. In the remainder of the Atee section, from Bijka up to the junction with the Supahi, these green beds occur with the grits, and no coal seams are exposed.

Talchir-like beds.

In the Koel river, from the mouth of the Supahi to the mouth of the Thatha, sandstones, &c., with south dip are occasionally exposed.

Section in Koel river.

In the Thatha river there are several seams of carbonaceous shale with coaly layers, but their position is uncertain, owing to the inaccurate plotting of the stream. Beyond the village the section is interrupted by the already alluded to Morwaie fault, in conjuction with which is the hot spring already described.

Section in Thatha river.

Further east a seam of about 1′ 4″ of coal is seen twice in the bed of the river, being bent by the fault into a synclinal.

Seam.

The section in the Koel, from the mouth of the Thatha to the Mondul stream, again exposes nothing noteworthy till near the latter spot, when a coal seam is partially exposed under the eastern bank. This is the only seam uncovered in the whole course of the Koel. The coal is much decomposed, and as only three feet is exposed, it is not possible to say whether the seam is of value; the dip is 10°, rising to 15°. The long hog-backed ridge which strikes eastward from this is made up of grits and conglomerates, and possibly coincides with a branching line of fracture, since fragments of fault rock are found in some abundance on the slopes. Half a mile to the north, fault rock, which marks the position of the Morwaie east and west fault, is seen

Section in Koel river.

Seam.

East and west fault.

in situ. In its neighbourhood the Barakar grits are intensely disturbed and indurated. West of the Koel, on the same line of strike, runs the foot of the Mahadeva scarp. I have already stated the possibility of the Mahadevas being faulted and a portion of the Barakars cut out here.

Section in Mundul river.

In the Mundul river the section exposes a number of thin seams of coal and carbonaceous shale alternating with sandstones. These seams are too thin to be of value.

Section in Purro river.

In the stream which runs through Purro, west of the road, there is a considerable section of sandstones with some carbonaceous shales, and four seams containing from 6 inches to 1 foot of coal. The coal is of good quality, but nowhere sufficiently thick to be of value.

Other sections in Supahi.

The Supahi and its tributaries south of the Doothoo hills afford several more sections. In the former, before it enters the hills, there is a narrow margin of Talchirs, above which there are coarse Barakar grits dipping at 25°, to north-west. Above these there are somewhat conglomeratic grits, which resemble certain beds occupying the same relative position in the Aurunga field. The next rocks seen are rusty Mahadeva sandstones dipping 15°, to north. It is uncertain whether they are superposed or are separated by a fault.

Section in Ledkee river.

In the Ledkee stream, which joins the Supahi near its entrance to the hills, there are rocks resembling the highest beds seen in the Atee at Bijka, and with them some others whose lithological affinities are certainly not with ordinary Barakars. Besides the green beds, there are grits which include angular fragments of gneiss, &c., and also fine calcareous sandstones.

Difficuty in separating top beds.

Any attempt to separate these rocks as constituting a distinct group is beset with difficulties, since there are not a few sections in which the Mahadevas

directly overlie normal Barakars. So that were the former really distinct, there would be a good deal of unconformity which would have to be explained away. Regarding them as being merely local varieties of Barakars would get over the difficulty of their not appearing in some sections. A dotted line on the map indicates the limits within which these rocks have been observed.

Section in Supahi river at Binda.

Still another section of Barakars is afforded by the Supahi where it traverses a small area of those rocks which are cut off by a fault at the extreme west end of the field. The following is the measured section in the Supahi at Binda from north to south, descending, dip 10°, to north :—

	Gneiss faulted.	
1.	Interval . . .33′	5′ 9″
2.	Grits, part concealed, 28′ at 10° =	4′ 9″
3.	*Seam* (*vide* assay) 25′	4′ 4″
4.	Sandstone	4′ 0″
5.	*Seam*—	
	Shale . . 0′ 4″	
	Coal . . 1′ 0″	1′ 4″
6.	Sandstone	3′ 0″
7.	*Seam*, very indistinct	2′ 0″
8.	Sandstone, part concealed, 50′ at 12° = . . .	10′ 5″
9.	*Seam* (*vide* assay), 53′ at 15° = ...	13′ 8″
10.	Felspathic grit, 50′ at 15° = ...	12′ 10″
11.	Carbonaceous shale, passing into grey sandstones and grits, 33′ at 10° = ...	5′ 9″
12.	Thin sandstones, with some thin coaly layers, 200′ at 10°	34′ 9″
13.	Interval, 100′ at 10° = ...	17′ 6″
14.	Grits = ...	12′ 0″
	Fine-grained yellow sandstones—Talchirs.	

It will be seen, on reference to the table of assays, that seams Nos. 3 and 9 contain coal of very good quality. On the other hand, a reference to the map will shew that, owing to the fault having brought up the gneiss so close to the outcrop, the quantity is very limited

indeed. Perhaps this is the less to be regretted, since the locality is too difficult of access ever to be of much importance.

Section 3.—Mahadeva Series.

Rocks of this series, though largely developed west of the Koel, are not now represented by any deposits in those parts of the Hutar field which lie to the east of that river. Their general aspect, throughout the elevated tract which extends from the west bank of the Koel, where they rest upon a great thickness of Barakars, to the end of the field, where they are cut off by a fault, corresponds closely with the appearance of rocks of the same age in the Karanpura fields. The lithological characters, too, are identical.

Possible unconformity.

Owing to the difference in the thickness of the sections of the Barakars which are found on the north and south, it is possible that the Mahadevas may have been let down by a fault, a portion of the Barakars having been cut out. This appearance may, however, be attributable either to original irregularity of deposit of the Barakars, or to unconformable superposition, the existence of which is rendered probable by the non-representation of the Raniganj and Panchet groups in this area.

Section in Supahi river.

The most complete section of these rocks is afforded by the Supahi, which traverses a deeply cut gorge through the mass of hills north of Purro. At the mouth of the gorge the rusty-looking grits and sandstones dip 15°, to north. At about the centre of the gorge the beds flatten, and the water runs between steep walls, 30 feet high, in which the rugged and honey-combed edges of the beds are exposed. Pot-holes abound, and contribute not a little to produce a striking effect. This is especially the case at the waterfall which is fed by the Hulka stream on the west.

Scenery.

The scene is one of peculiar beauty, not that there is, in the dry season at least, a copious fall, but because the water trickles into vast pot-holes, and flows over the edges of these natural basins, the innermost recesses of which can be

viewed through the pellucid waters. In the well-shaded Hulka valley the grotesque forms of the eroded sandstones and the brilliant hues of the vegetation, which includes ferns, a small *Arum*, *Drosera*, grasses, mosses, &c., combine to make up a scene which is most refreshing in March or April after the black, scorched, and dusty jungles outside.

Towards the northern end of the gorge the beds are tilted again, dipping west of south at an angle of 8°.

Bijka hill.

In the Bijka hill (2,479 feet) these rocks attain their maximum development, though it is difficult to estimate the thickness exactly. The summit of the hill is about 1,300 feet above the village. The inclination of the beds is from one point of view only 5°. The northern face of the hill is backed by a strong ridge of fault rock, which marks the position of the main boundary fault. In part, then, the elevation may be due to tilted Barakars at the base, but I think it probable that the thickness of Mahadevas cannot be far short of 1,000 feet.

Towards the top the sandstones present a somewhat vitreous appearance, being not unlike some forms of Vindhyan rocks. Beyond the Bijka hill the older groups are cut out completely, faulted junctions between the edges of the gneiss and the Mahadevas being exposed on the slopes. Before the Supahi is reached, a cross-fault limits the further extension. It is probable that a much thinned out deposit of Barakars has been here cut off. That the Barakars were dying out here is evidenced by the fact that only two miles further west the Mahadevas, at a level perhaps 200 feet higher, rest directly on the gneiss. A small patch of Talchir boulder beds at the foot of the scarp, and the Barakar and Talchir beds at Binda, are the sole remnants of the lower groups which are left to indicate former extension.

Cross-fault.

The outlier which in the Sitwa hill rests on a base of gneiss spreads westwards through the level country near Budhunya. The

southern and western boundaries appear to be continuations of the Bijka and Binda faults, which would intersect one another near Kajuri.

Sitwa hill outlier.

I have on the map indicated the probability of the Bijka fault being continued to Tatapani, but am as yet by no means certain that it is so.

The lithological characters of the rocks forming this outlier are normal, *i. e.*, identical with those of the adjoining main area.

CHAPTER VII.

ECONOMIC RESOUCES.

Section 1.—Coal.

In the accompanying table I have given the results of my assays of the specimens of coal which I collected in the three fields. These results are completely confirmatory of the opinions which I formed in the field as to the relative merits of the seams. The coal of Daltonganj has the advantage of having been opened up, but I doubt if this is sufficient to account for the difference in the percentages between it and the Aurunga coal, and this is the more probable, since the Hutar coal has yielded such good results.

Comparative merits of the coal.

The Daltonganj Field.

No doubt whatever exists as to the excellent quality of the coal in this field. It has been proved, both by assays and actual experiments, to have great heating power, and to be admirably adapted to steam purposes.

Mr. Hughes' estimate of 11,600,000 tons as the amount of available coal is, as far as I have had opportunities of forming an opinion, a safe minimum. Although there is good reason for believing that the coal of this area, as in the Aurunga field, occurs in basins of limited extent, that is to say, that it is not of equal extent with the coal-measures, still there is a fair probability that there may be basins of coal in the portion of the field to the south-east where the rocks are much concealed by superficial deposits. This can only be ascertained by systematically conducted borings. The Singra seams too, which are not included in Mr. Hughes' estimate, contain coal of so good a quality that it might very probably be worked profitably by open quarries for some years.[a] In any case, the 11,600,000 tons would last for 50 years, at the

[a] The Singra coal was being used for lime-burning at the time of my visit.

rate of 200,000 tons per annum, which is the amount that the projected line and canal would be capable of carrying, according to Colonel Haig.

The average composition of the four specimens, which were in each case taken from the coal actually stacked for consumption, amounts to—

Moisture 3·45, volatile 21·05, carbon 64·8, ash 10·7.

The Aurunga Field.

The coal which occurs in the rocks of the Raniganj group is of too unimportant a character, whether as regards quality or thickness to be considered as affecting the question of the amount economically available in this area.

Coal inferior in quality.

The improbability of this field containing a large supply of really good coal is very great. The appearance of the seams, and the result of the assays, both point to this conclusion. At the same time, it should be remembered that there is not a single fresh and clear section of the rocks, and that the coal has never been quarried to the smallest extent. Of coals with an average composition similar to that given in the accompanying tables, I think the following quantities would be available:—

	Tons.
Rajbar seams	12,000,000
Toobed „	3,000,000
Jugguldugga „	5,000,000
TOTAL . .	20,000,000

Minor localities not included.

It is unnecessary to include here any of the other localities, where I have indicated the presence of coal in the previous pages, and on the map. It is possible that borings may prove the seam in the outlier at Dudhoria, or those on the south of the field in the Gowa section, to have some value. But dealing only with the facts which are available, they must be omitted from consideration at present. The obviously bad quality, or limited extent of other seams, as at Hoochloo and north of Manjar, have been alluded to; and these also are therefore not included.

Coal not suitable for iron smelting.

Unless very much better qualities of coal exist in the Aurunga field than the very best seen by me, it is manifestly impossible that iron can be manufactured on the spot.

Hutar Field.

Lithological characters peculiar.

I have already pointed out that the coal-measure rocks of this area present many striking differences from those of the Aurunga field. To this rule the coal is no exception, as will at once be apparent by a comparison of the average assays in the accompanying table. From the Daltonganj coal that of Hutar differs in containing a notably smaller proportion (7·15 per cent.) of fixed carbon, and would, therefore, have a less heating power. The proportion of ash, 10·7 per cent., is the same in both. On the whole, however, the Hutar coal is quite equal to the average of Indian coals, so far as regards quality. Much uncertainty must attach to any estimate of quantity. Only three seams of good quality, containing a thickness which could be worked with profit, are known to exist; these are as follows:—

Coal compared with that of Daltonganj.

Dauri river section, south-east of Hurilong	8′ 0″	seam.
Hurtah river, at Toleh	8′ 0″	„
Supahi river, at Binda	13′ 8″	„

No definite estimate of quantity possible.

It is possible that the Dauri river and Hurtah river coals may be continuous right across, but since there is no intervening section exposed in the Koel, or elsewhere, it would be most dangerous to base any calculation on the mere supposition. In fact, the lateral extension of both these seams being quite unknown, it would be utterly futile to attempt any estimate of the number of millions of tons they may contain.

That the 13′ 3″ seam at Binda on the Supahi contains but a very small quantity of coal is as certain as anything can be, the fault along which the gneiss has been thrust up occurring within a few feet of the outcrop.

I do not at all despair of this field being found to contain workable seams of value, but the facts at present available do not justify any confident expression of opinion that such will certainly prove to be the case.

Assays of Coals from the Palamow Coal-fields.

	Locality.	Formation.	Moisture.	Valatile.	Carbon.	Ash.	Character of Ash.	Appearance of Coal.	Remarks.
AURUNGA COAL FIELD.	Subano river, 1′ 6″ seam	Raniganj Group	5·	33·8	36·2	25·	Dark-grey	Cubical fracture; bright layers.	
	Rajbar, No. 21 of section	Barakar ,,	8·4	28·6	33·	30·	,,	Laminated bright layers.	
	,, ,, 27 of ,,	,, ,,	7·	26·2	38·4	28·4	Grey	Earthy-looking, with irregular bright layers.	
	Bagh-Digwa river, 1′ 6″ seam	,, ,,	7·2	32·	45·	15·8	White	Laminated.	
	Stream west of Jornean, loose fragments 8″ thick.	,, ,,	6·4	26·6	33·6	33·4	Reddish	Laminated, contains altered pyrites (red hæmatite).	
	Toobed Section, No. 5	,, ,,	6·2	28·6	30·6	34·6	Dark-grey	Very dull and earthy-looking.	
	,, ,, ,, 11	,, ,,	6·8	29·	38·6	25·6	Reddish-grey	Laminated; contains altered pyrites.	
			47·0	204·8	255·4	192·8			
	Average for Aurunga Field	.....	6·7	29·2	36·5	27·5			
HUTAR-COAL FIELD.	Dansi river, 3′ 6″ seam	Barakar Group	6·2	30·6	53·	10·2	Reddish-grey	Somewhat homogeneous, but streaked with bright layers.	
	,, ,, 8′ 0″ ,,	,, ,,	7·6	39·	43·6	9·8	,, lighter	Ditto ditto.	
	Hutar ,, 1′ 4″ ,,	,, ,,	7·4	17·2	65·4	10·	Grey	Ditto ditto; cubical fracture.	This seam is difficult of access.
	Hurtah ,, No. 30 *a* 8′	,, ,,	4·	19·8	58·	18·2	Brick-red	Ditto ditto.	
	,, ,, ,, 30 *b* 8′	,, ,,	8·6	26·	57·	8·4	Brownish-grey	Very bright and very dull layers alternating	This is the most valuable seam known to exist in the Hutar field; the average composition of the two specimens is m. 6·3, v. 22·9, c. 57·5, a. 13·3.
	Binda No. 9 of section 13 8″	,, ,,	3·8	34·	53·8	8·4	Reddish-grey	Dull; lamination obscure	This seam is of too limited extent to be of much value.
	,, ,, 3 ,, 4′ 4″	,, ,,	5·6	36·	50·6	7·8	,,	Bright and dull layers alternating	
	Supahi river, loose block	,, ,,	4·4	21·4	61·4	12·8	Grey	Laminated: bright layers predominate.	Ditto ditto.
			47·6	224·0	442·8	85·6			
	Average for Hurta Field	.....	5·95	28·	55·35	10·7			
DALTONGANJ COAL-FIELD.	*a* Pandua Quarry	Barakar Group	2·	22·	67·8	8·2	Brownish-grey	Laminated; very bright looking	Had been stacked for two years.
	b ,, ,,	,, ,,	1·8	21·	66·4	10·8	Grey	Similar; but lamination finer	
	Singra 4′ 6″ seam	,, ,,	8·4	19·8	62·4	9·4	Dark-grey	Similar, stained with red hæmatite.	
	Specimen from Palamow forwarded by Mr. Hope.[a]	,, ,,	1·6	21·4	62·5	14·5	Reddish.		
			13·8	84·2	259·1	42·9			
	Average for Daltonganj Field	.....	3·45	21·05	64·8	10·7			

N.B.—None of the above are coking coals.

[a] Assayed by Mr. Mallet.

Section 2.—Iron.

The iron ores found in Palamow admit of a triple classification, founded both on their mode of origin, their geological position, and on their chemical composition. So arranged they stand as follows:—

Magnetite	*a.* Pure magnetic ore *b.* More or less decomposed and altered.	These occur either in bands and lodes in hornblendic rocks, or as detached crystals in granite veins.	Crystalline and metamorphic rocks.
Siderite and hæmatite	*a.* Carbonate or black band. *b.* Limonite or brownish hæmatite. *c.* Red hæmatite.	*a.* Bedded shales. *b.* Concretionary masses in sandstones.	Coal measures, Barakar group.
Red and brown hæmatite	Bands of one or other of these ores occur in the laterite which cap the plateaux above 3,000 feet in elevation.	. . .	Laterite.

Magnetite.

From time to time specimens of pure or nearly pure magnetic ore have been picked up by district officers and travellers, or brought in by natives to Dehree and elsewhere from the Palamow sub-division. Such specimens have, on being assayed, naturally yielded most favourable results. Occasionally the localities whence these ores have been brought have been described, on native or other irresponsible testimony, as containing *inexhaustible* supplies of similar ore. But what has perhaps more than anything else tended to give rise to misconception has been the fact

that descriptions of ores of quite distinct character[a] have been coupled with the assays of the magnetite, and thus conclusions have been drawn by combining the abundance of the former with the richness of the latter, which are not warranted by the real facts of the case.

That within the limits of the sub-division, inexhaustible deposits of magnetite may exist is quite possible. I know of places in the south-east of the Manbhoom District[b] where such is the case; and many of the chief deposits of magnetite throughout India occur in rocks of the same geological age as those which form the greater part of Palamow.

My observations were limited to mere superficial examination of the ground, there being no time for opening up trenches. I believe, however, that I have seen all the principal sources of iron within the tract under review, and am compelled to regard it as being most improbable that any considerable deposit exists clearly exposed. Any very remarkable deposit other than those about to be described would almost certainly have been brought to notice by the natives. There is ample consolation, however, afforded by the fact that, although the ores which have been mainly instrumental in attracting attention to Palamow are not of great promise themselves, there are others whose quality and abundance are of a most satisfactory nature. Before describing these latter, it will be necessary to give a detailed account of observations made on the several deposits of magnetite which have been visited. The following is a list of the villages in whose vicinity these deposits respectively occur:—

Rajhara[c]	Tuppeh[d]	Bari.
Lunkha	„	„
Kopeh, (south-west)	„	„
„ (south-east)	„	„
Satbarwah	„	„

[a] *e. g.*, the laterite of Neturhat.

[b] These are in the sub-metamorphic rocks.

[c] This is quite a distinct locality from Rajhara in the Daltonganj field. It is situated east of the Mylee river, and northwards from Satbarwah.

[d] Tuppeh is a local term corresponding, I believe, to parganah.

Hosir	. . .	Tuppeh Bari.
Monodag	. . .	„ Toree.
Hirhun or Harhunj	.	„ „
Kurahi	. . .	„ Doothoo.
Adur	. . .	„ „
Morwaie	. . .	„ Doorjag.
Kotam	. . .	„ Semah.

Rajhara.—I visited this locality in company with Mr. L. R. Forbes, Assistant Commissioner, who had previously been there, and had brought from thence some specimens of very pure magnetite. In a stream about $\frac{2}{3}$rds of a mile north-west of the village, for a distance of about 50 yards, flat, but weathered fragments of magnetite occur rather abundantly scattered through the gravel. In the bank of the stream there is an imperfect section of the rocks, which consist of hornblendic and granitic gneisses with granite and quartz veins. The strike of these beds is irregular, but the prevailing direction is from west-north-west to east-south-east, and the dip vertical. We failed to find any sign of the ore *in situ*, though it appeared to occur in so limited a section of the stream bed. The legitimate conclusion seemed to be that the fragments were the sole remnant of a nest or band of ore which had been eroded from its environment of hornblendic gneiss.

Leaving the stream and crossing some raviney broken ground westwards towards a small hill of hornblendic gneiss, similar fragments were found here and there at various levels through the detrital soil, from the beds of the ravines up to the top of the lower detrital slope of the hill, but there were neither fragments nor ore *in situ* discernible on the hill itself.

I am, under the circumstances, inclined to believe that these fragments now exposed in the channels are proximately derived from the reassortment of old detritus and not directly from any exposed vein or layer.[a] The toughness and power of resisting disintegration, together with the high specific gravity, would sufficiently account for the survival of the

[a] Magnetite occurs sometimes in nests or veins, sometimes in apparent beds which underlie with the metamorphic rocks.

fragments of ore long after the other materials had been washed away; these fragments might conceivably be a remnant left after the erosion of many hundreds of feet of rock.

From the tabular character of most of the fragments, which are rarely more than two inches thick and more commonly only one and-a-half, it seems probable that the layer was a thin one; and it is further probable from the dips of the rocks and of the veins of quartz and granite that its underlie was steep.

However promising this spread of fragments along a line of strike may appear to casual observation, it is, under the circumstances, not such as to justify a belief in the existence of an inexhaustible supply, though such may exist hidden away under the surface.

Lunkha.—In a small ridge north of the village of Lunkha there is a considerable abundance of fragments of magnetite. One irregular block measured upwards of half a cubic foot in content.

There being no higher ground in the immediate vicinity, these fragments must necessarily mark the position of the original outcrop, which extends at least as far westwards as the Semah road, but I did not see any sign of its being exposed in the section in the bed of the Aurunga. This ore is very pure magnetite. Should occasion arise, it would not be a very arduous undertaking to sink a few trenches at right angles to the strike. These could not fail to find the vein, if any of it remains to be mined.

