

C. 82
METALLIFEROUS DEPOSITS

OF

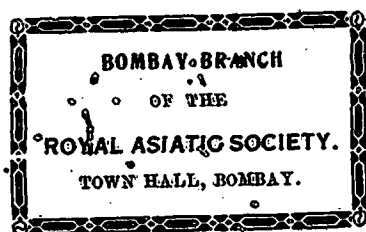
KUMAON AND GARHWAL

HENWOOD



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P. P. A. S.



TOPOGRAPHICAL SURVEY

of the *Alpallitrons* Districts of

KUMAON and GURHWAL

INDIA

Scale of Miles 0 1 2 3 4 5 6 7 8 9 10

Scale of Feet
0 100 200 300 400 500 600 700 800 900 1000
Scale of Paces
0 100 200 300 400 500 600 700 800 900 1000
Scale of Yards
0 100 200 300 400 500 600 700 800 900 1000
Scale of Fathoms
0 10 20 30 40 50 60 70 80 90 100





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Report

ON THE

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OF

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IN

North-Western India,

BY

WILLIAM JORY HENWOOD, F.R.S., F.G.S.,

SOMETIME HER MAJESTY'S ASSAY-MASTER OF TIN IN THE DUCHY OF CORNWALL,
Surveyor.

Calcutta:

THOS. JONES, "CALCUTTA GAZETTE" OFFICE.

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*Sometime Her Majesty's Assay Master of Tin in the Duchy of Cornwall,
Surveyor.*

INTRODUCTION.

1. THE Honourable Court of Directors having been pleased to employ me to examine and report on the metalliferous resources of Kumaon and Gurhwal, and to engage Mr. James Barratt as First, and Mr. Thomas Gray as Second Assistant in the Mining Department, as well as Mr. Rees Davies, an iron smelter, as Metallurgic Assistant, directed me to proceed with the latter to the iron districts of Styria, in order to acquaint ourselves with the application of *hot blast* to smelting iron ore with charcoal, and having done so, to meet our other associates at Alexandria: and thence to proceed together to Calcutta.

On reaching India in November last, we were directed to examine the iron ores of the Damôdoh Valley, on which I have had

the honor of presenting a Report. In obedience to commands from Cecil Beadon, Esquire, Secretary to the Government of India, in January, we proceeded to the North-West Provinces, and on the 20th of that month, we had the pleasure of reporting our arrival in Kumaon to John Hallet Batten, Esquire, Commissioner of the two Provinces.

Our labours commenced forthwith, and have been carried into every metalliferous district known in Kumaon and Gurhwal. They are now concluded, and I have the honor to submit their results, with such remarks and suggestions as they seem to dictate.

2. The metallic productions of the country are not collected into one extensive and continuous tract, but are spread through separate and distant districts, divided from each other by large areas of unproductive rocks. In two only of these districts most of the mines have a distinct and evident relation to each other, but in the remaining tracts no such dependence and connexion can be traced. Still they have in each case a common dependence on the fuel, the lime, the furnace-materials, and the water of the same neighbourhood;—they may be, therefore, more conveniently described in geographical than in geological groups.

3. Sands slightly impregnated with gold occur in the Ramgunga and the Alaknunda. Copper ores are found in the Gurhwal district, which includes *Pokree* and the small mines near it, *Dhunpoore* and *Agur*, and at no great distance at *Tarag-ke-Tal*; in *Gungolee*, which comprises *Rai*, *Belar*, *Seera*, and *Goron*, and in the neighbouring mine of *Kur-rye*, near *Bagesur*. Iron ores occur in the *Bhabur*, in the *Dhuniakote* district at *Ujowlee*, *Kyrna*, *Kyroolee*, *Patol*, *Khuloagar*, *Hurchniolee*, and *Tutyle*; in the *Agur* or *Ramgurh* district, at *Shealgar*, *Guarocoollee*, *Lusghanee*, *Nutoa Kanh*, *Gallà*, *Dhoora Kanhi* (1), *Capuà*, *Currocoolee*, *Bhoomkake*, *Bunnà*, *Chocootà*, *Purturburà*, *Udarke-Kanh*, and *Dhoora Kanhi* (2); in *Chowgurhika* and *Punaar*, at *Agur*, *Dhoola Devi*, *Bunna*, *Pahlee*, and *Munglu Lekh*; in the neighbourhood of *Gunnai*, at *Tilpoorè*,

Chitulee, Burrulgaon, Sigroolee, Godee, Bonegarh, Khetsaree, Ram-poore, Simul-khet, Melhelchoree, and Soongaree, and not far off at Pokree. A few specimens of blende (sulphuret of zinc) were found at *Belar*, and traces of the oxide of manganese were detected at *Guarocoollee*, as well as amongst the iron ores of several other mines. No other metals or ores were met with during the survey.