Kopeh, south-west.—One mile to the south-west of Kopeh, I found, in the ravines, a large rounded fragment of magnetite about the size of a man's head, which had probably been derived from a nest in the hornblendic rocks occurring in that neighbourhood. None was found *in situ*.

Kopeh, south-east.—The iron-workers at Kopeh, though living close to the Lunkha ore, do not make any use of it, and when I shewed them a very fine specimen of magnetite, said that it would not answer for their purposes.

The ore they do use consists of small semi-decomposed-crystals of magnetite derived from disintegrated granite veins, and laboriously

sifted from the sand accumulated in ravines near the Ledee stream south of the Aurunga. This ore has to be ground between stones to a fine powder before being smelted; hence, perhaps, the name *bali*, (sand).

Satbarwah.—To the south-west of Satbarwah, near Rubdah, on the slope of a small hill, there are traces of ore. These are mostly of decomposed and altered magnetite. Although a road crossing the hill gives a complete section of the hornblendic gneisses and granite of which it is formed, I could find no nest or bed of ore. This ore is not used at present, there being no Aguriahs in the vicinity.

Hosir.—The ore used at Hosir seemed to be similar in character and origin to that south-east of Kopeh. I did not, however, visit the locality whence it was brought. The iron-smelters at Gowa employ, I believe, the same ore.

Monodag.—In the stream south-west of Monodag, which is to the north north-east of Mooroop, there are some bands of magnetite seen in the gneiss. These are not of sufficient thickness to be of much importance.

Hirhun or Hurhunj.—In a stream near this village, when marching up to the Daltonganj field with Mr. Bauerman in 1873, we found a few small fragments of magnetite. There was no evidence of the existence of a large deposit.

Kurahi.—This locality is situated in the centre of the extensive group of hills south of Cheinpur, being about four miles south of Chandoo. The ore is used by the smelters of Chorhut.

Whether there are other localities besides the one I was taken to I cannot say, but all that the people knew of was a shallow hole in the middle of a standing crop of ráhar dhál, and which penetrated into an amorphous mass of decomposed ore. A large fragment of undecomposed ore had been thrown on one side, as being apparently unsuited for the smelter's purpose. In the cleared spaces on either side of the field, where the rocks were partly exposed, I could find no traces of the extension of the deposit, which is, therefore, probably a mere nest in the hornblendic gneiss and of limited extent.

Adur.—Mr. D. Smith describes some ore which he examined about two miles north of Chorhut in the vicinity of Adur, in the following words: it is "a very partial deposit of magnetic ore of the very richest quality, but so limited in quantity as to be of no importance."

Morwaie.—On the faulted boundary of the Hutar coal-field south of Morwaie there is, in conjunction with some fault rock, an outcrop of magnetite much altered and decomposed, principally into red hæmatite. It is imperfectly exposed, and I cannot speak definitely as to quantity; but I failed to meet with it again in any of the cross-sections of the line of faulted contact.

Kotam.—Near the junction of the Kaliburna river with the Koel and also close to Kotam, small fragments of magnetite, some superficially altered to brown and some to red hæmatite, are found scattered about with fragments of vein quartz. Save at Chipars, there are, I believe, no smelters in the Semah valley at present. Several families of Aguriahs have had to give up their trade owing to forest conservancy having put a stop to the manufacture of charcoal.

From the foregoing it will be seen, with reference to the commercial aspect of the question, that two conditions, which are of primary importance, 1*st*, the existence of an abundance of ore—a practically inexhaustible supply—and 2*nd*, the possibility of working such an ore by a simple system of mining, are not distinctly afforded by any of the abovenamed deposits; and, in the absence of such evidence, it will perhaps be, in the long run, more profitable to direct attention rather to those ores which, though less rich, are abundant and can be raised without any difficulty whatever.

The magnetites, if found near the line of transport, would always be of value for 'fettling' and, so far as the supply would go, for mixing with the less rich ores.

Carbonates and carbonates altered into hæmatites.

This heading has been adopted, as it is most probable that, notwithstanding the present rareness of carbonates, most, if not all, of the

ores[a] about to be described originally existed as such. At present we find that the ores commonly associated with coal-measures consist of brown or red hæmatites, or mixtures of both.

According to Mr. Hughes' report on the Daltonganj field, it would seem that within its limits there are no deposits of iron ore of importance. In certain parts of the Daltonganj field shaly and concretionary fragments of ore may be seen strewing the surface. And from the traces of slags it is apparent that iron has been manufactured from these ores. Such accumulations are, however, quite consistent with a great poverty of the deposit; and all experience shews that much reliance should not be placed on such apparent evidence of abundance.

In the Hutar field, as has been already indicated in the account of the coal-measures of that area, there are numerous deposits of ironstones, but since it is believed that none of these deposits are sufficiently extensive to justify the hope that the establishment there of iron works would have a favourable result, it will be unnecessary in this Economic account to recapitulate the details regarding that area.

In the Aurunga field and its neighbourhood, however, there is an undoubted abundance of good ore which is most favourably situated as regards limestone flux, if not as regards fuel.

Aurunga field.—Since from the inferior quality of the coal it is not likely that the iron ores would ever be smelted on the spot, the Rajbar ores are less conveniently situated than those which are found in the outlier near Chiru. The latter, as has been shewn, are sufficiently abundant to meet all possible requirements, and their quality is shewn in the assays given in the accompanying table. A very important point regarding these ores too is, that since they occur near the surface and could be easily worked, no expensive mining establishment need be maintained. The same remark applies to the limestone. This would not be the case with the magnetite ores, supposing them even to be vastly more abundant

[a] Possibly some of the concretionary masses were never carbonates.

than they appear to be. There remains only to be discussed the means of conveyance of these ores to the fuel.

The question of the expediency of constructing a line of railway to connect the canals with the Palamow coal-fields being under consideration and report by the Public Works Department, it is unnecessary for me to do more than add a few lines on the subject, and this the more particularly, as I have no personal knowledge of the comparative merits of the different routes which have been proposed.

From what has gone before, it will be apparent that, in so far as I have examined the country, I am committed to the opinion that the only localities where there are iron ores and limestone suitable in all respects for iron manufacture are situated in the Aurunga field and its outlier; and that the coal which is most likely to be suitable for smelting these ores and for steam purposes is that which is found in the Daltonganj field.

The connection of the Daltonganj field with the East Indian line is then the most important and primary part of the project, and that this should be effected by means of a line from Dehree and thence onwards by the canals seems a necessary conclusion. But it has been proposed to extend the line from Gya to the coal-field *viâ* the Mohur valley. Into the discussion of the comparative merits of these schemes I am unable to enter, and it only remains for me to point out that if iron is to be made, the ores and limestones of the Aurunga field will have to be carried to the Daltonganj coal, or *vice versâ*. Probably the former would be the less expensive plan, as the coal and iron would have to be carried to and fro respectively, while in the former, the ore and lime would simply have to be drawn from the Aurunga field and smelted at the coal mines.

Distance of iron from good coal.

Roughly speaking, the distance of the Aurunga field from the Daltonganj coal mines *viâ* the valley of the Amanut would be about 50 miles. The probability of its being possible to carry the ore with profit for this distance by a specially

constructed line, or by any other means of transport, seems to be somewhat slender, but I must leave it to others to decide this question. It depends upon the alignment adopted for the Gya-Daltonganj line whether some reduction would not be possible in the length required for the special branch to the ores.

Laterite.

The position of the excellent ores which are found at an elevation of 3,600 feet in the laterite of the Neturhat plateau renders them absolutely valueless from an economic point of view. A glance at the accompanying general map will be sufficient to shew the nature of the physical difficulties in the country surrounding the Tuppeh Semah in which the Neturhat plateau is situated.

Much simplification of the questions at issue will ensue by omitting all such localities from consideration.

I shall conclude this section by giving a brief sketch of the present condition of the native iron works in the area.

NATIVE IRON WORKS.

A photograph, for which I am indebted to the kindness of Mr. T. F. Peppe, has rendered it possible to give here a more life-like representation of the process of smelting, as practised by the Aguriahs, than has hitherto been published. In the lithographic reproduction of this photograph, M. Jules Schaumburg's artistic hand, which has done so much for the illustration of these volumes, will be recognized.

Although the direct process by which malleable iron is produced in native furnaces has often been described, and now finds a place in works on metallurgy, I venture to think that a few remarks on the subject, the result of my own observations, will not be inappropriate here. I have already, on a previous page, discussed the ethnology of the various tribes connected with the manufacture and working of iron.

J. Schaumburg, Lith:

AGARIAH IRON SMELTERS PALAMOW.

Dimensions of furnaces,

The furnaces of the Aguriahs are generally erected under some old tamarind or other shady tree on the outskirts of a village, or under sheds in a hamlet where only Aguriahs dwell, and which is situated in convenient proximity to the ore or to the jungle where the charcoal is prepared. The furnaces are built of mud, and are about three feet high, tapering from below upwards, from a diameter of rather more than two feet at base to eighteen inches at top, with an internal diameter of about six inches, the hearth being somewhat wider. Supposing the Aguriah and his family to have collected the charcoal and ore, the latter has to be prepared before being placed in the furnace.

Three varieties of ore are recognized, *viz.* :—

Bali = Magnetite.
Biji = Hæmatites from coal-measures.
Dherhur = Hæmatites from laterite.

Bali is first broken up into small fragments by pounding, and is then reduced to a fine powder between a pair of millstones. The hæmatites (*Biji* and *Dherhur*) it is not usual to subject to any other preliminary treatment besides pounding.

Blowing in.

A bed of charcoal having been placed in the hearth, the furnace is filled with charcoal and then fired. The blast is produced by the usual pair of kettledrum-like bellows, which are worked by the feet as in the accompanying illustration, the heels of the operator acting as stoppers to the valves. The blast is conveyed to the furnace by a pair of bamboo twyeres, and has to be kept up steadily without intermission for from 6 to 8 hours. From time to time ore and fuel are sprinkled on the top of the fire, the proportions used not being measured, but probably the operators are guided by experience as to the quantities of each which produce the best results. From time to time the slag is tapped off by a hole pierced a few inches from the top of the hearth. Ten minutes before the conclusion of the process, the bellows are worked with extra vigour and the supply of ore and fuel from above is stopped. The clay luting of

the hearth is then broken down, and the ball, or *giri*, consisting of semi-molten iron, slag and charcoal, is taken out and immediately hammered, by which a considerable proportion of the included slag which is still in a state of fusion is squeezed out.

Blowing out.

In some cases the Aguriahs continue the further process, until after various reheatings in open furnaces and hammering, they produce clean iron fit for market; or even at times they work it up themselves into suitable utensils. Not unfrequently, however, the Aguriahs' work ceases with the production of the *giri*, which passes into the hands of the Lohars. Four annas is a common price paid for an ordinary sized *giri*,[a] and as but two of these can be made in a very hard day's work of 15 hours' duration, and a considerable time has also to be spent on the preparation of ore and charcoal, the profits are small. The fact is, that although the actual price which the iron fetches in the market is high, the profits made by the mahajans, and the immense disproportion between the time and labour expended and the outturn, both combine to leave the unfortunate Aguriah in a miserable state of poverty.

Refining.

Price of crude iron.

The price varies with the quality of the finished iron. But the average prices at which the merchants of Seraidih and Cheinpur respectively purchase are 5 and 6 pasiri (36 cutcha seers), say 50 lbs., per rupee.

Prices of refined iron.

In the Karanpura field I was told that the price was Rs. 9 a tangi = 4 cutcha maunds, that would be about Rs. 3 per pucka maund, a much higher figure.[b]

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[a] At Nowatand, in the Karanpura field, the prices of *giris* by weight were—

		Rs.	
3	cutcha maunds for	1	in advance.
2 to 2½	„ „ „	1	on delivery.

[b] Owing to conflicting, and often deliberately untruthful statements, and the varying values of weights and measures, it is difficult to obtain perfectly reliable statistics on these points.

At Dehree I believe the merchant receives Rs. 9 for a pucka maund. This is a very high price indeed = Rs. 252 per ton.

It remains only to give a list of the localities where iron is now manufactured—at present in Palamow and Toree, so far as I have been able to ascertain.[a]

Palamow—

Village.	Tuppeh.	Number of furnaces.	
Hosir	Bari	1	
Gowa	„	1	
Kopeh	„	3	
Hurilong	Durjag	2	
Morwaie	„	3	
Hetlee	„	10	
Hutar	Doothoo	2	
Aror	„	6	
Korom Toleh	„	10	
Titaro or Toleh.	„	3 ?	
Binda	„	1	
Chorhut	„	?	
Neturhat	Simah	2	seen; others reported.
Chiparo	„	?	
Khugori	Buskhol	?	

Toree—

Olerpat	1
Chitag	2
Balunuggur	2
Rajbar[b]	1
Bejrah	4
Kurmahi	?
Ghootam	?
Nuwada	?

[a] A list supplied to me from Daltonganj proved so inaccurate that I only give the names of places where I have actually seen furnaces.

[b] This is the only furnace excavated in a bank of clay which I have seen in this area.

Table shewing character of Iron Ores collected and examined in situ *in Palamow.*

	Locality.	Formation.	Percentage of iron.	Name of Ore.	Mode of occurrence.	Remarks.
Assayed—						
Aurunga.	1. Rajbar	Barakar	49·2	Red and brown hæmatites	Bedded; concretionary structure.	
Aurunga.	2. Palee river, section north of village.	„	45·3	Brown hæmatite	Ditto ditto	These all occur in the outlying area between Balunuggur and Chiru; the proper position, no doubt, for iron works.
Aurunga.	3. Kurmahee	„	56·6	Red hæmatite	?	
Aurunga.	4. Dudhuria	„	33·7	Black band, with free carbon	Bedded	
Aurunga.	5. Ghotam	„	39·4	Red hæmatite		
Hutar.	6. Hills east of Sindhowrah	„	59·3	Brown „	Ditto	
Hutar.	7. Hetlee	„	43·5	Red and brown hæmatites	Concretionary in sandstone	These, though good ores, do not occur with sufficient regularity or abundance to be of value.
Hutar.	8. Hurilong	„	45·3	Brown hæmatite	Ditto ditto	
Hutar.	9. Neturhat	Laterite	45·5	„ „	Ditto ditto Bedded	An excellent and abundant ore, but occurs too far away from the coal-fields to be of much value.
Not Assayed—						
Aurunga.	10. Kolherwan, south of village	Barakar	...	Sandy concretions of red and brown hæmatites.	Bedded	These occur in the vicinity of Nos. 1 to 5, but are of inferior value.
Aurunga.	11. Hills south-east of Bijrah	„	...			
Aurunga.	12. Hooshloo	„	...			
Hutar	13. Korom Toleh	„	...	Brown hæmatite	?	Used by the Aguriahs.
	14. Kurahi, north of Chongo	Crystalline or metamorphic.	Not less than 60 per cent.	Nearly pure magnetite	Irregular lodes and bands in hornblendic rocks.	Smelted by Lohars of Chorhut.
	15. South-west of Kopeh	„ „		Ditto	In granite veins	This is of no commercial value, but is smelted by the Aguriahs.
	16. South-east of Kopeh	„ „				
	17. South-west of Monodag	„ „		Ditto	Irregular lodes and bands in hornblendic rocks.	Abundance unascertained.
	18. Rajhera, East of Mylee River	„ „				
	19. Lankha, near Kopeh	„ „		Ditto	Ditto ditto	Fragments of ore strewn over a wide area.
	20. Herhun	„ „		Ditto	Ditto ditto	This is the most promising deposit of magnetite.
	21. Morwaie	„ „		Magnetite, partly altered into red hæmatite.	Occurs with fault rock	Abundance unascertained.
	22. Hosir	„ „		Ditto ditto	Found as loose gravel	Probably valueless.
	23. Sat Barwah	„ „		Ditto ditto		
	24. Kotam	„ „		Ditto ditto		

Section 3.—Limestones.

Little remains to be added to what has been said of the limestones when describing the crystalline rocks. So far as quantity and quality go, the limestones on the west of the Aurunga field are eminently suitable for use as a flux for the iron ores. I fully expect that they will be found traceable from the position I have indicated north-eastwards in the direction of the village of Echak. This would bring them into nearer proximity with the iron ores of the outlier (*vide* map).

The other calcareous deposits alluded to in the course of the preceding pages will probably not prove to be of economic value. But the crystalline limestone near Sattarwah may contain better portions than that from which the sample was taken.

Section 4.—Lead and Copper.

The only lead ore I have seen from this part of the country consisted of weathered fragments of galena, which were picked up on the surface not far from Bankhap three miles north of Balumath. When passing that way I did not know of the occurrence, and had no subsequent opportunity of visiting the locality. I received the samples from the Sub-Inspector of Police at Balumath. At Hesatu, about 14 miles to the north-east of Bankhap and within the limits of the Hazaribagh district, galena was many years ago reported to occur. I visited the locality, but found that a series of excavations had been made which had destroyed all trace of the outcrop, so that there was no opportunity of forming any opinion as to its character.

Some traces of copper were found by Mr. Forbes in a well sunk in the station of Daltonganj. A notice of the fact will be found in Mr. Forbes' Settlement Report. A few traces of the copper carbonates were to be seen in the heaps of stone near the well at the time of my visit.

APPENDIX.

THE TATAPANI COAL-FIELD.

Although but little is known regarding the field upon which the above name has been conferred, there is no doubt that it covers a wide extent of country, and is not improbably in direct connection with the tracts of coal-measure and younger formations which are known to exist on the borders of Mirzapore and Rewah, and in Chung-Bookhar, Koria and other parts of Sirguja. Should this surmise prove to be correct, there would be an area within the limits of the northern districts of Sirguja alone of, probably, 2,000 square miles of Gondwana rocks.

The first and only published allusion to this field that I know of is to be found in the account of Captain Franklin's remarks on the Palamow coal-field.[a] "On the 5th of May," (1830) we are told, "Captain Franklin reported his discovery of coal at a place called Chergurh in the district of Sirguja."

"This coal was of superior quality, being much more bituminous than the Singrah coal, but being situated in a mountainous and jungly country, and the navigability of the Kunhur river being doubtful, the prospect of the discovery proving useful was slender." This discovery was alluded to by Dr. McClelland in the Coal Committee's report.[b]

From the mention of the Kunhur as affording a possible means of transport for this coal, I am inclined to believe that Captain Franklin's Manpur should be identified with a place of that name which is marked on the Atlas sheet, 14 miles west of Tatapani; but it may perhaps be a wholly different locality, since it is spoken of in the Coal Committee's report as being 8 or 10 miles west of the Ramgurh hill in Lukanpur which is about the position of the Gej river, a tributary of the Husdoo, where there is reason to believe coal-measures do occur.

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[a] Gleanings in Science, vol. ii, p. 218.

[b] Calcutta, 1838, p. 69.

The position of Chergurh would settle the point, but so far I have been unable to find that place on the maps.

In the year 1866 Mr. Medlicott visited the eastern end of this field near the hot springs, and noted the presence of both Barakars and upper Panchets (Mahadevas), as is indicated on his manuscript route map.

After I had completed the examination of the area occupied by the Aurunga and Hutar coal-fields but little time remained for carrying on examination on the western side of the Kunhur; however, I was enabled to pay a flying visit to Tatapani. On a previous page I have given an account of my observations on the hot springs.

Besides the Barakars and Mahadevas I found a narrow margin of Talchirs on the east of the field, I saw no coal seams of value in the neighbourhood of Tatapani, nor did the people I interrogated seem to know of the existence of any.

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OF THE

GEOLOGICAL SURVEY

OF

INDIA.

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OF

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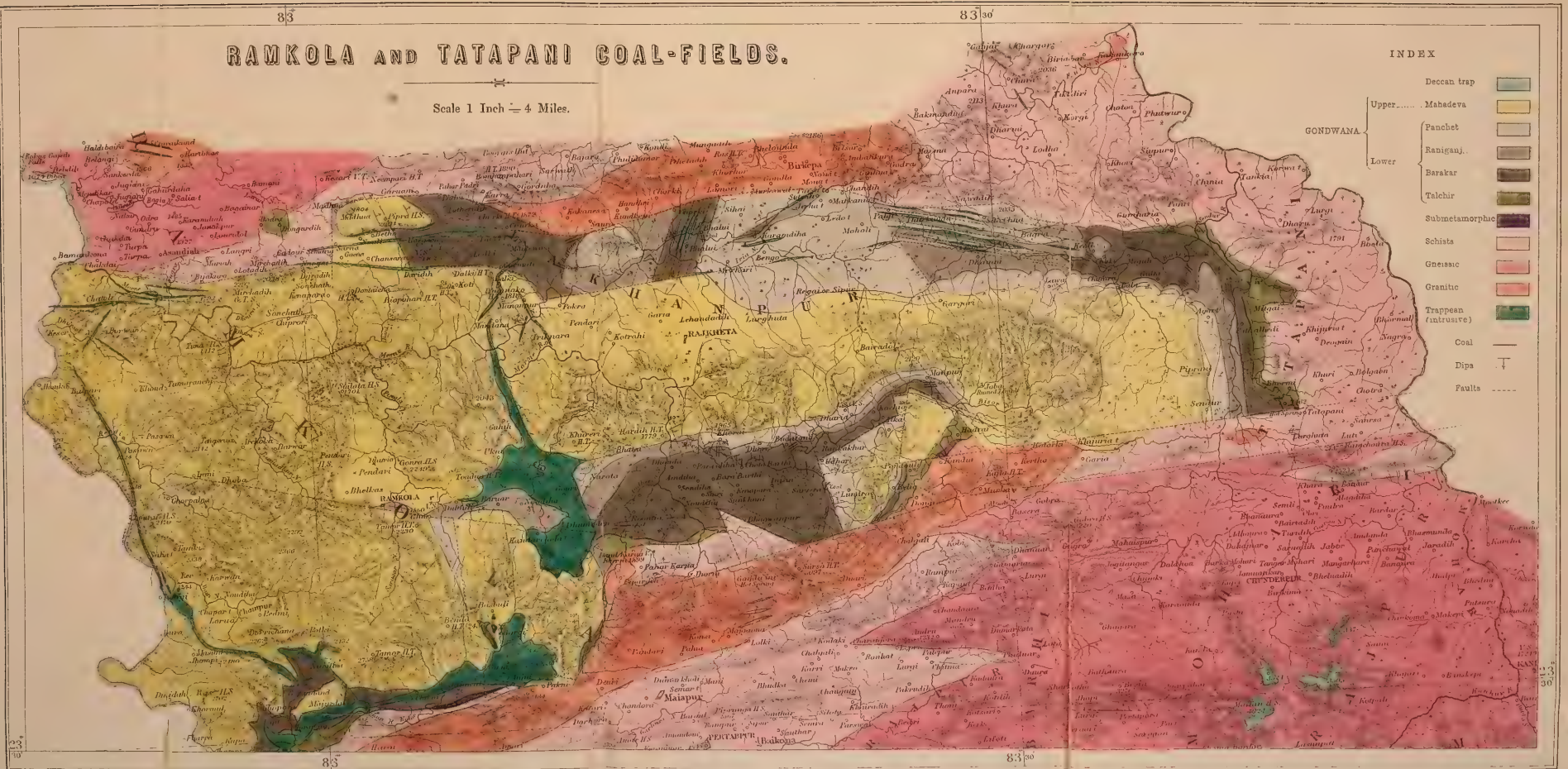

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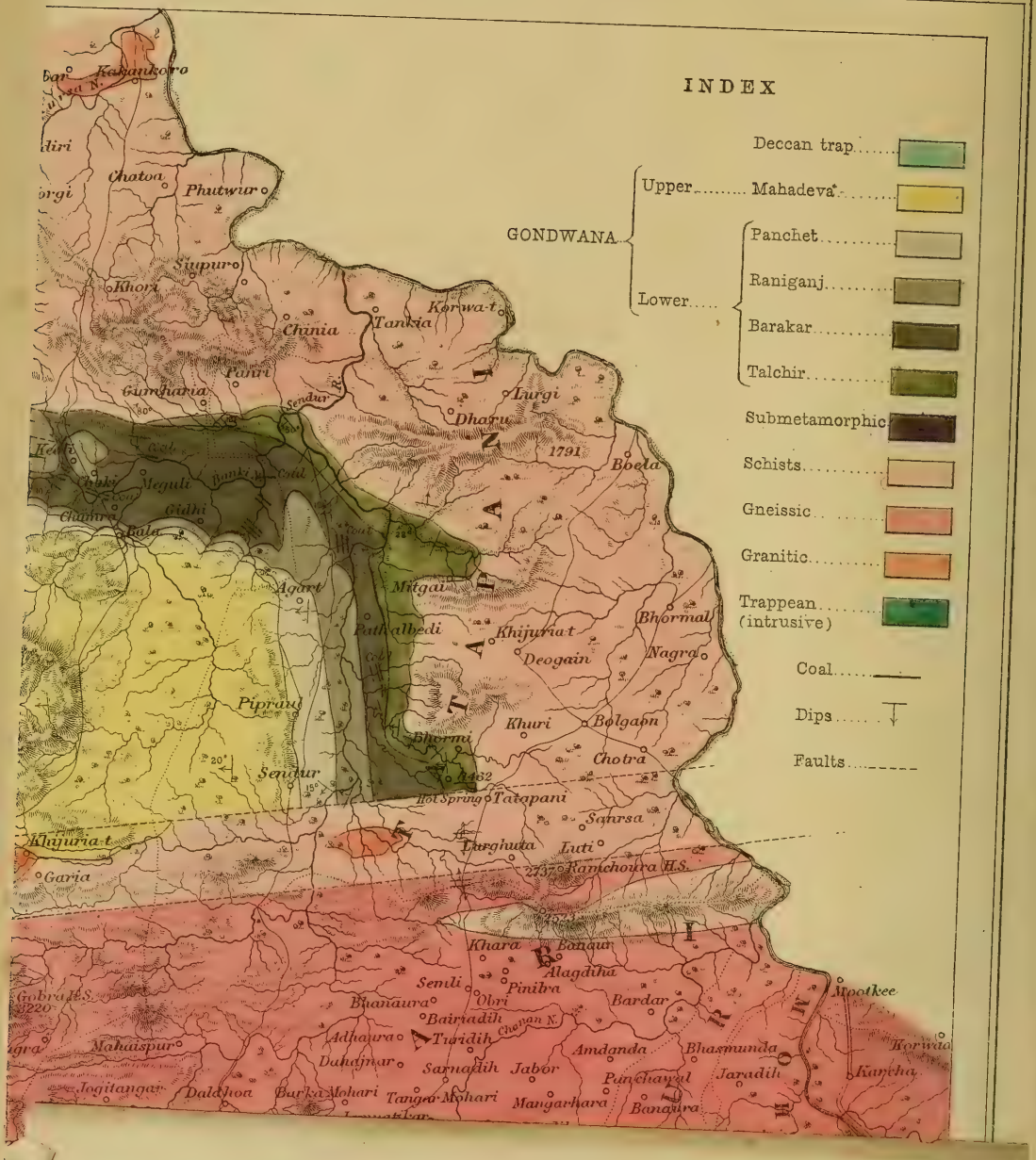
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MEMOIRS

OF THE

GEOLOGICAL SURVEY OF INDIA.

GEOLOGY OF THE RAMKOLA AND TATAPANI COAL-FIELDS:

BY

C. L. GRIESBACH, F.G.S.,

GEOLOGICAL SURVEY OF INDIA.

PART 1.

GENERAL GEOLOGY OF THE AREA.

PHYSICAL FEATURES.

THE area examined during the season 1878-79 is situated between latitudes 23° 30′ and 23° 55′, longitudes 82° 50′ and 84°, comprising the north-eastern parganas of the Sirguja state, with some portions of South Rewa, and may roughly be defined as being the area between the rivers Kunhur and Rer. Within these limits the coal-field is bounded on the south by the great gneissic plateau of Chota Nágpur, the latter rising to about 3,000 to 4,000 feet, with steep escarpments facing the north. Originally the deposits belonging to the Gondwána series may have extended up to that long line of escarpment; but, the coal-bearing rocks having gradually subsided, the surface of the present lower levels has undergone extensive denudation by the Kunhur and Rer river systems, and now only patches of Talchirs and sandstones of doubtful age, filling up here

Memoirs of the Geological Survey of India, Vol. XV, Pt. 2.

and there hollows in the metamorphic rocks, indicate the former extent of those deposits.

From a distance scarcely to be distinguished from the flat-topped gneiss plateaux, are the Mahadeva sandstone-hills, so conspicuous towards the central west of the coal-field, forming, as they do, vast table mountains occupying the centre and composing the main portion of the Gondwána area in the vicinity of the Rer river.

I have only examined the basin between the rivers Kunhur and Rer, where I found the actual coal-measures exposed in patches lying within the areas of denudation of four tributaries of these rivers, and, for convenience of description, I divide the coal-field therefore into two groups, namely—

I. The eastern basin, belonging to the Kunhur river system, comprising—

A. The Tatapáni and Sendur river sections.

B. The Banki river sections.

II. The western basins, belonging to the Rer river system, comprising—

A. The Iria river sections.

B. „ Morne „ „

C. „ Mahán „ „

With the exception of a few miles of natural boundaries along the eastern and south-western limits of the coal-field, the latter is brought alongside of the metamorphic rocks by extensive lines of fault, here and there of remarkably straight direction, along which, as is to be expected, hot springs occur. The most remarkable ones are situated in the vicinity of the Tatapáni village near the Kunhur river ; Mr. V. Ball has mentioned the occurrence of these springs and gives the temperature of some of them.[1]

[1] Mem. Geol. Surv., Vol. XV, Pt. I, p. 22.

Between Tharni and Lurghuta (one mile south of Tatapáni) I could trace evidences of a great fault, which is very well shown near the junction with the sedimentary rocks, where a ridge of fault-rock runs in the line of dislocation.

Fault.

The hot spring of Ganduáni is also situated in this line.

Hot spring.

Crystalline area.

Most of the time available had to be devoted to the coal-bearing rocks: it was therefore only possible to examine the crystalline rocks of the neighbourhood cursorily; but at least three great groups could be distinguished, namely, the oldest gneiss formation, crystalline schists, and granitic rocks.

Division of crystalline series.

The old gneiss formation.

This is met with in two areas: *first*, forming the great Chota Nágpur Páts and their slopes to the north, and *second*, the area north of the coal-field in the vicinity of the Rer river. The latter is probably connected under ground with the gneiss of the Páts, merely denuded to a lower level (about 1,400 feet) and in parts covered by younger rocks.

Gneiss.

The usual variety of rocks composing the Páts is a coarse, porphyritic gneiss, with bands of hornblendic rocks, here and there passing into a hornblendic gneiss traversed by numerous veins of pink pegmatite and of epidote.

Lithological character.

The profile of the Páts is characteristic enough, rising more or less abruptly into plateaux, and distinguished from the escarpments of the Vindhyans or the upper Gondwánas by more gradual slopes and irregular outlines, all covered by dense jungles.

I may here mention the occurrence of rock-laterite with trap on all the Páts as already described in former Memoirs.

Occurrence of laterite with trap.

The gneissic area north of the coal-field on the right bank of the

Gneiss of the Rer river.

Rer river is somewhat different in general aspect. Though I believe it to belong to the same formation as that which forms the Páts of the south, this gneiss never rises to any great height, being confined to an almost uniform level of about 1,400 feet and less, only here and there rising in isolated rocks a few feet above the denuded surface of the country—the whole, as indeed the whole of the area examined, being covered by tree jungle. In this stretch of gneissic rocks we find the picturesque falls of Rokas Kas of the Rer river. The fall is not less than about 80 to 100 feet, and the water rushes through a series of narrow chasms to join in a rock-surrounded pool below, the whole forming by far the most striking picture in this part of the country.

Rokas Kas Falls.

Crystalline schists.

These form two belts, one south, one north of the coal-field, and are certainly distinct from the main gneissic area.

Descending from the great Chota Nágpur plateau in the direction of Tatapáni, say *viâ* the Chanderpur road, we traverse at first an undulating denuded area still belonging to, and connected with, the gneiss of the Páts.

Anticlinal folds in schists.

But before reaching the Gondwána basin of Tatapáni, we come across one or more anticlinal rolls, composed of metamorphic schists, apparently faulted against the gneiss and certainly faulted against the Gondwána rocks between Tatapáni and Khijuria-t.

I have shown the sequence of these rock groups in fig. 1 of Plate I. Standing on the slopes skirting the Gobra hill (3,220 feet) south of the deserted village of Gugra, we observe gneiss of a porphyritic character *in situ*, traversed by numerous veins of pegmatite. This gneiss forms all the lower hills around the base of the Chunderpur Páts, of which the plateau on the right (south) of the profile is a continuation (about 3,500 feet) situated near the village of Chunderpur. It is there capped by sheets of trap in common with a large part of the southern gneiss plateaux, here and there associated with rock-laterite.

Towards the left (north) of the profile the anticlinal folds of schist, as above described, form a series of low rolling hills. In the distance the continuation of the Páts towards Chatania is visible. The schist hills slope gradually down towards the Tatapáni basin, where (5 in fig. 1, Plate I) the Talchir boulder bed and shales are seen, at once distinguished from the former by the dry jungles of thorns so characteristic in all the older Gondwána rocks.

Sandstone-like gneiss.

There is a variety of hornblendic gneiss remarkably like decomposed sandstone in appearance, with quartzose schist dipping at a high angle towards the gneiss on the south, but forming a great fold as the dip turns round to the north again. The strike is east-north-east to west-south-west, the same as the great bounding fault which cuts off this area and throws the Gondwánas against the schists.

Second area of metamorphic schists.

Another area, but strategraphically related to the preceding, forms a fork inclosing the gneiss of the Lurgi-Chandaura hills (Mandru 3,373 feet, Andru 3,232 feet), and stretching in a south-west direction, forms the low hilly country near Pertábpur.

Ridge of the watershed of Rer and Kunhur.

The extreme eastern extension of the fork is composed of the sandstone-like gneiss, thin-bedded and in parts resembling mica schist; it rests on the old gneiss formation on which Dhanuar is situated. It is *in situ* in the nullah flowing north of the village in an east-west direction, and dips at a high angle from the gneiss. From thence in a south-west direction stretches far away a low range of hills of nearly uniform height, and forming at the same time the watershed between the confluents of the Rer and Kunhur rivers. This range is entirely composed of mica schist with associated quartz schist and quartz rock. Following it from east to west, I found it near Kobi, in the Goga stream section, composed of pure quartz rock, which changes near Rámpur into a quartz rock with a few leaves of white mica disseminated through it. Crossing the range from Rámpur to Kapaut, we find also patches of

Quartz schist.

hornblendic schists and garnet rock associated with this micaceous quartz schist. The bedding is somewhat obscure, owing to the dense vegetation covering the whole country. Though there is much of the rock exposed in patches and isolated masses, yet the bedding can only be observed here and there.

Garnet rock.

The general character of a micaceous quartz schist remains the same, with the only difference that the lamination is more distinct towards the west; and near Maiapur the rock is almost a mica schist. The southern prong of the great fork above mentioned is different in aspect and lithological character. It forms a lower undulating country, stretching away to the gneiss Páts south of it, and well exposed in all streams between Dumarkola and Pertábpur. Though still quartzose, the rock has here more the character of a mica schist, extremely brittle and friable, being made up of very fine sandy grains of quartz and minute laminæ of white mica, with garnets as accessory mineral. Separated from this area by the granitic ridges is a series of true mica schists, hornblende schists and quartzites dipping from the main mass of the granitic ridges; their strike is nearly east-west, and the dip is high, about 55°, to north.

Changes into a mica schist.

Pertábpur mica schist.

Third area of metamorphic schists.

Isolated masses of similar schists are met with and were mapped within the granitic area, probably left standing when the intrusive granite forced its way in between the beds of metamorphic schists, thus probably explaining also the disturbed and folded character of the bedding of the schists.

Isolated masses of schist in granite masses.

Another and by far the largest area of these schists was traversed north and east of the Gondwána basin. Beginning east of the basin immediately below the Talchirs near Mitgain we meet mica schist, strike nearly east-west, dip north; a little further north, forming No. 326 H. T. (1757),[1] we meet with

Fourth area.

Mica schist.

[1] On the 1-inch map.

chlorite schist, strike west-north-west, east-south-east, dip north. Near the northern boundary of the coal-field, about a mile west of Gumharia, the strike of the crystalline schist becomes north-west to south-east, dipping north-east, at 80°. It is there true mica schist, which rises up to considerable heights in the Khori hills. The road from Chumra to Kakankoja on the Kunhur traverses this ground, which is formed by one or more steep folds in the schist, there seen to alternate with a quartz rock of pebbly character. With the exception of a few isolated masses of intrusive granite, the rocks between the Khori hills and the gneissic region above described consist chiefly of mica schists and quartz schist, forming a slightly undulating country of an elevation of about 1,200 to 1,300 feet, with deeply eroded river-courses. Some of the folds rise somewhat higher and form these isolated masses, cut into deep valleys and sharp ridges by the numberless streams. The strike near Bluthar Chura, as indeed nearly all over this area, is north-west to south-east, dip north-east, but varying occasionally to an east-west strike. Numerous quartz reefs traverse the area, mostly in an east-west direction.

Chloritic schist.

Many hornblende dykes occur; they may be taken as altered trap dykes. Such is observed east of Chura, in the Kursa stream; direction north-west to south-east, thickness about 20 yards. It is a very close-grained rock, and has caused some local disturbance near the junction with the mica schist, which there shows the same strike as the dyke, with dip to the south-west.

Hornblende dykes.

Trap dykes.

Near the boundary with the gneiss area of the Rer the folds in the mica schist gradually turn round to a north-east to south-west direction—in fact, following the boundary line of the gneiss, which, I believe, is a natural one.

Boundary with gneiss natural.

Granitic rocks.

These rocks occupy a considerable portion of the area examined, and probably form the base on which the Gondwána rocks of the more central parts of the coal-field rest. As exhibited on the map, we now find two long strips of

Granitic rocks.

granitic rocks north and south of the field, of from three to four miles width on either side. Besides these, I came across several detached masses of intrusive granite north of my area, as well as numerous pegmatite veins in the older rocks, especially the old gneiss plateau of Chota Nágpur.

Extent.

As near as possible, the boundary-line of the granite with the metamorphic rocks is parallel with the line of faults which have lowered the Gondwána basin. An examination of the southern mass of granite between the villages of Khijuria-t (east) and the limits of my map on the Mahán river (west) shows that it probably includes both intrusive and metamorphic granite; but the hills are quite inaccessible, being covered by dense jungle and not traversed by any roads or even jungle paths, so that a distinction could not be made on the map. The section between the Mahadeva sandstone on the north side and the Gobra hill on the south exposes a coarse-grained granite, showing all the constituents of the granite in single hand-specimens even, with isolated masses of garnet rock amongst it, the relation of which to the granite could not be ascertained. Near the Chalgali section the minerals composing the granite get separated, and we meet there large masses of nearly pure felspar with scarcely any quartz or mica in it. The best exposure in the granitic ridge is seen along a rocky path leading from Lotki to Bhagwánpur. Starting from the former place (Lotki), we soon leave the mica schist (quartz schist) and enter the granitic ridge. There, veins of granite traverse the schist for long distances, and prove beyond doubt the intrusive character of the rock. Towards the centre of the granitic ridge (about 3,000 feet high) we meet with a finer variety of granite, consisting of equal proportions of quartz, felspar, and white mica; but between that point and Lotki a coarse-grained porphyritic variety is seen, containing the same constituents, with tourmaline as accessory mineral, sometimes in large crystals.

Garnet rock.

Intrusive character.

Lithology.

It is possible to find large blocks, consisting of nothing but milky

quartz with tourmaline. In others, these two minerals are predominant, the mica and felspar being scarcely distinguishable. Similar varieties are found on the northern slope of this mass, passing gradually into a coarse-grained variety of granite, but without the tourmaline.

Tourmaline granite.

Along this section I observed several isolated strips of mica schist, much crushed and contorted, and showing signs of having been subjected to further alteration, by heat or otherwise; near the junction with the granitic mass, particles of felspar are found disseminated in the mica schist, and give it a gneissic character. The strike of the mica schist masses is generally that of the boundaries with the metamorphic schists, which also corresponds with the general strike of the latter in this region. Probably these masses are connected with the main mass of mica schist, and the intrusive granite has simply forced its way between the beds of the schists, separating some portions of them.

Mica schist inclosed.

The parallel section between Maiapur and Pahár Karua is very similar, excepting that I did not meet with any remains of crystalline schists in the granitic area.

The boundary between the schist and the granite I found about a mile north of Maiapur in crossing a small stream south of Deuri. For about two miles the path traverses a well-defined plateau of a finer-grained variety of granite, which here and there shows a somewhat gneissic character, but which I cannot separate from the main granite area.

Gneissoid granite.

North of the coal-field, between Palgi and Churka, granitic masses appear again, apparently a continuation of the granites of the south. In general outline of hills, as well as in lithological character of the rock, the granite of this ridge is identical with the rocks of the southern area. Tourmaline granites prevail, and form the main mass of the eastern extension of the ridge, sending out long spurs into the neighbouring schists.

Area north of the coal-field.

Lithology.

Hornblende dykes.

Between Palgi and Birkepa, numerous hornblende dykes and veins traverse the granite, and, being able to withstand disintegration better than the surrounding granite, these dykes have become gradually high ridges and prominent points in the outline of the hills.

Intrusive granite of Chiraikund.

Granite of probably intrusive nature, exactly similar in lithological character to the Birkepa rock, occurs in the neighbourhood of Chiraikund, east of the Rer river. In it, or probably along its contact with some trap dykes, was found galena, which has been already noticed by Mr. Mallet.[1]

Detached areas of granite.

Another detached mass of granite is found east of Chargar, on the Kunhur, about nine miles north of the boundary of the coal-field, and it resembles in lithological character the granite of Chiraikund.

In fig. 2, Plate I, I have shown these isolated masses of granite visible from a considerable distance, elevated in sharp ridges over the evenly denuded surfaces of gneiss as described above, page 4. The foreground of the profile, near the deserted village of Chatoli, is one of the numerous trap dykes showing concentric structure. The faulted boundary of the gneiss with the Mahadeva sandstone, in which this trap occurs (*vide* map), is not traceable in the landscape, owing to the even denudation of the two rocks.

The sub-metamorphic rocks.

As before mentioned, there is a natural boundary of the sedimentary rocks with the metamorphics on the southern edge of the field between the villages of Hadrai and Belia, and again further westwards, south of Jajáwal. It is near these two boundaries that I observed two narrow strips of rocks of pre-Gondwána date, on which the Talchirs rest unconformably. The best exposure is the one between Hadrai and Kandia. The river Morne cuts through the whole section just above Kandia, forming a narrow and rocky gorge. I found a

[1] Records, Vol. V, p. 23.

gneissic granite at the base, nearest the village, and the uneven surface of it plastered over by a coarse conglomerate, which at first sight looks not unlike the Talchir boulder-bed, but is essentially different from it. It is entirely composed of metamorphic boulders, perfectly rounded pebbles, chiefly of granite and gneiss, with a few blocks of mica schist. The whole is cemented together by a silicious rock which in some parts resembles a true chloritic schist. Thin beds of this material, with strings of pebbles, separate the boulder-bed into banks.

Old conglomerate.

The dip is very uneven and disturbed; the conglomerate seems crushed against the metamorphics. Near the contact, the bedding is nearly normal, but within a few hundred yards I found the beds of the upper sandstones (presently to be described) raised up, dipping 30° south, strike nearly east to west; on these the Talchir rocks rest unconformably. (See section, fig. 3, Plate IV).

Lower down the river, relatively north-westwards, we find that the conglomerate passes gradually into a very hard quartz sandstone, which at once reminds one of the sandstone of the Vindhyan range. It exhibits beautiful examples of ripple-marking, and the thicker beds of sandstone show false-bedding and contain many strings of grits and pebbles.

Passes into quartz sandstone.

Though the conglomerate is not identical with, still it looks suggestive of a possible relation with, the jasper boulder bed of the lower Vindhyan formation, as I saw it south of the escarpment near Agori Khás. I may mention here also that I could not help again being reminded of this and the Vindhyan jasper conglomerate when I saw the great development of slates, quartzites and conglomerates of the Himalayas, which form a complex of beds not less than about 5,000 feet thickness below the lower silurian formation, and rest near Malári on the metamorphic series. Both at Malári and in the grand sections of Kharbasia in the Himalayas, the lithological similarity of this series with the jasper conglomerate of the penin-

Possible correlation with jasper conglomerate of Vindhyans.

Similarity with the old slate series of the Himalayas.

sula is complete, even as to the colour. Again we meet with a mass of rocks, but this time of calcareous character, inclosed in a great fold of metamorphics between Munshári and Bageswar on the southern slope of the Himalayas. Here are shales, more massive beds, and conglomerate beds, the debris in which is all, however, made up of limestone. Supposing the identity of these formations with the lower Vindhyan jasper conglomerate and with the beds near Kandia, it would assign a pre-Silurian age to the latter, probably Cambrian.

Slates of Jajáwal.

South of Jajáwal, in the Rámkola pargana, I met with a narrow strip of hard dark blue slates, resting on mica schists, and dipping at a high angle (about 55°) to the north-east. They are overlaid there by gritty Barakar sandstone. Most probably, these slates belong to the same group of semi-metamorphic beds, of which the Kandia beds are the type in the Rámkola field. Possibly the semi-metamorphic rocks described by Mr. Ball[1] from the Bisrámpur field also may be included in this group, but I have not seen his section. It is not at all unlikely that formerly this group has extended over a much larger area south of Sirguja, and from there the red quartzite boulders of Vindhyan type may have been derived, so common in the Talchirs of my area.[2]

The Gondwana Series.

The coal-fields under description occupy a principal eastern arm of the main central area of Gondwána rocks, stretching from Tatapáni due westward for more than 200 miles to near Jabalpur, and from the latter position extending for 300 miles by a long prolongation to the south-east to near Sambalpur, into close proximity of the Talchir field in Orissa.

Extending over larger area formerly.

There is no doubt that the Gondwánas spread originally over a much wider extent of country than they do at present, and numerous detached remains of Talchirs and uncertain sandstones plastering over some of the metamorphic rocks

[1] Records, 1873, pt. 2.

[2] *Vide* Plate. II, fig. 2.

north and south of the actual basin indicate their probable former extent. Starting from Tatapáni, we find a natural contact of Gondwánas resting on metamorphic schist along the eastern and north-eastern boundaries of the field. From near Gumharia a nearly east to west fault, indicated by fault-rock and much crumpling of the strata, extends along the whole northern boundary, defining an angle in it near the boundary of the Rewah State, where we find a high escarpment of Mahadeva sandstone abutting against the metamorphics. From there the boundary is again natural, and we find Talchirs resting on the gneiss.

Boundaries mostly faulted.

From Tatapáni eastwards we see the coal-field cut off on the south by a great fault, throwing the several beds of Gondwánas successively against crystalline rocks. Here and there the fault has traversed the latter and left natural boundaries with the Gondwánas, exposing the Talchirs as lowest beds, which probably covered the floor of the basin over the entire surface. Such a natural boundary we find along the exposure of Talchirs west of Kandia, between Bhagwánpur and Dandkarua, and along the exposure in the Mahán-Rer nullahs; the section through all the rocks of the Gondwánas near Námadháka (about five miles south-by-west of Dandkarua) I fancy is brought about by denudation only, as there can be little doubt that the line of contact with the granite is faulted.

Few natural boundaries.

Roughly speaking, the Gondwána area examined forms a narrow bay (from twelve to about thirty miles wide) of sedimentary rocks in the metamorphics, preserved from denudation only by their having subsided between lines of nearly parallel faults. The remaining portions of Gondwánas left at higher levels, resting on metamorphics, have been removed by denudation, though isolated patches of them are still found, here and there, outside the area of the field, thus clearly indicating the former extent of the basin.

Present extent of Gondwánas.

Much denuded.

Talchirs.

Extent.

The ground covered by the beds of the Talchir formation is not of great extent in the Tatapáni coal-field, though rocks belonging to this series are seen wherever the boundaries of the Gondwána basin are natural. The largest area covered by these rocks is to be found along the eastern extremity of the field, cropping out from beneath the Barakars in a belt of varying width of from half a mile to three miles, extending from Tatapáni to near Gumharia.

Lithology.

I have generally found them forming irregular beds and filling up hollows in the metamorphic rocks, which latter are often exposed through the Talchirs by denudation. The base bed is usually a reddish-brown and olive-coloured greenish shale of marly character, breaking into small angular pieces, being jointed in three directions. Light coloured, fine-grained sandstones, with occasional pebbles, generally overlie these shales, and are followed by the Talchir conglomerate; this series is often repeated several times by faulting, but the whole complex of beds may attain a total thickness of not more than 900 feet. The bedding is most irregular and the dip rolling; the beds themselves are of very uneven thickness, thinning out often at a few yards distance, and again thickening rapidly.

Boulders.

This is especially the case with the fine-grained sandstones found alternating with, and replacing, the boulder bed and shales. Pebbles and boulders, from the size of a pea to enormous blocks from 30 to 40 feet in diameter, are seemingly disseminated throughout all beds of this formation. These boulders were evidently deposited from above in a fine silty matrix, and it is impossible to detect a regular or even deposition in this bed. Many of the boulders, of elongated shape, are standing perfectly upright in the matrix, and seem to have dropped from above into the fine clay.

The latter is usually of a bluish or olive-green tint, but occasionally dark red or brownish silts prevail, as, for instance, in the Talchirs of

South Rewah, a continuation of the Rámkola-Tatapáni field. This variety is then often mottled, and lumps and clunchy masses of the greenish clay are inclosed in the red silt.

Such is shown in the beautiful exposures of Talchirs near Kandia, and, in fact, in all the nullahs cutting through these beds in that part of the coal-field. I have shown it in fig. 2 of Plate II. We find there rounded and angular blocks of gneiss, hornblendic rock, quartzites and tourmaline granite along with pebbles, and blocks of red quartz sandstone of Vindhyan type enclosed in the silt and also in the shales. In fact, throughout the Talchir beds, even in the fine, silty, greenish sandstone, pebbles are disseminated more or less.

Sandstone.

There are also the usual intercalated masses of fine-grained, yellowish green sandstone, with occasional strings of pebbles and worn boulders; they are almost invariably thick-bedded and often pass into either the shales or the boulder-bed, as, for instance, near Mitgain, where I noticed a thick mass of unusually hard sandstone with pebble strings, passing into fine-grained bright-coloured sandstone of the usual character.

The sketch, fig. 1, Plate II, represents this mass of Talchir sandstone near Mitgain, where it suddenly swells to a considerable thickness, and is denuded into enormous pot-holes all along the course of the nullah. Nearly everywhere the exposed portions of Talchirs are much denuded, and generally only form a thin layer over the underlying metamorphics. This denudation seems partly, at least, to have taken place during pre-Barakar times, since I found at one place, in the detached mass near Dongardih, a denuded surface of Talchirs presenting old pot-holes filled by thinly laminated bluish-grey Barakar shales. Several of these pot-holes with their contents are now traversed and cut through by the present stream, which forms new pot-holes exposing sections of the old erosions with their shaly contents.

Denuded surface of Talchirs.

Barakars.

Lithological character of Barakars.

A considerable thickness of beds, consisting of sandstones, flaggy beds and shales, with numerous seams of coal, is found resting on Talchirs everywhere within the limits of this area and cropping out beneath beds belonging to upper groups of the lower Gondwánas. Next to the Mahadeva sandstones and shales, they occupy by far the greatest extent of ground, and are readily distinguishable from the underlying Talchirs, the boundary with which is very sharp and well marked.

Boundaries.

An unconformity with the Talchirs is at least very probable in some sections. The boundary upwards is not well defined, as the change, both lithologically and palæontologically considered, is gradual. With the exception of the most eastern development of these beds near Tatapáni, the whole area of Barakars is traversed by long faults, especially near and parallel to the great boundary fault of the north-eastern part of the coal-field. The upper series (Mahadevas), occupying the centre and main extent of the Gondwána basin, stretches eastward as a long strip, being there faulted against the metamorphic rocks on the south side. In this field, at least, the Barakars are very distinct from the Talchirs, and lithologically the change is *sudden* to the fine-grained flags and sandstones with shales, all of which contain Barakar fossils. Where the junction is natural, the Barakars dip inwards and apparently conformably under the Mahadevas along with the intermediate Raniganj and Panchet beds.

The rocks most frequently met with are:—

1. Sandstones, fine-grained, greyish-yellow, with varieties of white and reddish gritty sandstones, often false-bedded, and alternating with flaggy micaceous beds.
2. Micaceous, thin-bedded, grey, shaly or flaggy sandstones, containing carbonaceous matter.
3. Coal-seams of variable thickness. As yet three distinct bands were met with; they occur mostly in the middle of the group,

and one near the top and just below the iron measures of the Raniganj group.

The largest and best seams are in the vicinity of the Morne river, where we find a series of coal seams, ranging from a few inches to 1 foot, and a fine seam of a little more than 7 feet, which remains pretty constant; towards the west this seam thins out considerably, and in the Suknai nullah the same bed decreases rapidly to 3 feet 6 inches. In the nullah east of Budatand, falling into the Morne river, there is a band of coal with shaly partings of 17 feet, probably representing the 7 feet seam of the Morne river sections.

In the Barakars of the northern part of my area, the character of the rocks composing the group does not change, and we still meet with micaceous shaly sandstones and shales, containing coal, but of inferior quality, and having thinned out considerably; but as the Barakar beds are only brought up by faulting, it is possible that the coal-seams are only some of the top ones, also seen in other sections, and that the better seams, which are elsewhere constant, are hidden beneath.

Towards the extreme western tracts of the coal-field near the Banki nullah (tributary of the Morne river), the Barakars are faulted against the Mahadeva sandstone, and consist of hard, gritty sandstones, with numerous pot-holes.

Thickness.

The entire thickness of the Barakars, as calculated from the Tatapáni sections, is probably not more than 900 feet.

Raniganj.

Roughly defining it, the Barakar group is characterised, as already stated, by fine-grained sandstones, dark micaceous and carboniferous shales, and coal-seams with decidedly a Barakar flora.

Lithological character of Raniganj.

Though it is difficult, in some sections even almost impossible, to lay one's hand on the exact point of junction of Barakars and the next overlying group, yet it is not difficult to define in general the character of this latter, which is most

distinctly developed in this field. Placed side by side, the specimens with fossils from this group could not be distinguished from those of the Raniganj field, but other petrological characters are somewhat different, conspicuously so by the absence of coal. The Raniganj here consists chiefly of white felspathic and gritty sandstones, white shales with numerous Raniganj fossils (plants), with thick beds of clay iron ores, ferruginous sandstones, with nodules of iron ores and iron shales, these latter well shown in the Sendur river sections. In short, whereas the Barakars are distinguished by the presence of coal-seams and carbonaceous shales, we find the Raniganj remarkably rich in iron ore bands, or nodules in other beds, and thin bands of iron shales.

Thickness.

The approximate thickness of the whole group is probably not more than 1,300 feet. Deposits of this horizon are probably represented in all sections, but I have only mapped them as such where fossil evidence supports this view.

Panchets.

Lithological character of Panchets.

Under this head I have included all the sandstones, grits, clays, and shales which occupy the space between the Raniganj and the typical Mahadevas, from which it is not always easy to distinguish them. The commonest rock of this series, and which occupies a large area, both vertically and horizontally, is a red clay, changing here and there into red clay shales and clayey sandstone. These rocks are generally alternating with white and yellowish hard shales, and in many sections changing into an olive-green clay, sometimes mottled both colours. It is invariably overlaid by white friable sandstones, or similar red sandstones, which latter are difficult to distinguish from similar beds in the Mahadeva sandstones,—especially as some beds of the former have even the brown gritty appearance of the latter with ferruginous partings. At several localities I have found in the Panchet horizon a coarse brown or red conglomerate or grit, made up chiefly by round or angular pieces of quartz, the latter sometimes attaining the size of

Grit or conglomerate.

pigeon eggs. These beds then form low hills of rounded outline, but easily distinguished in appearance from Mahadevas. I have included this rock in the Panchets, though I have no fossil evidence to support my view, whereas in the Panchets proper I have found several characteristic forms of plants.

Thickness.

The thickness of the Panchets in the Tatapáni sections is estimated at from 1,200 to 1,500 feet, but it thins out considerably towards the west.

Mahadevas.

Escarpments.

Rocks, chiefly sandstones, belonging to this series occupy by far the largest extent of ground. Unlike the rest of the Gondwána rocks, which do not rise above 1,500 feet above sea level in my area, the Mahadevas form bold escarpments, many of them perpendicular, even overhanging sometimes, and plateaux of from 2,000 to 3,000 feet above the sea.

Whereas the Barakars are remarkable for the dryness of soil, which is very sandy, and consequently the rivers of which rarely contain much water during the dry season, the Mahadevas by decomposing, as they do, into a heavy clay soil, give rise to perennial streams. Owing to this circumstance is also the freshness of the sâl and mixed jungles on ground composed of Mahadevas, whereas Barakars and Talchirs invariably only can boast of dry thorns and species of Mimosa trees.

Lithological character of Mahadevas.

I could not divide the Mahadevas farther in this area. Nearly the whole mass is composed of thick beds of reddish-brown, ferruginous, gritty sandstone, generally false-bedded and remarkable for hard ferruginous partings, which cut up the beds in a most singular manner, and, after the rock has undergone disintegration by denudation, remain standing like thin walls and long ridges in the mass of sandstone.

Ferruginous partings.

Sometimes these partings make a network in the sandstone, and after the latter has been worn away, they form a cellular mass of striking appearance. Here

and there, thick layers of red iron ore are intercalated between the Mahadevas; and a few earthy beds are met with, the only beds which have yielded fossils.

Thickness of the Mahadevas.

The total thickness probably does not exceed 800 feet, this being the difference of height between the top of the Tamor escarpment and the level below, which is composed of older rocks.

Jointing.

The rock masses of the Mahadevas are traversed in all directions by joints; the steep outlines of the escarpments no doubt owe their existence to this extensive jointing. As masses of the rock are undermined by the rivers below, blocks, more or less approaching a cubical shape, separate from the cliff above and come down the hill sides, thus always preserving a freshly broken surface to the escarpment, as shown in fig. 1, where, owing to the

Fig. 1. Mahadeva escarpment of the Tamor hill, valley of the Mahan river.

inclination of the strata, the face of the cliff is actually overhanging, the rocks splitting off along the joints, which are mostly normal to the line of bedding.

The boldest and highest escarpments of the Mahadevas face the south, rising to nearly 3,000 feet (Tamor hill, 2,758 feet), as shown in the above sketch, fig. 1; the sandstones there form quite inaccessible cliffs, high above the older Gondwána rocks below (see fig. 3, pl. V), whereas towards the north they gradually flatten down to the general low level of the older rocks, with a few remarkable exceptions, as in the Pipra hill, 2,004 feet in elevation and which is nearly 800 feet above the level of the surrounding country (see fig. 1, pl. V).

Proceeding from east to west, I noticed the Mahadeva sandstone first in the long north to south escarpment of Sendur-Pipraul; it is formed of thick massive beds of gritty ferruginous sandstone dipping 20° to the west. From there the Mahadeva ridge ascends in one or two great steps of bold outlines, covered by dense jungles, the supposed haunts of numerous dacoits. The lithological uniformity is remarkable; for miles and miles the character of the rock remains the same, a coarse gritty reddish-brown sandstone.

Slope towards the north.

Towards Rájketa the hills gradually subside into lower levels; until seen from the north near that village, they appear but as small hillocks above the low undulating ground.

In fig. 2, pl. VI, I have shown the natural profile of this part of the Mahadevas as seen from the south, from near Bara Barthi, in the Upper Morne valley; the dip is there rolling about 20° towards the north-west, and in consequence the outline of the hills is rounded and totally unlike the usual contour of hills composed of this formation.

Ferruginous partings.

But the rock is there, as elsewhere, composed of a succession of coarse brownish-red sandstones and rough grits with occasional pebble beds. Ferruginous partings are found in every bed—not always along the line of bedding, but traversing it and forming sometimes a network, the meshes of which vary in size from a few inches in diameter to many feet.

Many thick layers of good hæmatite occur amongst the sandstone beds, but the native iron-smelters never make use of this or similar ores, but invariably only of very inferior ones of the upper Barakar beds.

Rámkola plateau.

The most considerable patch of Mahadevas of my area is the large plateau of nearly square outline, in a denuded bay of which is situated the village of Rámkola. It presents a steep precipitous escarpment (fig. 1, p. 20) towards the south, with a more or less level surface, covered by jungle, traversed and denuded by numerous perennial streams. It is nearly surrounded by copious outbursts of trap, which appears on the surface both as huge dykes of many miles length, and on the south-eastern and eastern face of the escarpment as great intrusive sheets, spreading for miles over the lower rocks. In fig. 1, pl. VI, I have given the profile of the eastern escarpment of the Rámkola plateau, in which the Mahadevas (1) are seen to slope to the north-west, with the trap (2) forming the intrusive sheet beneath the strata of the sandstone.

Trap.

The beds of the Mahadeva plateau, fig. 1, Plate VI, slope gently towards the north-west, excepting near the bounding fault, which extends from near Turpa (Rer river) towards the east, accompanied and flanked by parallel trap dykes (see fig. 3, pl. VI), where the dip increases considerably, and in one or two minor instances approaches the vertical. But this north-western corner of my Mahadeva area (see fig. 2, pl. V) is noteworthy for the fact that there I found a few traces of fossils. In a dark reddish-brown earthy shale between beds of Mahadeva grits, north of Khond, I found a few traces of plants, which Dr. Feistmantel determines as:

Fossils.

Alethopteris, spec.
Glossopteris?[1]

As shown in the last-mentioned section, the Mahadevas are thrown directly against the metamorphics, south of Turpa, the strata being raised up to about 45° to 50° south. A few miles to the south, however, the bedding becomes quite normal—almost horizontal—and is penetrated by several trap dykes running more or less in an east-west direction. South

[1] For the naming of my specimens, as well as for the forthcoming description of a few new species of fossil plants from this coal-field, I am indebted to Dr. O. Feistmantel.

of Burwar, I found in the Dhursot nullah the trap shown in fig. 2 (p. 25), beyond which the dip increases to the south or south-west, the sandstone beds containing a few earthy beds of shales with the above fossils.

Probable overlap.

Though I have observed throughout the coal-field an apparent conformity of the Mahadevas with the older Gondwána rocks, it is yet probable that the former overlap the lower beds here and there. The nature of the jungle-covered country, however, makes it extremely difficult to decide this point. Near the south-eastern boundary of the field on the low ridge of metamorphics separating the Tatapáni field from the Bisrámpur field, patches of coarse reddish-brown grits and sandstones abound; they form only a thin covering on the metamorphics, and are evidently only the remains of a vast extent of Mahadeva rocks which once probably covered a great area, connecting the various fields.

Trap.

Altered trap.

I have certainly come across three varieties of trap rock in my survey. A semi-metamorphic trap forms a dyke of somewhat less than a mile in length, and only some 20 yards wide in the mica schist south-east of Chura. Near the dyke a disturbance is visible in the mica schist, the latter dipping from it. The direction of the dyke is north-west to south-east. It is an extremely dense variety, and almost resembles hornblendic rock.

Basalt caps on gneiss.

A basaltic rock caps nearly all the main gneiss plateau south of the coal-field, and forms continuous sheets of perhaps not more than 50 feet thick. Remains of the trap sheets are found on the top of all the plateaus wherever the original surface has been preserved; on the lower hills, which evidently have undergone extensive denudation, we miss these traps. On the tops of the Lamti-pát and Gulgul-pát, fig. 1, pl. I, we find laterite associated with the trap, but the exact connection was not observed, owing to the dense vegetation covering the whole.

But the main mass of the trap rocks in my survey is situated within the boundaries of the coal-field, where it occurs in the form of dykes and intrusive sheets. Having reached the western extension of the basin before I finished the centre, I came on large sheets of trap in Barakars, and there took it at first for contemporaneous trap, owing to the regularity of the apparently interbedded sheets between strata; but I soon found out my mistake when I saw the continuation of the same traps traverse the Gondwánas as enormous dykes and without any regard to the stratification or age of the beds, cutting through all rocks from metamorphics to Mahadevas.

Dykes and intrusive sheets of basaltic trap.

The principal spreads of intrusive sheets are noticeable between the villages of Majurdaki and Gorgi, where they have pushed between beds probably of Barakar age and the overlying Mahadevas; subsequent denudation has then exposed great sheets of this trap, the latter showing nearly throughout a spheroidal structure.

A similar but even larger sheet is found in the valley of denudation of the Morne and tributaries, extending across the whole width of the valley, covering the Barakars and loosing itself below the Mahadevas. Here and there the former are exposed in patches where the trap was removed by denudation, and good examples of the contact effects are then shown. Towards the north this intrusive sheet is connected with a dyke little less than half a mile in width, which extends in a north-westerly direction beyond the Morne river and cuts through the Mahadeva sandstone.

The narrow strip of trap north of Námadháka (5 miles north-west of Maiapur), at the foot of the Kalhota hill, is probably part of the intrusive sheet which is hidden by the Mahadeva sandstone of the Churipat hills.

The northern half of the basin examined is traversed by numerous trap dykes, most of them being situated along faults. Some of the traps in the Nowadih sections (north of Damni) and of the Bhalui nullah section might be explained as being intrusive and repeated by faulting; but there is clear evidence

Dykes along faults.

that the traps, many of them very narrow, along the great east-20°-north to west-20°-south fault along the Iria nullah are dykes erupted along the fault; also the east-west dykes which run nearly parallel from near the Banki nullah westwards are clearly along lines of fault. This is especially well seen near the contact of Mahadevas and Barakars of the Pipra hill, which is faulted, the lower beds of the former disappearing towards the east against the Barakars, and apparently dipping below them. The long dyke south of that locality, which at first runs nearly east and west, turns sharp round to the south-west near Maihewa, near which village the trap has intruded between beds of Barakars laterally and still connected with the dyke.

A similar example of intrusive trap was found in the Dhursot nullah (Rer river), where a north-west to south-east dyke, about 8 feet thick, has penetrated right and left into joints of the Mahadevas, forming veins of only a few inches thickness and conforming exactly to the surfaces of the joints, filling up every crevice in the sandstone, as shown in the accompanying fig. 2:—

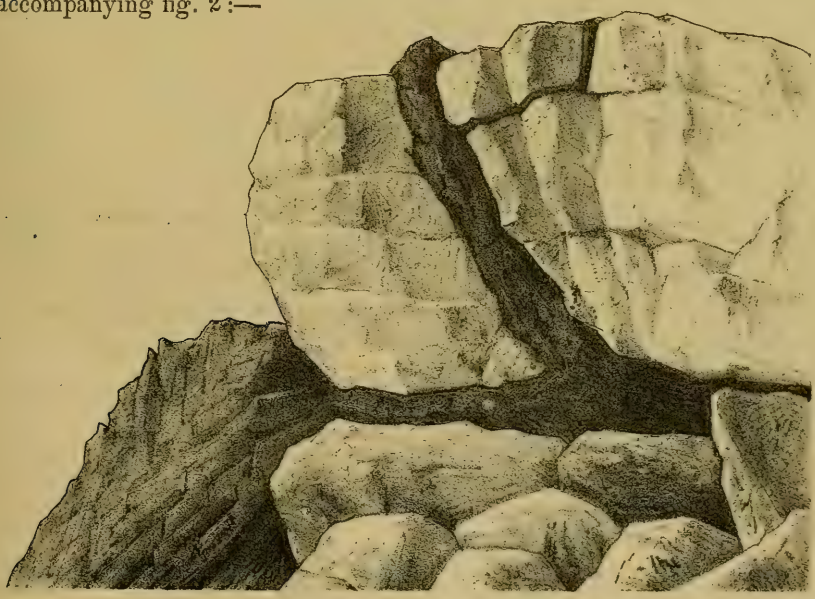


Fig. 2. Trap dyke, filling up joints in Mahadeva sandstone north of Khord, in the Dhursot nullah.

The dykes south of the Pipra hill continue for some distance into the metamorphic rocks west of the Gondwánas, and two of them are found south of Chiraikund amongst granitic rocks.

Numbers of parallel dykes are found near the north-western boundary of the Mahadevas in the neighbourhood of Naogai and Assandiah, some of them penetrating into the adjoining metamorphics. In fig. 2, pl. I, I have shown one of these long ridge-like dykes of trap south of Assandiah. They are only covered with very little soil, and the onion-like structure of the trap is visible all over, and thus the presence of the trap can always be detected with the greatest ease. A long dyke (see fig. 3, pl. VI) of this trap extends along the valley of the Rer, forming a high and precipitous wall of nearly north-west to south-east direction. It is connected in the south with the great intrusive sheets of the Jajáwal area shown in fig. 3, pl. V.

Recent Deposits.

Before closing my description of rock-groups, I must briefly allude to the enormous deposits of recent sands and clays covering, more or less, the entire surface of the area examined by me. They present the greatest uniformity throughout the area, and are in no way different from the great alluvial deposits observed in the Palamow districts. It is mostly a fine silty deposit of sands with a few partings of clay, and here and there layers of pebbles from the neighbouring rocks. The greatest deposits were found in the northern half of my area, in the neighbourhood of the Ledho and Iria nullahs, where banks of 80 to 100 feet of them are exposed by the rivers. They usually show beautiful examples of false bedding, and here and there alternating layers of sand and pebbles. Wherever exposed, they have weathered into high, almost perpendicular, cliffs, and are washed out into a semblance of organ pipes. Not less common are examples of pillar structure, caused by the denudation of all the sand and clay, except the portion protected by capping pebbles or stones. The recent deposits covering the Talchirs are remarkable in so far that they contain a great deal of kunkur limestone of precisely the same character as that described from Daltonganj.

PART II.

DESCRIPTION OF SECTIONS IN THE COAL-FIELD.

I.—THE EASTERN BASIN (TATAPANI, GIDHI) BELONGING TO THE KUNHUR RIVER SYSTEM.

A.—Tatapani and Sendur River Sections.

The boundaries of the lowest Gondwána rocks with the metamorphic rocks being natural between Tatapáni and Mitgain, I obtained complete sections through all groups represented in this field.

Talchirs in Tatapáni Nullah.

Descending the Tatapáni nullah (tributary of the Sendur river), I found Talchirs immediately below the hot spring; they form beds of fine conglomerates, much denuded and merely plastering over the metamorphic rock beneath, which crops up in isolated patches. This is soon followed by the typical boulder-bed with intercalated beds of fine-grained yellowish green sandstone. Boulders of irregular shape and evidently worn, derived from the surrounding metamorphic rocks, are cemented together by rounded pebbles of the same material, as well as fine-grained sandstone and clays. Also here and there huge blocks of metamorphic rocks are found in this mass. The general direction of the strike is north-east to south-west, and rolling to north-west, under an angle of from 30° to 40°. Near the bend of the nullah at Moua-t the strike is north-south, the dip west. In fact, the strike is so changeable and the dip rolling, as usual in the Talchirs of this basin, that it is difficult to record all observations on the map. This conglomerate is overlaid by about 15 feet of an irregular bedded whitish-green sandstone with a few boulders and gravel of metamorphic rock scattered here and there. Above this sandstone again follows boulder-bed. The villages of Tithert and Bhormi are on Talchirs, the boundary of which with the metamorphic rock below is well seen about 500 yards east of the latter village.

The triangular-shaped hill range north of Tatapáni is composed of metamorphic schist, chiefly mica schist, and the boundary of the Talchirs skirts this hill along the western escarpment, the Talchirs dipping away from it.

1.—Section along the nullah north of Bithiau.

In all the nullahs north of Bithiau (deserted village) we observe the following section in descending order, fig. 1, Plate III—ground between the Sendur river and the Metamorphics:

D.—Iron Shales ...	17.	Clay shales alternating with thin leafy iron shales.
C.—Barakars ...	16.	*Coal-seam* 5.′
	15.	Shales alternating with thin-bedded sandstone.
	14.	*Coal-seam* 1.′
	13.	Shales, carbonaceous.
	12.	*Coal-seam* 6.″
	11.	Sandstone with bituminous shales alternating.
	10.	*Coal-seam* 2′.
	9.	Bituminous shales.
	8.	*Coal-seam* 10″ passing into—
	7.	Thin bed of sandstone.
	6.	Clay shales, dark, with traces of fossil leaves.
	5.	*Coal-seam of* 1′ *thickness.*
	4.	Shales, carbonaceous.
	3.	Thin *coal-seam* passing into—
	2.	Shales, micaceous and grey.
	1.	Sandstone, fine-grained ochre-coloured.
B.—Talchirs ...	9.	Boulder-bed.
	8.	Sandstone, bright olive-coloured, irregular bed and thinning out.
	7.	Shales of same character as bed 1.
	6.	Sandstone.
	5.	Pebble conglomerate.
	4.	Thick-bedded sandstones.
	3.	Talchir boulder-bed of typical character.
	2.	Sandstone, whitish-yellow, with bands of pebbles.
	1.	*Shales*, reddish-brown and olive-coloured, traversed by jointing in three or more directions, thereby separating into small cubes and long needle-shaped forms. Here and there gritty, with scattered boulders of metamorphic rocks.
A.—Metamorphic schists.		

Thickness of Talchirs.

It is very difficult to arrive at a true estimate of the thickness of the Talchir beds, owing to the rolling character of the dip; but it is probable that the estimate of about 700 feet for the Tatapáni sections comes very near the truth.

Thickness of Barakars.

The strike and dip of the Barakars remain perfectly uniform in the Bithiau nullah; the former is north-south, and dip is at 20°, to west, and the total horizontal length of the Barakar section being 2,640 feet, the thickness is exactly 900 feet. This is confirmed by the sections north of Tatapáni, in the Chechra section and neighbouring nullahs, where I found a total horizontal length of section of 4,336 feet with a dip of 12°, to west-20°-south, which results in a total thickness of Barakars of 902 feet.

Iron shales.

The iron shales (17 to 18) which are intercalated between the Barakars and the following groups are very characteristic, and occur near the junction of the Bithiau nullah with the stream which rises near Moua-t.

Raniganj base-bed.

Though there is no break of conformity between this series of Barakars and the following beds, yet there is a sudden and decided change of lithological character. On the iron shales rest masses of clay iron ore of considerable thickness, which being *in situ* in the river, have been denuded into the most grotesque forms. Evidently lying on it conformably, are masses of thick-bedded sandstone (19) of ashy-grey colour with angular grits of quartz and large leaves of mica. Carbonaceous markings and indistinct plant-remains are found throughout the rock. It is very friable and crumbles away. Inclosed in this mass of gritty sandstone are lenticular masses of light grey micaceous shales, without fossils. Above it follows a pebble conglomerate of similar general character. These sandstones I consider as the base-bed of the Raniganj series, and it remains pretty constant in all the Tatápani sections.

2.—*Section along the nullah south of Agar-t.*

Section along nullah south of Agar-t.

As the Moua-t nullah, and subsequently the Sendur river, run along the strike, more or less, of the Raniganj series, the section is not very clear; but we obtain a very good one along the nullah south of Agar-t, where in descending order the following series occurs (see fig. 1, Plate III) between the Mahadevas and the Sendur river:

G.—Mahadevas	. .	Sandstone of the Pipraul escarpment, described above, page 21.
F.—Panchets	. .	47. Shales. 46. Conglomerate with angular fragments of metamorphic rocks. 45. White friable sandstone. 44. Clays, clunchy. 43. Thick beds of fine-grained white friable sandstone and shales alternating with grits. 42. Thin bed of yellow, hard, ferruginous clay shales. 41. Bed of carbonaceous clay. 40. Thick-bedded white gritty sandstone, alternating with grey shales. 39. Fine-grained white sandstone, very sandy. 38. Sandstone with bands of iron ore. 37. Clay shales. 36. Grits, very friable, chiefly consisting of pebbles and fragments of quartz. Dip 15 to 20° S. W. 35. Grey shales. 34. Coarse conglomeratic sandstone and grits. 33. Clunchy shales. 32. Coarse-grained sandstone. 31. Clunchy clay shales. 30. Felspathic sandstone and grits. 29. Thin bed of grey clay shales with boulders of beds beneath.
E.—Raniganj	. .	28. Quartz sandstone alternating with red shales. 27. Yellowish finer-grained sandstone with beds of red sandstone. 26. Thick-bedded red ferruginous sandstone with pebbles of quartz separating into jointed masses. 25. Thick masses of quartz sandstone with occasional beds of finer-grained yellow sandstone.

E.—Raniganj—contd.	24.	Friable coarse-grained felspathic sandstone with bands of iron ore.
	23.	Sandstone and shales.
	22.	Band of iron ore, 1 foot 6 inches.
	21.	Calcareous, friable quartz sandstone, 1 foot 7 inches.
	20.	Conchoidal grey clay shales, 9 inches.
	19.	Grey sandstone, micaceous, with carbonaceous markings, occasional nodules of clay iron ore. The thickness is not seen, but about 8' is exposed.
D.—Iron Shales	18.	Ferruginous sandstone and bands of red iron ore.
	17.	Iron shales with clay iron ore band.

Raniganj.

The entire thickness of the Raniganj series in this field is 1,550 feet, thus considerably exceeding the Barakars. Further west I observed that the Raniganj, of precisely similar lithological character and containing typical fossils, thins out considerably and the Barakars are developed in greater force. The general dip is the same as that of the Barakars, namely, about 20° west or south-west, strike nearly from north to south. The physical conditions under which the Raniganj were deposited must have been very different from those prevailing during Barakar times, at least in this field. Instead of dark bituminous clay shales and fine brownish-yellow sandstones with coal-seams, we meet here generally felspathic sandstones, ferruginous shales and bands of iron ore, resting on the characteristic micaceous ashy-grey sandstone bed No. 19. No trace of a coal-seam is visible, and, though I have found no fossils in this section, it is not difficult to identify this series with typical Raniganj elsewhere well developed in the coal-field.

Panchets.

The following series of Panchets begins with a contact bed made up of boulders and debris from the beds beneath No. 29, and from this point the dip gradually decreases to about 15° south-west, the strike turning more to the north-west to south-east; the total thickness of the group in this section is about 1,300 feet. The beds composing it can readily be distinguished from those forming the Raniganj. They are, as seen in the accompanying section, chiefly clays, variegated or red, alternating with shales and

gritty sandstones. No fossils were obtained in this section, but in the same beds further westward several typical Panchet fossils were obtained.

Mahadevas.

The Mahadeva sandstone of usual type follows, but it is not clearly seen how this group is related to the underlying Panchets in this section; but it is certain that the general strike and dip is the same, and it may be assumed to be conformable.

This succession of beds, dipping at about 20° to west, remains tolerably constant along the eastern part of the field and of the Pipraul-Sendur escarpment, and there is no doubt the groups represent a natural boundary of the field; whilst south of the Sendur river, the whole series is cut off by the great Tatapáni fault, as is well seen in all the small nullahs, which join the Sendur river from the south.

The Mahadevas are somewhat disturbed near the fault, and some remains of them are found in hills and isolated blocks south of the fault, as, for instance, near Khijuria. The general dip of the Mahadeva sandstone is about 15° to 20°, to west-20°-south, forming a high and precipitous escarpment facing east.

North and north-west of the described sections, the dip of the beds of Gondwánas gradually decreases, and as the strike turns round to the west the bedding becomes almost horizontal.

3. Section in the Nullàhs between Chechra and No. 326 H. T., north of Mitgain.

In descending order we find (fig. 2, Plate III.) upper part of section obscured by recent deposits:

C.—*Raniganj.*

24. Thick-bedded, coarse, gritty sandstone, felspathic, with nodules of ferruginous sandstone inclosed. Eroded in potholes.
23. Purple thin-bedded sandstone, thickness 3′ 6″.
22. Dark-blue shales, with clay iron ore nodules 2′.
21. Felspathic sandstones 5′.

20. *a.*—Dark-blue and grey shales, clunchy, with fossils, thickness about 2′ 6″.

b.—Purple and blue shales with fossil leaves, thickness about 3′ 6″, lying nearly horizontal except near outcrop, where the dip is 5° west.

19. Grey micaceous sandstone 14′.

B.—*Barakars.*

16, 17, & 18. Coal and coaly shale 5′; blue shales 2′.

15. Purplish and greenish-blue shales 5′.

14. Coal-seam 6″, rather shaly.

No exposure, about 40′.

Fault.

C.—*Raniganj.* 19. Carbonaceous grey sandstone 150′, same as bed 19 of the Agar-t section.

B.—*Barakars.* 16. Coal, with shaly partings, 3½′.

15. Shales 5′.

11 &c. Sandstone 21′.

7 ? Ferruginous brown sandstone 115′.

C.—*Raniganj.* 19 ? Micaceous shaly flags, purplish, with carbonaceous sandstone.

B.—*Barakars,* are much faulted, and, as the nullah is extremely sandy, it is scarcely possible to make out the sequence. At first the beds are much obscured by sand for about 500 yards, followed by beds which I identified with beds of the Sendur sections as follows:—

4. Purplish-red and grey shales, about 14′.

2 & 3. Grey carbonaceous sandstone, locally faulted and crushed.

1. Red and grey shales, 14′, with the following fossils:—

Vertebraria indica, Royle.

Glossopteris communis, Fstm.

„ *browniana* (*indica ?*).

„ *damudica,* Fstm.

A.—*Talchirs,* are represented in this section in great thickness, and are typical in lithological character. Great masses of the boulder bed, with associated marly shales showing the jointing as usua , of greenish-grey colour, occasionally reddish-brown and mottled. The strike is north-west to south-east, with a dip to the south-west of from 25 to 30°. With it occur large masses of fine mealy yellowish sandstones, with layers and bands of boulders, rapidly swelling or thinning out, being then often replaced by boulder beds. The sandstones are worn into

grotesque forms by denudation in the river and are full of pebbles. In fig. 1, Plate II, I have represented this worn sandstone, which is seen well in the Mitgain nullah. The dip is rolling and the strike changeable. Near Mitgain the strike is north-east to south-west, and the dip south-east. In the nullah north-west of Mitgain they rest on mica schist, and near the No. 326 H. T. on chloritic schist.

B.—Banki river Sections.

4.—Section along the nullah east of Gidhi and in the Banki River to Panri village.

In descending order: fig. 3, Plate III.

The numbers correspond with those of beds in the Sendur river section.

G.—*Mahadeva sandstone.*

F.—*Panchets.*

Dip 8° south-west

38. Soft greenish-yellow sandstone.
37. Grey shales, with conchoidal fracture and much jointing.
36. Ditto, but with covering of oxide of iron on joint surfaces.
35. Purple shales, with carbonaceous markings and fossil traces.
34. Purple clays, with fossils.
33. Micaceous and ferruginous sandstone.
32. Light-coloured grey shales with carbonaceous markings.
31. Ferruginous micaceous sandstone separating into square blocks.
30. Soft yellowish sandstone.
29. Ferruginous hard sandstone with beds of pebbly softer sandstone jointed.

E.—*Raniganj.*

Dip rolling ...

No exposure.
Rolled boulders of nodular clay iron ore in sand.
23. Yellowish thinly laminated shales, nearly horizontal.
22. Grey shales with fossils, passing into beds above containing—
Glossopteris angustifolia, Bgt.
„ *retifera*, Fstm.
„ *communis*, Fstm.
21. Felspathic white sandstone.
20. Dark shales and sandstones, much disturbed.
Shales with conchoidal fracture, with flaggy sandstone beds, horizontal and rolling, much jointed.
19. Thick beds of sandstone, with strings of quartz pebbles, jointed.
No exposure.

B.—*Barakars.*

10. *Coal-seam* exposed 2′.
9. Shaly sandstone 1′ 2″.
8. *Coal-seam* 1′ 2″.
7. Sandstone 8′ 2″.

Fault.

16. Coal-seam 8′ 6″.

Fault.

19. Thick-bedded sandstone.
18. Thin band of clay iron ore 6″.
17. Grey shales, nearly horizontal.
16. Coal-seam, partly hidden under water.
15. Fine-grained grey sandstone, micaceous; strike east-west, dip slightly south, locally disturbed, about 5′ thickness.
14. Shales.
13. Sandstone, strike east-west, dip 8° south, but rolling.
12. Shales.
11. Ferruginous sandstone.
8, 9, 10. Coal-seam and shales 1′, south-east to north-west, dip 10° south-west.
6, 7. Ferruginous sandstone and shales.
5. Coal-bed 1′.
1 to 4. Ferruginous sandstone, showing a very corroded surface; much hidden by alluvium.

A.—*Talchirs.*

Of typical character; boulder bed with silty sandstones and shales of conchoidal fracture, dip 50° south-west.

Resting on metamorphic schists.

Descending from the village Pánri, which stands on mica schist, to the Banki nullah by the road to Pipraul, we find Talchir boulder bed and shales resting on the metamorphics in the river, raised to 50° probably by lateral pressure, this boundary being near the great subsiding fault, which farther to the west cuts off the coal-field on the north.

The section through the Barakars is completely analogous to the sections already described in the Bithiau nullah. The greatest subsidence in the Tatapáni portion of the field having taken place towards the

south-west, some disturbances and faulting are visible in the second half of the Barakar section, which are not difficult to recognize. But the Raniganj and Panchet groups are much obscured by the covering of alluvial deposits in all the gullies leading down from the Mahadeva hills.

5.—*Section along the nallahs left and right of Banki River west of Chumra.*

This section presents considerable difficulties in comparing it with former ones, being much faulted, and certain beds have a peculiar local development, others evidently have died out. But descending from the Mahadeva sandstone which there has been denuded considerably, sloping gradually down to the level of the Banki valley, we find in descending order, fig. 1, Plate IV :—

I.—Panchets . .	21. For some distance no exposure; after that, here and there a friable felspathic sandstone grit and conglomerate beds, probably of Panchet age. 20. Ferruginous mottled sandstone, almost ironstone. 19. About 20 feet of sandstone. 17. Red friable conchoidal shales, breaking up into small fragments through extensive jointing, with intercalated bed of yellow shales (about 20 feet). Top bed a white clay.
II.—Raniganj . .	16. About 50 feet thickness of shales, some very ferruginous, alternating with clay shales and bands of ferruginous nodules of spherical structure, containing the following fossils: *Glossopteris angustifolia*, Bgt. „ *indica*, Bgt. „ *communis*, Fstm. These shales are jointed in several directions, and consequently break up into small needle-shaped forms; they are much faulted and several times repeated. Dip 10° south-west. 15. Sandstone 8′. 14. Shales 6′.
III.—Barakars . .	13. Shaly coal, the base hidden below water; dips under low angle south-west. (16 of Bithian section, p. 28).

Fault.

ASCENDING.

II.—RANIGANJ

16. Light-coloured shales with thin partings of sandstone containing—
Glossopteris angustifolia, Bgt.
„ *indica*, Bgt. (Schmp.)
„ *communis*, Fstm.
17. Ferruginous sandstone.

The last two beds are repeated several times by faulting.

16. Thick bed of clay shales of conchoidal fracture, drab and yellowish coloured, with oxide of iron on joint surfaces.

Fault.

III.—BARAKARS

3. Sandstone.
4. Purple and bluish shales with micaceous layers on partings and fossils:—
Glossopteris communis, Fstm.
5. Sandstone with bed of mica shale full of carbonaceous matter.
6. Dark shales with shining coaly matter about 4′, containing a bad *coal-seam of* about 1′ thickness.
7. Ripple-marked brown sandstone, 3′.
8. Sandy shales and hard flaggy sandstone.
9. Hard flaggy quartz sandstone, 1′.
10. Dark carbonaceous shales (jointed) 2′.
11. Flaggy quartz sandstone, 1′ 6″.
12. Clays and grey micaceous shales.
13. Barakar sandstone and shales with coal 6′ 4″, position not clear.

The detailed section of bed 13 (16 in Agar-t section) is as follows:—

In descending order:

Sandstone	2′	
Carbonaceous shales	0	3″
Shales	0	7″
Sandstone	1′	
Shaly coal	1′	
Shales	1	
Shaly coal		6″
	6′	4″

This section is not always clear, owing to the numerous local disturbances and repetitions by faulting. In fact, the field is so greatly

shattered, especially towards the western and south-western portion of it, that a strict correlation of the beds is not always possible. But it is very probable that beds 16, 17, 18, and 19 correspond with beds of precisely similar lithological character seen in the Sendur river section near Mitgain and in the nullah near Bithiau (north of that place).[1]

The coal is nowhere seen to advantage, and the quality seems very inferior; it is, in fact, only a lignite, and does not promise to be profitable for working.

6.—Section along the Nullah north of Meguli.

In descending order from south to north :—

South: Banki Nullah

5. Thin-bedded sandstone with shales and a thin bed of COAL; dip gradually flattening.
4. Light-coloured shales with bands of reddish shales and some ferruginous hard bands, with concentric nodules of iron ore.
3. Soft clay shales, dark coloured near base, lighter towards top. Strike as sandstone. Containing *Glossopteris ovalis*, Fstml. n. sp.
2. Hard quartzose white sandstone, alternating with softer beds and shales, probably repeated by faulting, strike nearly east to west, dip 20° south. A few nodules of ironstone are scattered throughout the mass.
1. Micaschist, strike north-north-west to south-south-east, dip 80° north-east to east.

North:

BANKI NULLAH.

Both this section and the exposure in the nullahs south of Gumharia show that the Talchirs are overlapped by the Barakars, and that the latter rest directly on mica schist, being represented by hard quartz sandstone with ripple marking on surface of beds. On the map I have marked this group of shales and sandstones as Barakars, but Dr. Feistmantel considers the form of *Glossopteris* contained in bed 3 as a Raniganj form : it may be that beds of that horizon, which is well represented in the sections west of this locality, strike across. It is at any time

[1] See fig. 1, Plate III.

very difficult to make out the relations of beds in the dense jungles which cover every square mile of ground in this field.

7.—Section along the Nullahs between Bagra (North) and Lawa (South).

In ascending order :—

North : village of Bagra on mica schist. Just south of that place a series of low ridges extend in a nearly east-westerly direction, being composed of a hard porous (cellular) rock, resembling Rauchwacke. This rock puzzled me a good deal at first, but afterwards I found that it is merely filling up the long lines of fault, scarcely without interruption, and I obtained clear sections through it afterwards near Palgi and also south of Lundra, where the relation to the other rocks is unmistakeable. Immediately south of this ridge I found sandstone and shales of probable Raniganj age faulted against the old rocks, but so shattered that a succession of beds could only be obtained here and there.

In descending order, a short distance further down stream, I could make out :—

1. An unevenly bedded red grit or sandstone in thick masses, very soft, strike north-west to south-east, dip south-west.
2. Thin-bedded red hard ferruginous sandstone, in places with a good red iron ore, denuded into furrows and ridges on the surface, not unlike some of the partings in the Mahadeva sandstone. Quartz pebbles and grits in strings.
3. White sandy beds, very soft, dip 5°, to south-west.
4. Coarse-grained sandstone.
   Trap dyke, showing concentric structure here and there, strike east-west, thickness 36′.
5. Sandstone, ferruginous.

These beds, however, are so much shattered by local faulting that it would be impossible to say with any degree of certainty to which group they belong ; and in addition, the nullah does not afford a good section there, the rocks being obscured by alluvium. But a little further down, clay shales of a Barakar appearance come in, which I have classed as such on the map. From there the section is an ascending one, but still, and for some distance, disturbed by faulting. However we get

again into the ferruginous grits and sandstones with clay iron ore, characteristic of Raniganj. Further on again—

Ascending :—

Panchets:

1. Red plastic clay of Panchet type.
2. Purple and yellow banded gritty sandstone, towards base, a band of hard shale 1", and partings of micaceous shales.
3. Purple banded clays, nearly horizontal, thickness 6', with parting of micaceous shale.
4. Sandstone, 9' thickness.
5. Ferruginous ditto.
6. Mahadeva sandstone.

8.—Section in the Sita Chua Nullah.

Nearly the same succession of rocks, crushed and tumbled together in the most perplexing manner, is met with in the dry nullah of Sita Chua, running into the Banki nullah east of Dhamni. North of the former village I met metamorphic rock (mica schist and quartz schist). In the nullah near the village I met a white mealy soft sandstone, not unlike what I saw in the former section (No. 301 H. T. is composed of it); here and there it is mottled with reddish beds, but otherwise it resembles the Mahadevas. It is hollowed out in large pot-holes, one of which is worshipped as Sita Chua (the rise of Sita). In the many windings of this rivulet, only here and there rocks appear *in situ*, the rest are hidden by sands and rubbish. In the bed of the Banki nullah near the junction with the Sita Chua nullah Raniganj clay shales are exposed, and a little further west in the bend of this river trap is *in situ*, and forms a dyke across it; I traced this dyke for miles in a nearly east-west direction towards Nowadih. The rocks, however, right and left of the Banki nullah, are so much denuded and the whole country levelled down to the river banks, that no exposure is seen for miles round until we get to Dhamni, where red clays are seen, overlaid further on by Mahadeva sandstone. These red clays occupy invariably the place just below the Mahadevas, and most probably represent Panchets. This section, and

the one previously described, would not be intelligible if I had not obtained a clear section between Nowadih and Gargori.

9.—Section in the Nullahs (tributaries of the Banki river) between Gargori and Nowadih.

In descending order: fig. 2, pl. 4.

SOUTH.

M. Mahadevas.

Ferruginous sandstone.

P. Panchets.

1. White sand or mealy sandstone.
2. Red and purplish sandstone and marls.

R. Raniganj.

1. Grey micaceous and thin-bedded sandstone.
2. Micaceous and carbonaceous shales with fossils:
   Glossopteris communis, Fstm.
   „ *angustifolia*, Bgt.
3. Marly ochre-coloured shales, with numerous traces of leaves and equisetaceous stalks.
4. Hard yellow sandstone.
5. Micaceous shales and sandstone.

Fault 1.

M. Mahadeva sandstone.

P. Panchets.

1. White marly sandstone.
2. Red clays and marls.

R. Raniganj.

1. Shales.

Fault 2.

P. Panchets.

1. White sands.
2. Purple clays.

R. Raniganj.

1. Shales and sandstone.

Fault 3.

P. Panchets.

Marls.

R. Raniganj.

Shales.

Fault 4.

T, trap dyke, showing all gradations from hard igneous rock to concentric structure and greenish tuff, in the latter condition resembling Talchir shales. The Panchet shales are altered into a burnt brick-like appearance, with steel-blue contact surfaces.

P. Panchets.

Marls and clays, dipping north, from the trap.

M. Mahadeva sandstone.

Fault 5.

R. Raniganj.

Shales, dipping 7° north.

T. Trap dyke.

P. Panchets.

Red clays and marls, with white, somewhat chalky, sandstone above.

M. Mahadeva sandstone.

Fault 6.

R. Raniganj.

Shales with—

Glossopteris, spec. nov.

T. Trap dykes.

P. Panchet.

Clays.

M. Mahadeva sandstone.

Fault 7.

T. Trap dyke.

Bounding fault with fault-rock.
Metamorphic quartzite.
North, village of Nowadih.

Undoubtedly the great lowering of the area by the fault near Nowadih has crushed and shattered the beds near it, mostly in long parallel lines, the traces of which could be observed in the former sections.

II.—THE WESTERN BASINS, BELONGING TO THE RER RIVER SYSTEM.

A.—Iria River Sections.

The country between Dhamni and Karamdiha forming the watershed between the Banki and Iria nullahs is very difficult of access; dense jungles cover most of the ground, and great deposits of alluvial sands and clays extend all over that part of the field, so that the nullahs seldom expose rock *in situ*, and that only at long intervals.[1]

10.—Regai Nullah and neighbouring country.

In the Regai nullah, near the village, I met with clayey sandstones with marly partings of a dense red brick colour, which I noticed in many sections intercalated between the Panchets and Mahadeva sandstone, and which I connect with the former. They are lithologically identical with the Panchets near Chumra and near Lawa already noticed, and I have also met them in great force in the southern outcrops of the basin near Kachia, overlying the Raniganj series; all are most probably to be correlated with the red and purple clays of Lawa. Between the Regai and Iria nullahs calcareous gritty sandstones, very soft, alternate with and pass into this red sandstone. Partings of ferruginous plates of slag-like appearance remind one of the Mahadeva sandstone, but still I separate the group from the overlying sandstone of that period.

These sandstones all show false bedding, sometimes as much as 45° with the plane of stratification; an overlap occurs in every section, so that it is very difficult to correlate beds of even adjoining sections. The red clays usually appear between the sandstone beds as thin partings and often as lenticular masses of considerable dimensions. Here and there the red clay passes into motley lavender-coloured clay shales in which I found fossils a short distance down the river.

A long fault of east-by-north direction separates the mass of Panchet sandstones and shales, and along this line of fracture a narrow

[1] Several names that have to be used in describing this wild country are only marked on the 1-inch maps. Special copies of those maps can be obtained at the Geological Survey Office by any one wishing for the detailed information.

dyke of trap may be traced for a considerable distance. Between Palgi and Thurkunda the sequence of beds is the same as in the Nowadih section, but between that locality and Karamdiha the relations are very obscure, only here and there reddish sandstone or clays indicate the presence of Panchet rocks.

11.—Sections in the Ledho Nullah north of Karamdiha.

Near the village of Karamdiha trap is *in situ* and forms the hill on which the village is situated. But immediately north of the place, in the Ledho nullah, I found :—

2.—*Raniganj beds* consisting of a series of shales and thin-bedded sandstones of a type which is best seen near Parasdiha in the Morne river, as will be shown further on. These beds are exposed north-east of the Karamdiha village on the slope down to the river; the strike is north-east to south-west, dipping about 5° to south-east, below the upper beds, which I shall notice presently. The cliff consists in descending order of:—

(*d*) light-coloured soft shales, and sandstone 1'; (*c*) clay shales, very friable; (*b*) carbonaceous shales with a thin bed of leafy *coal;* this bed resembles a similar layer of carbonized leaves seen in the Reonti cliff, to be described further on. Remains of *Glossopteris communis*, Fstm., and *G. angustifolia*, Bgt., were found in these shales. (*a*) Dark conchoidal shales.

1. Barakar shales and sandstones of the typical character; the base is not seen, being covered up by the alluvial deposits of the river.

A short distance higher up the river, at a place where two small streams join the Ledho, south-east of Sihai, a group of beds are seen consisting in descending order of—

3. *Panchets.* *k*. Gritty sandstones with ferruginous partings, overlaid and interstratified with red clays and gritty sandstone.

i. Red shales ... ...
h. Ferruginous sandstone ... ... } Dip 5 to 7° north-east.
g. Whitish grey marly shales ...

f. Red shales.

e. Thin beds of sandstone of Mahadeva character with ferruginous partings.

d. White shales and thin-bedded sandstone.

c. Red shales 3′6″ of the same type as those seen in the Lawa section (7).

b. Ferruginous yellow and variegated sandstones and shales with bands of iron ore, with an irregular band of gritty sandstone of about 8′ thickness, thinning out to about 1′6″ within a distance of 20 yards. The dip is rolling, about 5° to north-west.

In places where the upper beds are denuded, this sandstone is overlaid by a coarse breccia consisting chiefly of fragments of Mahadeva-like sandstone, ironstone nodules, with rolled fragments of metamorphic rocks cemented together by a matrix of ferruginous matter, the whole, however, only of recent origin.

a. Whitish-grey marly shales with—

Glossopteris angustifolia, Bgt.

„ *communis*, Fstm., and

Thinnfeldia-like ferns.

Ascending the southern branch of the Ledho nullah, south of Salsuli, I got again into the Raniganj group dipping below the above beds of Panchet type.

12.—Sections between Karamdiha and No. 506 H. T., including the Lower Ledho, Chorki, and Kundkepi Nullahs.

The river bed between Karamdiha and Bhalui is so sandy that only few exposures are met with, but it is probable that the isolated cliffs seen belong to the Panchet group, being a continuation of the Panchets of the upper Ledho nullah. The first rock *in situ* is found in the great bend of the river about a mile west of the village, where in *descending* order I found :—

Panchets. f. Yellow marly clays with ferruginous nodules.

e. Red marls.

d. Yellow marly clays.

c. Light grey marly shales, very friable.

b. Dark and variegated clay shales, towards top micaceous and shaly, with

Glossopteris communis, Fstm.

Pecopteris? odontopteroides, M.

a. Light grey marly shales and clays, very friable.

The dip is rolling, but generally to the south; the whole is overlaid by thick-bedded masses of grits with strings of pebbles very similar to the Lundra grits which will be described further on.

Between the villages of Bhalui and Boder the beds are much shattered, and a series of local parallel faults run across in a south-west to north-east direction. Since we find trap dykes along these lines of disturbances, similar to the Nowadih section, it is probable that the local disturbances are only owing to the eruption of trap. The Ledho and Bhalui nullahs afford the only opportunities for examination, so it was impossible to trace the lines of faults beyond the beds of the rivers, and I had to trust to conjecture for the remainder.[1] In the Ledho south of Bhalui I observe the coarse Panchet grits to dip southwards, where they are suddenly cut off, thrown down to the level of the Barakars, which dip there at 8°, to east; descending I found :—

a. Thin-bedded sandstone and shales.
b. Grey clays with patches of variegated shales with—
Vertebraria indica, Royle.
Glossopteris communis, Fstm.
c. Ripple-marked sandstone with partings of iron ore.
d. Green micaceous marly shales, somewhat like Talchirs in appearance.
e. Marly yellow and reddish shales of great thickness, near base friable grey shales.
f. *Thin bed of coal.*
g. Same as *e*.
h. Coal with shaly partings 5′ 2″
i. Greenish marly shales, breaking into small rhomboidal fragments, with intercalated grey shales and a parting of bituminous shales 1″
j. Great thickness of bituminous shales.
k. Grey micaceous fine-grained sandstone.
l. Blue shales.

Trap dyke.

Barakar sandstone and shales.

Trap dyke.

Barakar sandstone jointed into brick-like masses.

Trap.

Blue shales with coal seams above sandstone beds, dipping about 70° east.

[1] This remark applies also to the Sita Chua and Nowadih sections; rocks appeared *in situ* only in the beds of the streams, and the lines of fault had to be continued in perfectly straight lines as shown on the map, owing to the obscurity of all the intervening country.

Fault.

Raniganj shales and sandstones in high cliffs along bank of Ledho nullah, dip south-east, gradually changing to south.

Exposure in Bhalui Nullah.

Descending : dip 6°-7° to east.

Barakars. *h.* Blue clay.
g. Same as *e*, with parting of thin bed of micaceous sandstone.
f. Thick bed of micaceous grey sandstone.
e. Friable dark blue and ferruginous shales.
d. Same as *b*.
c. Bituminous shales.
b. Thin ferruginous bed.
a. Greenish and blue shales with nodules of iron ore.

The Chorki Nullah.

Dip 25° east, exposes a section through the following Raniganj rocks; descending :

p. Thin-bedded sandstone and shales, reddish micaceous, very soft.
o. Micaceous clayey shales.
n. Hard micaceous sandstone.
m. Coaly shale with thin seams of *coal*.
l. Banded leafy sandstone.
k. Hard thick-bedded sandstone, fine-grained.
i. Thin-bed of calcareous soft sandstone.
h. „ „ micaceous shaly sandstone (Reonti type).
g. Thin beds of clay shales.
f. Same as *h*.
e. Ferruginous shales.
d. Soft thick-bedded sandstone.
c. Ripple-marked thin-bedded sandstone (as *h*).
b. Thin-bedded ferruginous and variegated sandstone and shales; marly and micaceous at places, with concretionary structure.
a. Thick beds of ferruginous sandstone.

About a mile south of Kundkepi these beds are cut off by the bounding fault, which throws them against the metamorphics—here tourmaline granite.

In all the small rivulets falling into the Iria nullah east of Colhuar village (not on the map), we find shales and sandstone evidently belonging to the same group of rocks (Raniganj) dipping below the hill No.

506 H. T., which is composed of red grits and sandstone with red clays below, which I identify with the Panchets, as shown in the eastern sections. These strata cover the Raniganj below, forming an oblong patch on them.

South of the Iria nullah the Raniganj series is cut off by a fault, probably the same which I observed south of Karamdiha, but here it is well shown in all the nullahs coming from Kotrahi and Garia. The direction of this fault is then west-10°-south to east-10°-north, the fracture is nearly perpendicular with a slight dip to the south, bringing the sandstone and shales on the same level with the adjoining Mahadeva sandstone. The fracture is filled up with fault-rock, very ferruginous and hard, which is less affected by subaerial denudation than the adjoining rocks, and consequently is left as a wall-like ridge of about 5 feet in thickness standing high above the sandstones.

13.—Section along the Balsotha Nullah.

The Balsotha nullah and the nullahs west of it falling into the Iria and Morne have denuded away the whole of the Panchet grits and Raniganj beds and left only the Barakars in shattered remains, bounded on the north by the fault between Chorki and Geruáni, and along the south and west by the Mahadeva hills, which are faulted against the Barakars, as is well seen in all the river sections.

The section along the Balsotha Nullah between Saura on the north and the Iria nullah south is as follows:—

Saura village is on tourmaline granite, and the fault boundary with the Gondwánas is shown well in the bed of the river, where a ridge of porous fault-rock (chiefly quartz) fills up the fracture.

In ascending order:—

Barakars.

1. Fine-grained sandstone and shales with shaly sandstone, dip 35° south-east.
2. Grey and variegated conchoidal shales.
3. *Coal*, with partings of shales, thickness 2′ 6″, dip 25° south-east.
4. Ripple-marked variegated sandstones.
5. Bituminous shales, with thin partings of coal, thickness 1′.

6. Shales.
7. Thick-bedded sandstone.
8. Shaly micaceous sandstone, 15° south-east.
9. Soft unevenly bedded calcareous sandstone, with gritty beds.
10. Shales and shaly sandstones.
11. Thick mass of false-bedded sandstone overlappng locally the series below.
12. Shales and banded sandstones, 5° south-east.

Fault.

Thick bed of sandstone.

Fault.

Beds are here much disturbed, and the dip changes gradually to east and north-east, and finally to north, at 38°, when we find in descending order :

Banded sandstones and shales.
Soft sandstones.

Fault.

Same beds as above :

1. Sandstone.
2. Grey conchoidal shales, bituminous, with banded micaceous and ripple-marked sandstones, dip 15° north, with—
   Grey clay shales (near junction with Balsotha nullah, dip 8° north-east.
   Banded micaceous sandstone.
3. Shales with Coal.

The whole series is, however, very much disturbed and shattered, and further on it appears that the same group of shales and sandstones are several times repeated.

The oblong expanse of Barakars mapped between the Balsotha nullah and the Pipra hills offers only a few exposures in the shallow nullahs. At several places south of the Pipra hill, fig. 1, Plate 5, and again near Maihewa, Barakar shales, with traces of leaves, are unmistakeable, but the remainder seems to be mostly fine-grained sandstone of Barakar type, traversed in several directions, as already described, by trap dykes, which have altered the neighbouring shales into a brick-like rock.

The faulted boundary with the Mahadevas is well seen south of Hargaon and of Gurmuti, where a fault-rock similar to the one described from the Garia nullah forms a high dividing ridge between the two groups.

B.—Morne River Sections.

14.—Section in the Morne Nullah between Kandia and Hadrai, Fig. 3, Plate 4.

3. *Talchirs.* In the Hadrai nullah they show the following section:—
   a, boulder-bed; *b*, irregular bed of marls and shales with boulders; *c*, thick beds of greenish fine-grained sandstone with lenticular masses of boulder-bed; *d*, silty-green boulder-bed; *e*, fine-grained sandstone with marly yellow and green shales, strike north 20° east to south 20° west, dip 10° to north-20°-west.
2. Sub-metamorphic conglomerate as described before, page 10.
1. Granite, with two hornblendic dykes.

Near the junction of the Morne with the Joba nullah the Talchirs are brought into direct contact with the Mahadevas by faulting. Tho beds are a good deal crumpled here by a succession of north-west to south-east faults, which in one or two places expose the purple and variegated coloured marls or clays of Panchet type below the Mahadevas which now dip 25° to 27° south-west.

15.—Sections of the Lundra Hills.

In the nullahs flowing from the Lundra hills, and joining either the Suknai or the Morne later on, we obtain very good sections through all the beds of Gondwána rocks.

In descending order:—

6. Mahadeva sandstone, forms a cap as it were on the top of the Panchet grits and clays, and with the latter is much shattered and traversed by local faults, difficult to trace. Near Lundra the lower beds (Panchets) appear again from below the Mahadevas and present a rolling dip, wherever seen, in the small nullahs intersecting this plain.
5. *Panchets.*
   e. Gritty sandstone with angular pebbles of metamorphics and hard ferruginous conglomerates consisting of angular fragments, some of considerable size.
   No exposure for some distance.
   d. Bluish silts, similar to (*b*), here and there variegated, with gritty masses and bands of clay iron ore.
   c. Gritty ferruginous shales.
   b. Silty beds, not unlike Talchirs in some respects, but densely red.
   a. Marly beds, splitting into rhomboidal pieces.

No exposure for some distance.

4. *Raniganj.* Fine-grained ferruginous grits.

No exposure seen for some distance.

3. *Barakars.* *c.* Shales and sandstones of Barakar type.

b. Coal-seam, 7′ thickness. Strike north 30° east to south 30° west: dip 9° north 30° west.

a. Sandstone, worn out in potholes.

2. *Talchirs.* Same succession as that seen in the Hadrai nullah. In the southernmost part of the Lundra sections the belt of Talchirs is only about a quarter of a mile in width; near Pandauli village it is nearly a mile wide, but forms now only a thin plastering over the metamorphics. North-east of Pandauli the Talchirs are worn away, and the underlying granite is exposed for some distance, forming an island as it were in the Talchirs.

1. Granite.

About a mile west of Lundra village the Panchet grits are again cut off by a north-west to south-east fault, which brings them into direct contact with the Barakars, which are well exposed in the Suknai nullah.

The sections shown in the Tabor and similar nullahs are greatly obscured by alluvial sands, and do not afford good material for observations. Similar clays and grits, as before described, are seen at intervals in the rivers and show a rolling dip, and in a red clay, containing lumps of hæmatite, *Vertebraria indica*, Royle, and *Glossopteris communis*, Fstm., were found; the bed corresponds exactly with bed 30 of the following section. Below Udhari I came suddenly on Barakars, of exactly the same type as seen in the neighbouring Suknai nullah; and west of Lundra, in the Suknai nullah itself (south-east of the Sarsera), a faulted boundary between the Barakars and Panchet grits is clearly shown.

16.—The section in the Suknai Nullah, between Sarsera and the junction with the Morne River.

In *descending* order as follows :—

Barakars.

Starting from the Morne river:

Dip 5° W. 20° N.	48. Bluish shales with faint impressions of leaves	
	47. Banded micaceous sandstone with coal markings	2′ 6″

46.	Shales with band of hæmatite ...	8'	
45.	Banded sandstone	6'	
44.	Blue shales	2'	
43.	Sandstone	4'	
42.	Shales	2'	
41.	Banded sandstone with carbonaceous markings	2'	
40.	Shales	1'	6"
39.	Banded micaceous sandstone ...	0'	4"
38.	Sandstone	4'	6"
37.	Conchoidal shales	5'	
36.	Shales and sandstone, not well shown, about	25'	
35.	Fine-grained yellowish sandstone ...	3'	
34.	Shales	0'	6"
33.	Red banded sandstone	3'	
32.	Shales with hæmatite band	6'	
31.	Grey fine-grained sandstone	1'	
30.	Clay shales with hæmatite band containing—*Vertebraria indica*, Royle, *Glossopteris communis*, Fstm.	9'	
29.	*Coal-seam*	0	4"
28.	Shales with *Glossopteris communis*, Fstm.	4'	
27.	Fine-grained micaceous sandstone with coal-markings; ripple-marked ...	1'	6"
26.	Conchoidal shales	2'	
25.	Fine-grained greyish yellow sandstone ...	4'	
24.	Sandstone and shales; the former micaceous with carbonaceous markings ...	25'	
23.	Blue shales	2'	
22.	Fine-grained sandstone with ripple-marks	10'	6"
21.	Blue shales.		
20.	Fine-grained micaceous sandstone with carbonaceous markings; purplish-coloured fine-grained sandstone with ripple-marks and grey sandstone	3'	
19.	Gritty sandstone	7'	
18.	Blue shales	1'	
17.	Banded micaceous sandstone with marks of coal overlaid by thin shales and bluish grits; the latter contains a thin parting of shales	8'	

16. Shales	1′		
15. Thick bed of sandstone	8′		
14. Conchoidal clay shales	2′		
13. Thin-bedded reddish sandstone overlaid by grits in thick beds, with intercalated thin beds of shales	12′		
12. Blue conchoidal shales	6′		
11. Greyish gritty sandstone	6′		
10. Bluish clay shales	4′		
9. Coal-seam	3′	6″	
8. Conchoidal shales	4′		
7. Banded sandstone	1′		
6. Blue carbonaceous shales	4′		
5. Coal	0′	1″	
4. Conchoidal shales	1′	4″	
3. Reddish sandstone, gritty	2′		
2. Shales	3′		
1. Sandstone.			
TOTAL ...	211′	7″	

Along the Suknai Nullah, south of Sarsera, I found in descending order :

II. Ranigang? Soft white felspathic grits with pebble beds ; jointed.
Dip 70° W.-30°N.

I. Barakars.

Dip 50° W.-20°N. 29. Yellowish and blue conchoidal shales alternating with sandstone.

28. Dark shales alternating with ferruginous sandstone.

Dip 30° W. 27. Gritty earthy sandstone, micaceous, with carbonaceous markings and partings of hard ferruginous shales.

26. Micaceous clay shales.

25. Hard sandstones.

24. Carbonaceous shales.

23. Hard sandstone.

22. Carbonaceous shales.

21. Banded reddish micaceous sandstone, with partings of shales.

20. Grey conchoidal shales.

19. Hard fine-grained sandstone.

18. Dark shales.

17. *Coal-seam* 1

16. Hard thin-bedded sandstone with micaceous bands.
15. Thin bed of hard blue shales.
14. Thin bed of hard sandstone.
13. Dark clay shales ... ... 4′ 6″
12. *Coal*, with shaly partings, thickness ... 7′ 4″
11. Reddish-banded micaceous sandstone.

Dip 40° W. 20° N.

10. Dark-grey very hard clay.
9. Thin irregular bed of felspathic grit.
8. Banded shales; traces of leaves.
7. Grey clay shales, with papery-yellow shales, towards top densely red; traces of fossils.
6. Thin-bedded grits, towards base micaceous.
5. Friable grey shales.
4. Grits alternating with micaceous shaly sandstone.

Dip 35° W. 20° N.

3. Banded shaly sandstones, traces of fossils.
2. Micaceous shaly sandstone, very carbonaceous.
1. Dark hard conchoidal shales.

The section ends against Panchet beds along a fault.

The section in the Suknai nullah is evidently a continuous one, as is proved by the coal-seam; the 7′ 4″ coal-seam bed 12 of the last section is probably identical with the 7′ seam of the Lundra (Belia) section, and I identified this seam and nearly the whole group of beds in the following section.

17.—Section along the Nullah north-west of Ranka Khar.

Between the Mahadeva escarpment and the Morne river, I found the following beds in descending order:

No exposure for some distance; just below the Mahadevas are whitish grits and clays, which probably belong to *Panchets*.

18. Shales with coal ... ... 3′ 6″
17. Sandstone.
16. Shales with a thin carbonaceous layer ... 1′ 6″
15. Sandstone.
14. Shales ... ... 0′ 6″
13. *Coal* ... ... 2′ 2″
12. Thin splitting shales.
11. Sandstone with iron ore beds ... ... 14′ 0″

	10. Shales with coal	10′ 0″
	9. Shales and banded sandstone	56′ 0″
	8. Shales.	
	No rock seen *in situ*.	
	7. *Coal-seam*	1′ 3″
	6. Shales	300′
	5. Hæmatite bed	
	4. Sandstone and shales ...	
	No rock seen *in situ* ...	...120′ 0″
	3. Banded micaceous sandstone ...	... 3′ 0″
	2. Shales with a thin seam of coal	... 6′ 0″
Barakars.	1. Coarse-grained yellowish sandstone.	

18.—*Section in the Budatand Nullah.*

In the adjoining Budatand nullah I obtained nearly the same succession of rocks and coal-seams.

In descending order:

IV. Mahadevas.

III. Panchets ?
3. White gritty sandstone with strings of pebbles.
2. Hard brown micaceous sandstone.
1. Greenish sandstone with strings of pebbles.

II. Ranigang.
4. Soft micaceous shales with fossils.
3. Shales with fossils—
Schizoneura gondwanensis, Fstm.
Glossopteris angustifolia, Bgt.
2. Soft light grey micaceous shales, marly, with traces of fossils.
1. Thick-bed of mealy felspathic sandstone.

I. Barakars.
Dip 20° north-west, but rolling considerably.

29. Shales and sandstone.	
28. *Coal*, with shaly partings.	
27. Thin-bedded sandstone and shales.	
26. Conchoidal shales.	
25. For some distance rocks *in situ* are only seen here and there higher up—	
24. Carbonaceous shales, with partings of *coal*...	0′ 6″
23. Hard sandstones with grey micaceous and bituminous shales alternating ...	43′ 0″
22. Shales and sandstone alternating with banded shales on top	92′ 0′

21.	Conchoidal shales with thin ferruginous partings and clayey shales at base ...	17′	0″
20.	*Shaly coal*	0′	3″
19.	Banded shales with micaceous sandstone ...	97′	0″
18.	*Coal with shales*	17′	0″
17.	Shales and sandstone with fossil leaves	17′	0″
16.	Sandstone		
15.	Shaly coal	2′	0″
14.	*Coal-seam*	3′	2″
13.	Dark bluish shales	4′	0″
12.	Sandstone in a thick bed	23′	0″
11.	Thin-bedded sandstone and shales ...	42′	0″
10.	Coaly shale with nodules of iron ore ...	0′	6″
9.	Banded grey micaceous shales and sandstone	24′	0″
8.	Shales	5′	0″
7.	Hard sandstone	24′	0″
6.	*Coal*	0′	9″
5.	Sandstone and shales	15′	0″
4.	*Coal*	0′	8″
3.	Sandstone and shales	12′	0″
2.	*Coal*	0′	8″
1.	Hard fine-grained sandstone.		
	TOTAL ...	440′	6″

19.—Section South of Manpur.

In the Morne river south of Manpur, I found Barakars well developed; the series is cut off by a fault about a mile south of Manpur village, and thrown against Mahadevas, which apparently dip below the Barakars.

In descending order I found:

I. Barakars:

Dip 15° N.	40. Shaly sandstone	0″	8″
	39. Grey shales with clunchy clays and sandstone with thin coal-seam 2″... ...	6′	
	38. Same as 36.		
	37. *Coal*	0′	2″
	36. Dark-blue shales with clunchy ochre-coloured clays	1′	10
	35. Shales	2′	

34.	Coaly shale	3′	
33.	Same as 31	7′	
32.	*Coal-seam*	1′	4″
31.	Blue conchoidal shales with lenticular lumps of clay iron ore and bands of ferruginous sandstone	10′	
30.	Earthy bed gradually passing into clayey shales	1′	6″
29.	Dark shales, jointed	5′	
28.	*Coal-seam*	1	
27.	Shales and flaggy laminated sandstone, very fine-grained and white	4′	
26.	Not exposed 200′ in the bend of the Morne river. The following is the escarpment seen on the right bank, immediately below the village :—		
25.	Sandstone with partings of shales ...	39′	
24.	Blue shales	74′	
23.	Banded carbonaceous sandstone and shales...	14′	
22.	Carbonaceous shales	15′	
21.	*Coal-seam*	1′	2″
20.	Shales	5′	6″
19.	Carbonaceous sandstone	1′	
18.	Shales (with coal-seam 1″)	0′	10″
17.	Micaceous sandstone with carbonaceous markings	1′	6″
16.	*Coal*	7′	9″
15.	Shaly banded sandstone	15′	9″
14.	Shales	17′	6″
13.	*Coal*	1′	6″
12.	Sandstone and shales.		
11.	Shaly micaceous grey sandstone with fossil traces; partings of shales and ripple-marked.		
10.	Same as 7.		
9.	Layer of hæmatite.		
8.	Dark grey shales.		
7.	Grey shales and flaggy sandstone : some distance section hidden by river ...	3′	7″
6.	Thin-bedded sandstone with bed of shales ...	1′	8″
5.	Bluish-grey conchoidal shales	9′	6″
4.	Hæmatite bed	0′	3″

3. Hard ferruginous sandstone	1′	
No exposure.		
2. Grey shaly micaceous sandstone ...	3′	3″
1. Micaceous sandstone	3′	6″

20.—Section in the Morne near Parasdiha.

Between the junction of the Morne and the Budatand river and Parasdiha nullahs there is a succession of beds of Barakar type shattered by a series of parallel faults of north-20°-west and south-20°-east direction. I observed not less than four distinct faults in that portion of the section. The dip is very varying, and rolls from 5° north-west to about 5° east; but the section is too much covered by recent deposits to afford opportunities for study. Between the junction of the Parasdiha with the Morne river and the junction of the latter with the Satnachna, I obtained a very broken and faulted section of Raniganj beds as follows :—

Ascending:

Raniganj shales, &c.

Fault.

Raniganj.

1. Sandy micaceous soft shales with fossil traces ...	20′	
2. Sandstone	3′	6″
3. Grey shales containing—	0′	6″
Vertebraria indica, Royle.		
Glossopteris communis, Fstm.		
„ *damudica*, „		
„ *angustifolia*, Bgt.		
4. Thin-bedded sandstone	2′	8″
5. Grey flaggy and micaceous sandstones	1′	8″
6. Grey friable shales	1′	
7. Beds 5 and 6 alternating	6′	
8. Sandstone	1′	
9. Grey friable shales	0	2″
10. Sandstones	1′	7″
11. Flaggy sandstone and shales alternating	22′	
12. Grey, very friable shales	2′	6″
13. Flaggy sandstone	2′	9″
14. Sandstone	3′	
3 repetitions of this series by faulting.		
15. Blue shales, sandstone flags and shales	6′	

16. Micaceous shaly sandstone	3′	1″
17. Sandstone ripple-marked	0	6″
18. Micaceous shaly sandstone and clays alternating ...	4′	
19. Shaly coal, with partings of shales	1′	4″
20. Shales	1′	4″
21. Flaggy sandstone and shales alternating	3′	6″
22. Shaly coal	0′	6″
23. Sandstone flags and shales	18′	
24. Thick bed of sandstone, ferruginous and capped by bed of hæmatite (2″)	2′	10″
25. Shales with fossils	4′	8″
26. Sandstone flags and shales	25′	
27. Thick bed of sandstone	1′	
28. Soft felspathic sandstone in irregular beds.		

Fault.

28. Sandstone.

Shales, &c.

At first the dip is 15° north-west, but it increases to 20° north-west within a short distance.

21.—Sections in the Suidud, Kubia, and Andherua Nullahs and the country westwards.

The sections along the Suidud, Kubia, and Andherua nullahs seem to be equally affected by the parallel faults noticed in the Morne river, for the Gondwánas there are completely shattered, and it is scarcely possible to identify the beds. The only point I could settle with any degree of certainty is, that the metamorphics south of these nullahs, near Dand Karua for instance, are covered by a considerable thickness of Talchir boulder-bed and shales; enormous boulders of lenticular shape are scattered throughout the silty matrix of the Talchirs, many of them being weathered out by sub-aerial denudation. Above Talchirs follow the remains of Barakar sandstones, shales, and coal-seams. The Barakar sandstone of the Suidud nullah, containing *Nöggerathiopsis hislopi*, Bunb., affords a very good illustration of erosion by water; large pot-holes and narrow gorges are formed by the rush of the water during the rainy season, as shown in the annexed drawing, fig. 3 :—

Fig. 3. Erosion in Barakar Sandstone of Suidud nullah.

Just beneath the Mahadevas of the Kathota hill a narrow strip of red sandstones crops out with red and purplish clays, which I include amongst the Panchet rocks on lithological grounds.

Similarly obscure are all the sections afforded in the Satnachna nullah; I could only obtain broken groups of rocks, and if they had not fortunately yielded fossils, it would have been very difficult to make out their relations.

The nullah cuts through the strata near Reonti, exposing them in two vertical cliffs of very nearly horizontal bedding. One of them due west of the village is as follows :—

Descending :

12.	Thinly-bedded grey shales and soft sandstones ...	25′	
11.	Bluish shales	0′	6″
10.	Micaceous sandstone flags with carbonaceous markings; they weather purplish	6′	
9.	Blue shales with layers of mica	1′	
8.	Conchoidal blue shales	4′	
7.	Same as 10	4′	1″
6.	Bluish shales	2′	
5.	Hard purplish sandstone flags	0′	6″
4.	Shales	0′	6″
3.	Hard purplish sandstone flags	1′	
2.	Clay shales	2′	
1.	Same as 10 and 7	1′	
		47′	7″

Similar is the vertical cliff north-west of Reonti village (southern village).

Descending :

11.	Soft calcareous sandstone	1′	6″
10.	Micaceous purplish-grey sandstone flags ...	1′	
9.	Marly, ochre-coloured shales	0′	10″
8.	Grey, very friable shales	0′	6″
7.	Leafy lignite, consisting entirely of fossil leaves ...	0′	1″
6.	Uneven bed of clunchy clay	0′	4″
5.	Same as 8	0′	9″

4. Grey marls, micaceous, alternating with yellowish-coloured soft sandstone; the beds of the latter are only about 1″ thick near top; towards base the divisions widen and sandstone predominates ...	3′	6″
3. Dark-grey bituminous shales		6″
2. Grey micaceous shaly sandstone with— ...	4′	
Glossopteris indica, Schmp.		
1. Grey shales, base not seen.		
TOTAL ...	13′	0″

About three miles further down the Satnachna nullah west of Dhonda village, I found another exposure, in descending order:

6. Fine marly yellowish-brown sandstone	1′	4″
5. Micaceous shales with carbonaceous markings ...	2′	6″
4. Marls	1′	10″
3. Nodular iron ore band with reddish shales, containing—	0′	3″
Glossopteris indica, Schmp. ...		
,, *communis*, Fstm. ...		
2. Clay shales	0′	6″
1. Grey micaceous shaly sandstone with coaly markings, base not seen.		

There is very little doubt that these beds all belong to the Barakar group; both the lithological character as well as the palæontological evidence point in that direction.

Crossing over the level jungle country from Dhonda to Narola, I came successively across felspathic grits and ochre-coloured shales, which probably belong to the Raniganj series, as seen in the Morne river near Parasdiha, the beds of which section strike across that part of the country, but no absolute certainty can exist in the absence of a good section. The micaceous clay shales and red grits with purplish clays of Narola itself may in that case be Panchets, immediately underlying the Mahadevas. It is tolerably certain that all the groups of lower Gondwánas are represented in the patch between Noudiha and Ramkola, but the beds seen there are merely detached portions of rocks, surrounded on all sides by trap dykes and intrusive sheets, and in many places are quite altered by the trap flows into a brick-like mass. The shales with

sandstone beds of the Panphica nullah contain the following Barakar forms :—

Glossopteris damudica, Fstm.
„ *indica*.
„ *communis*.
Nœggerathiopsis hislopi, Bunb.

The shales and clays dipping below the scarp of the Tamor and Bendo hills contain *Glossopteris angustifolia*, Bgt., *Vertebraria indica*, Royle (branched form), and may probably belong to the Raniganj series, which they resemble in some respects. Near Namadháka[1] I obtained a nearly complete succession of the Gondwána series :—

I.—*Mahadevas* of the Kathota hill.

II.—*Barakar type* resting on the Talchirs, but nothing further was exposed between these and the—

III.—*Talchir silts* rest there on metamorphics (granite), containing many boulders of red Vindhyan quartzites. They are well seen in all the gullies coming down from the Kathota hill.

The great trap-sheet already mentioned has chiefly forced its way between beds of the Panchets and the Mahadevas, so that in nearly all the sections hereabouts, trap is met with in that horizon, though not always seen *in situ*.

C.—Mahan River Sections.

A very good section through nearly all beds of the Gondwánas is obtained between the Mahadevas of the Tamor scarp and the metamorphic series south of the Mahán river, fig. 3, Plate 5. I found in descending order :

6. The *Mahadeva sandstones* and grits form the wall-like escarpments of the Tamor and Dokrichana hills, which rise up to 2,758 feet, and which I have already described in my general chapter on Mahadevas, p. 19.

[1] Namadháka is a favourite encamping ground of the Gaewallas (herdsmen) of Singrowli, who take their cattle to the Sirguja jungles during the dry season for grazing purposes; it is south of Dand Karua and north-west of Pandari, just below the Mahadeva scarp, which stretches in a nearly north-south direction from near Pakni to Dand Karua, and which is called the Kathotha hills on the large survey maps.

5. *Panchets* are at least very probable below the Mahadevas in the neighbourhood of Garuatand, where yellowirh shaly clays are seen *in situ*, but the relations to the surrounding rocks are not clear enough to show them on the map.

4. *Raniganj* beds with numerous specimens of *Schizoneura gondwanensis*, Fstm., present in the Jokna nullah, but the boundary with the underlying Barakars cannot even be guessed at, as the nullah does not afford a continuous section. Similarly difficult is the adjoining section near Majurdaki, where the trap dyke has altered all the rocks, converting the whole into burnt brick-like masses.

3. Barakars, containing *Vertebraria indica*, Royle., *Glossopteris indica*, Schmp. The shales and sandstones near the trap have been altered into a glass-like slag in some places, and in many ways the trap has disturbed and shattered the adjoining rocks.

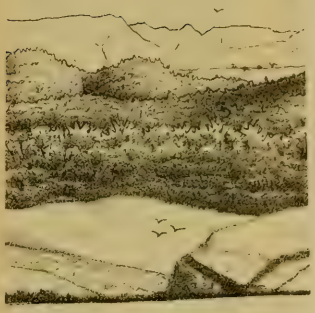
2. *Talchirs*. South of Ahirapara I found Talchir sandstones and silts with boulders of the usual yellowish-green colour resting on the metamorphic series. They form only a thin plastering over the older rocks, filling up hollows here and there, and thinning out and disappearing below the Barakars south-west of Chikni village.

A great trap dyke cuts through the area covered by Talchirs south of Ahirapara and altered the shales in some measure, so that it is not easy to distinguish them from the overlying Barakars.

1. *The Metamorphic series*.—Mica schist with veins of granite form the high ridge south of the Mahán river, and is a continuation of the range of metamorphics which stretches from near Tatapani in a south-west direction towards the Jilmilli field, separating the Bisrampur coal-field from my area. South-east of Majurdaki the mica schist immediately underlying the Talchirs contain numerous hornblendic veins, the whole dipping 55° to the north.

S.

Gulgulpat



of the Melamorphic series

caschist ~ 3. Pegmatite

Fig 5. Talchirs.

E.

Assandiah

Chirakund

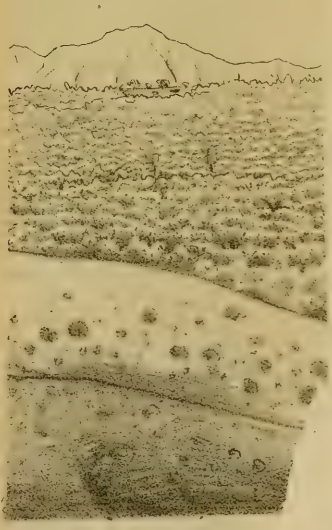


Fig 2. Profile

1. Gneiss ~ 2. Gran

Ginsbach Coal-field of Ramkola and Tatapani.

Fig 1. Profile of the Metamorphic series between the Chunderpore Pats and Tatapani.

1. Gneiss ~ 2. Micaschist ~~ 3 Pegmatite veins of the Gobra Hill. ~ 4. Trap with Laterite ~~ 5 Talchirs.

Fig 2 Profile [illegible] tamorphic series of Assanduh

1 Gneiss ~ 2. Gran[illegible]kund ~~ 3. Trapdyke ~~ 4. Mahadevas

Griesbach. Coalfields of Ramkola. Fig. 1. Vol. XV. P^t II. Pl. II.

Fig. 2.

C. L. Griesbach, F. G. S. del. R. Mintern lith. Mintern Bros. imp.

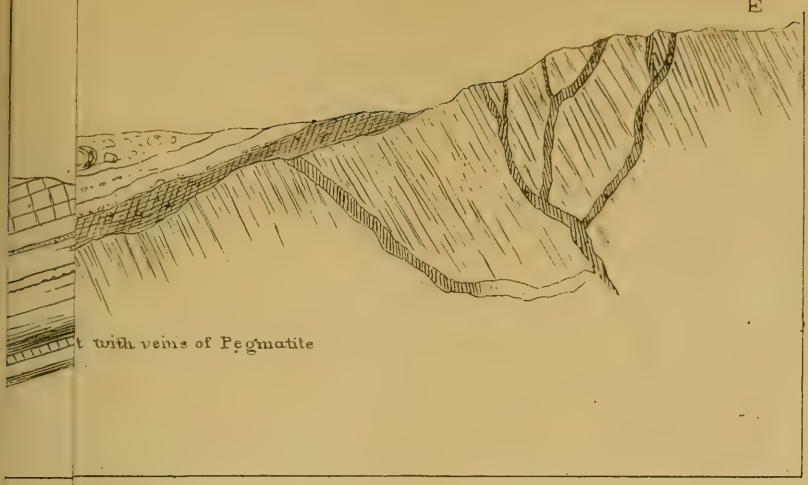
Fig. 1. *Potholes, in* ***Talchir*** *Sandstone, North of* ***Mitgain***.

Fig. 2. ***Talchir*** *boulder-bed and shales, Southwest of* ***Kandia***.

1. Gneiss. 2. Hornblendic Rock.
3. Tourmaline Granite. 4. Vindhian Quartzite.

A

E



Mahade

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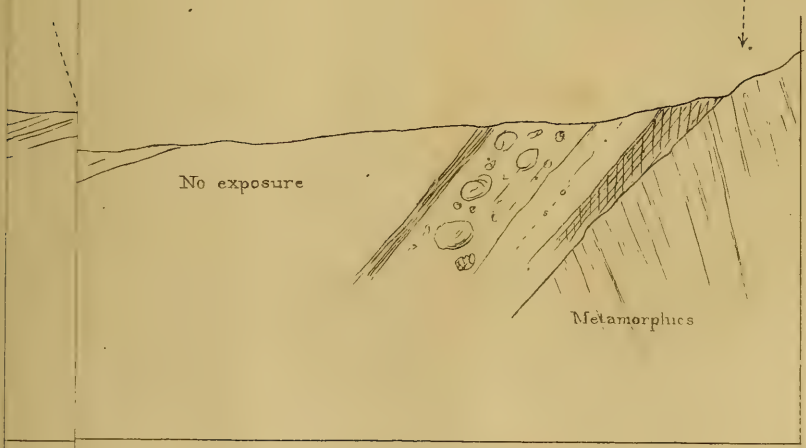

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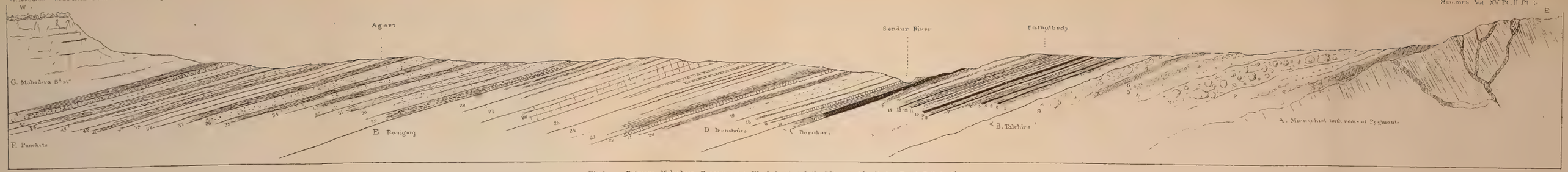


Fig 1. *Between Mahadeva Escarpment W of Agart and the Metamorphic Rocks E of Pathalpedi*

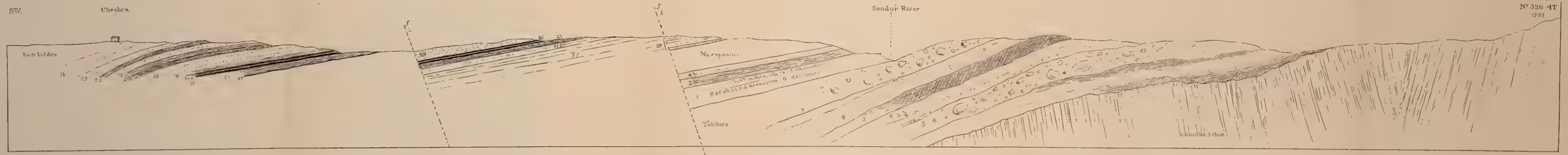


Fig 2. *Exposed in Nullahs between Chechra and N° 326 H.T.*

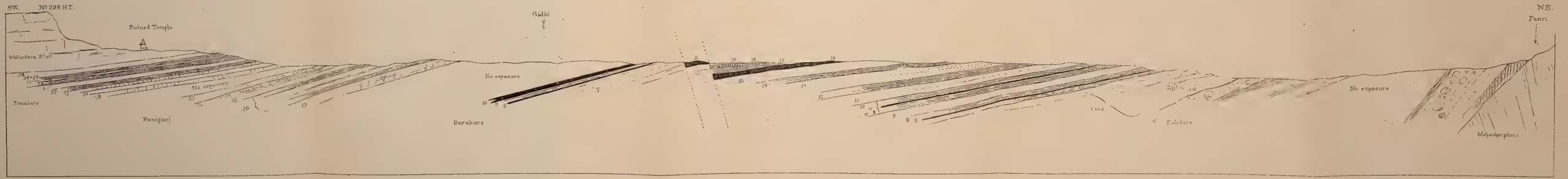
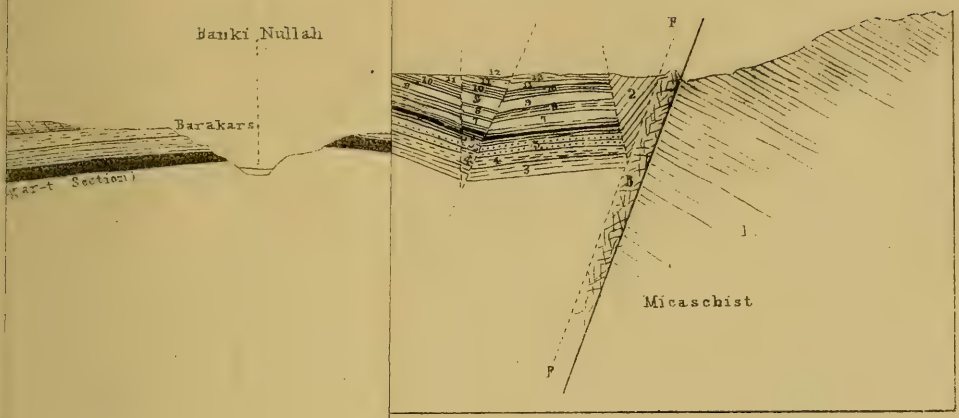


Fig. 3. *Exposed in the Nullah East of Gidhi and along the Banki Nullah to Panri.*

R V E Y C

Memoirs: Vol. XV. Pt. II. Pl. IV.



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14 to 16. Raniganj 17. to

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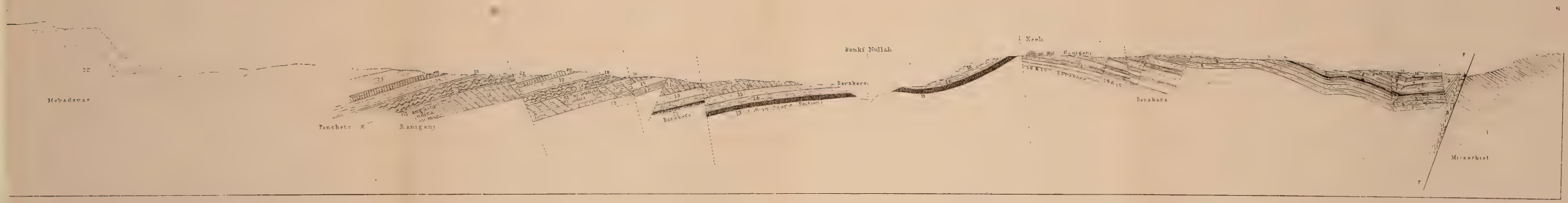


Fig 1. Section along the Nullah's Left and Right of the Banki Nullah West of Chumra

F. fault with F faulttrack. 1 Mesoschist 2. to 13. Barakars 14 to 16. Ranigany 17. to 21. Panchets 22 Mahadevas

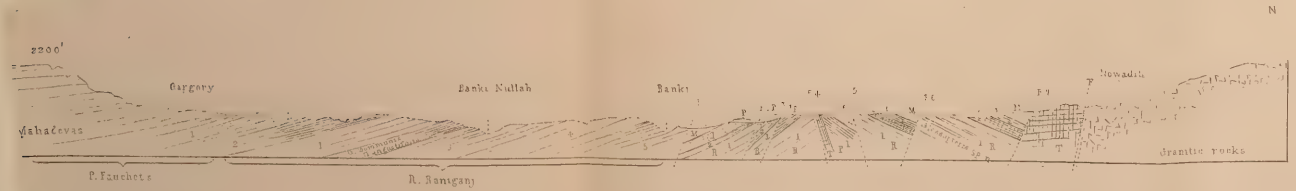
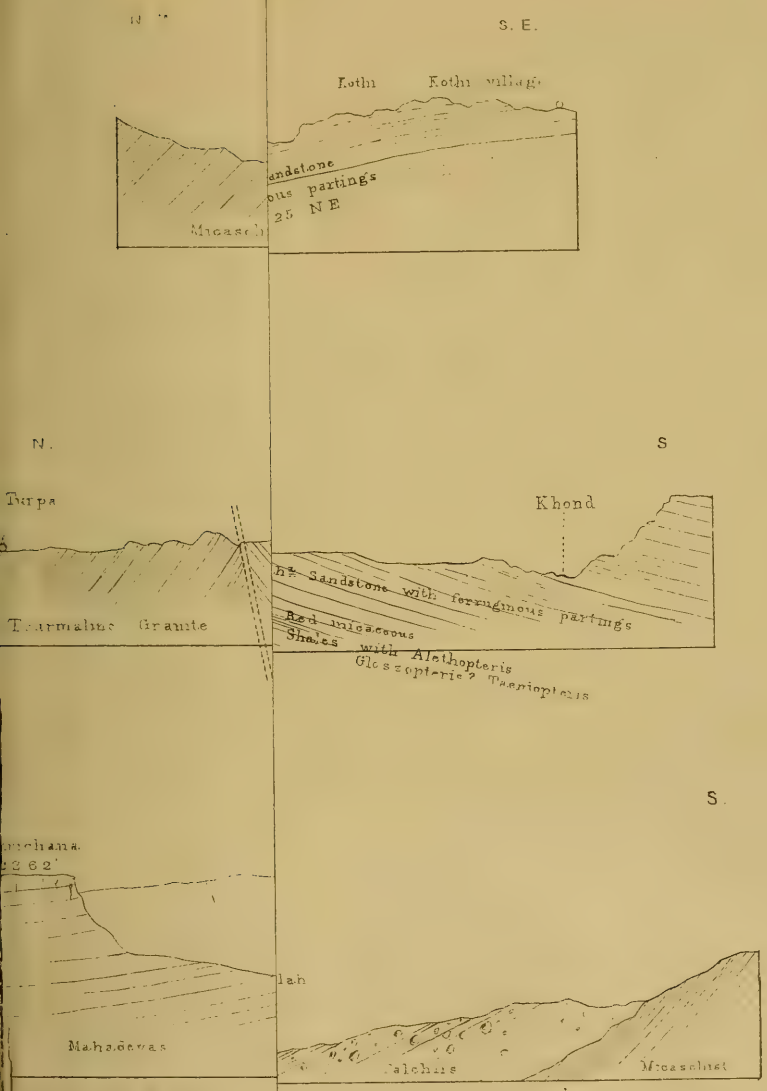


Fig. 2. Section between Gargary and Nowadil

Fig. 3 Section between Kandra and the Morne Nullah

1. Granite 2 Sub-metamorphic 3. Talchirs 4 Barakars of the Morne Nullah 5. Panchet clays 6. Mahadevas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Kothi village
...andstone
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25 N E
N.
S
Turpa
Khond
Sandstone with ferruginous partings
Red micaceous
Shales with Alethopteris
Glossopteris? Taeniopteris
Tourmaline Granite
S.
...rchana
...262'
...lah
Mahadevas
Calchiris
Micaschist

Fig 1. Section between the Pipra Hill and Kothi village.

Fig 2. Section through the Mahadevas between Tirpa and Khond.

Fig 3. Section between the Tamor plateau and the Mahan valley

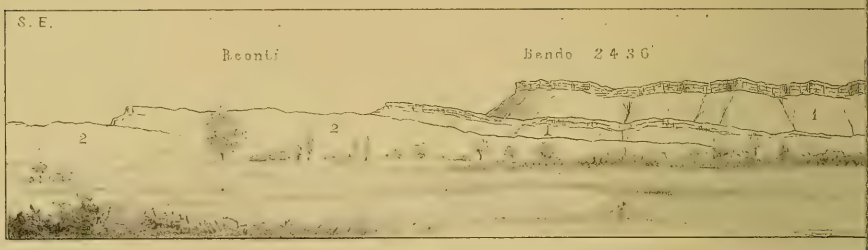


Fig. 1. Mahadeva escarpment (1) of the Tamor plateau (so

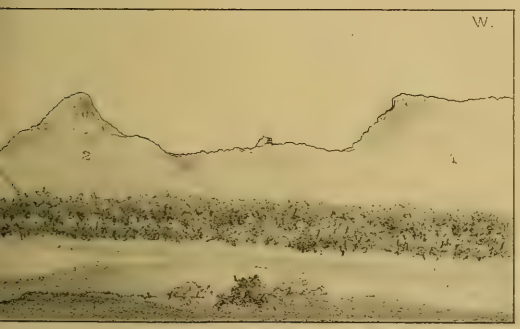
Fig. 2. Profile of Mahadeva hills as seen

C.L. Griesbach, del. & lith.

Fig. 3. Mahadeva hills (1) with Trapdyke (2)

of Rarikola) with intrusive sheet of Trap (2)

om Bura Berbil.



thwards from Pasaun.

Fig 1. Mahadeva escarpment (1) of the Tawar plateau (south of Ramkola) with intrusive sheet of Trap (2)

Fig 2 Profile of Mahadeva hills as seen from Bura Barthi

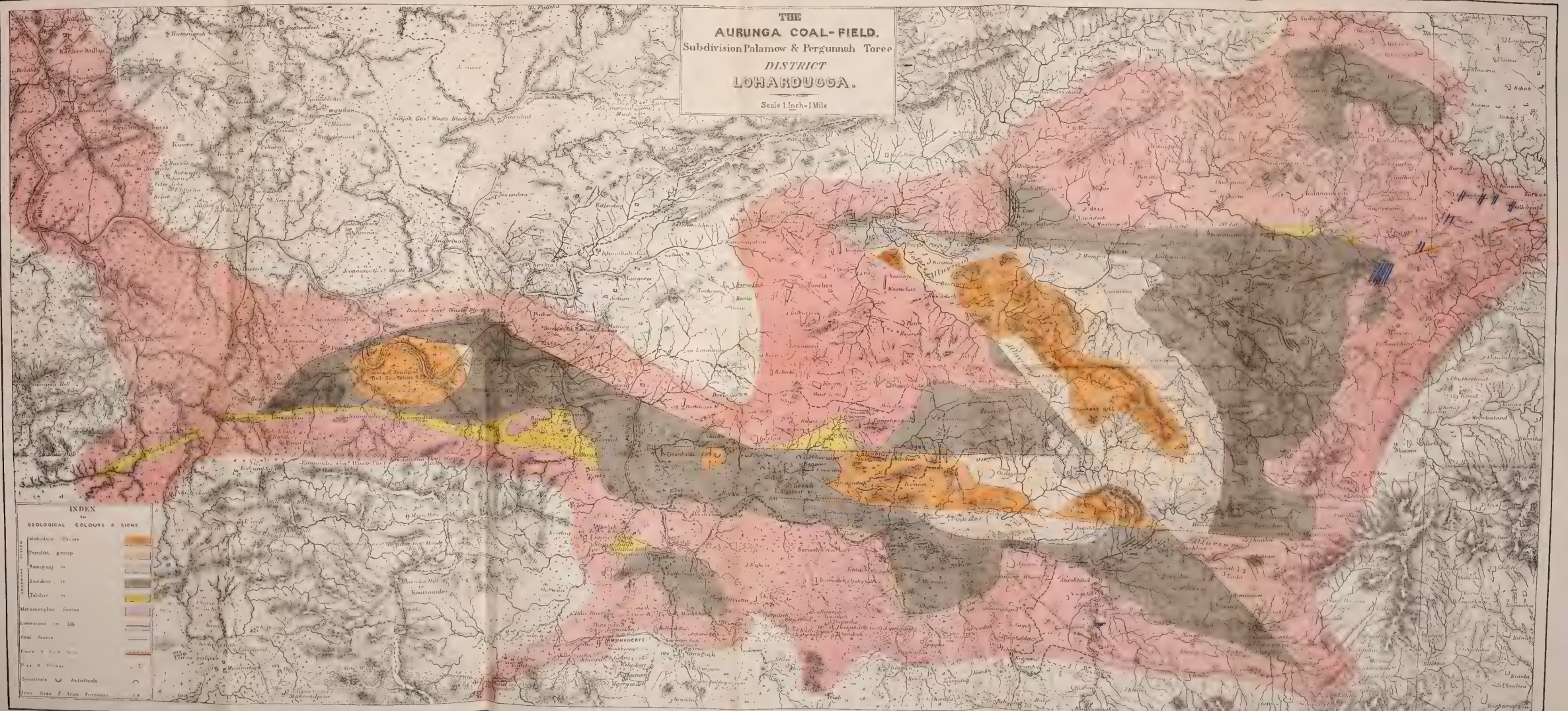
C.L. Griesbach. del. & lith.

Fig. 3. Mahadeva hills (1) with Trapdyke (2) southwards from Pasawn.

Fig.3. Exposed in the Nullah East of Gidhi and along the Banki Nullah to Panri.

Compiled from sheets Nos. 2, 4 [illegible]

Photozincographed under the Superintendence of Capt.ⁿ Waterhouse, Surveyor General's Office Calcutta. July 1878.



1. &c. From sheets Nos 10, 11, 13 and 14 of the Revenue Survey Map of Sub-division Palamow, District Lohardugga.

MAP

SHEWING THE RELATIVE POSITIONS of the

COAL-FIELDS OF PALAMOW

and

ADJOINING DISTRICTS.

SCALE 1 INCH = 8 MILES.

Names of Fields	DISTRICTS
1. Daltonganj	PALAMOW
2. Hutar	
3. Aurunga	
4. Karanpura N.	HAZARIBAGH
5. Dº S.	
6. Chope	
7. Itkuri	
8. Tatapani	SIRGUJA
9. Bisrampur	

INDEX to GEOLOGICAL COLOURS

- Laterite
- Deccan Trap
- Mahadeva Series
- Panchet Group
- Ranigunj Dº
- Barakar Dº
- Talchir Dº
- Metamorphic Series
- Faults

Compiled from sheets Nos. 13 and 18 of the Map of Western Bengal.

Photozincographed under the Superintendence of Capt. J. Waterhouse, Surveyor Generals Office, Calcutta. July 1878

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