* GEOLOGICAL, MINING AND ECONOMIC DETAILS.

4. We found several parties of natives washing for gold amongst the sands of the Aluknunda, near Chetoo Peepul, Gold. of the Pindur, above Kurn Pryag, and of the Ramgunga, between Kala-bun and Gunnai, but were unable to obtain from them by purchase any of the metal they had extracted. Having examined the gravel which their labours had exhausted, we were not without hope of being able to reach deeper unwrought spots; but in this we were unsuccessful, for they had extracted all the shallower deposits; therefore, although we obtained a few particles of gold, it was from materials which had been already wrought by the natives, and which would not repay the expense of washing a second time.

The sand and gravel within their reach is doubtless that only which is brought down periodically by the rains, and if richer deposits exist, they must be found beneath, amongst the remains of the more powerful but transient floods, of which traces are every where visible.

The iron ores of *Burrulgaon*, near Gunnai, and of *Bunna*, in the Punaar valley, resemble very closely deposits which are auriferous in Brazil, a country with which Mr. Gray and I have had long acquaintance. Both were examined, but without success.

Whilst other metals, which are more obviously, speedily, and certainly remunerative, remain unwrought, it would be imprudent to divert attention from them; but when they shall have been put into a regular course of working, it may not be unworthy of consideration, whether Mr. Gray might not advantageously proceed to

the sources of those rivers,* as his long and extensive experience in the gold deposits of California and Brazil well qualify him for such a task.

5. At *Pokree*† there have been made at various times five galleries on the (so called) *Chumittee lode*, of Copper ores. which the upper two made by the natives, the lowest *driven* by Mr. Wilkins, and the next above it opened, as we were informed, by Captain Ramsay's orders, are all crushed and useless. The middle gallery (*level*) only, which was Mr. Wilkins's upper drift, is open at present to an extent of about 15 fathoms from its entrance. There is no (*lode*) metalliferous vein visible in it, nor have we seen one during our enquiries in this country. The copper ores extracted lie in thin plates between the laminæ of the slate-rock, which bear about 20° W. of N. (magnetic) and dip N. of E. 50°.‡ The formation exposed in the deeper part of the gallery is a fissile, homogenous, lead-blue slate, which closely resembles the "*killas*" of some parts of Cornwall and the metalliferous slate of Wicklow: on this reposes an equally thinly laminated rock of a pale yellowish-buff color, which seems almost exclusively composed of talc. Extremely thin short beds of quartz occur conformably at intervals between the slaty laminæ, occasionally tinged with earthy-brown iron-ore. Copper pyrites and purple copper ore, in plates equally as thin as those of quartz, but perhaps rather longer and broader, are in like manner interstratified amongst

* Capt. Herbert obtained a specimen of granite, which enclosed "a speck of gold" from the Aluknunda, near Kédarnath.—*Asiatic Researches*, Part I. (1829), p. 236.

—Mr. Commissioner Batten, *Official Reports on the Province of Kumaon*, p. 157, *Note*.

† Notices of *Pokree* are numerous, by Capt. Herbert, *Asiatic Researches*, Part I. (1829), p. 236, and *Journal of the Asiatic Society*, Extra, No. CXXVI. (1842), p. 96; Lieut. Glasfurd, *Ibid*, No. XC., N. S. (1839), p. 471; Mr. Commissioner Lushington, *Ibid*, No. CXXXVIII. (1843), p. 454; and Mr. Engineer Reckendorf, *Ibid*, No. CLXIII. (1854), p. 471. Mr. Lushington's is by far the most minute and practical.

‡ Messrs. Schlagintweit determine the magnetic variation at Nynce Tal to be now (May 1855) 4° 0' 10" E., but all directions in this Report refer to the *magnetic meridian*.

the rocks, possibly rather more abundantly near their junction than elsewhere. Where they touch the quartz, they transfuse it, and the united mass for an inch or two increases in size, but it as rapidly dwindles, and they soon separate. They seldom exceed half an inch in thickness: the metallic equally with the earthy ingredients evidently being part of the rock formation; which is copiously stained with the green and occasionally with the blue carbonate of copper. Near the mouth of the gallery of the native miners next above there is a rock of quartz, felspar, talc, and the carbonate of iron of massive structure, but with no other ingredient.

On "the Rajah's lode," all Mr. Wilkins's, as well as the more ancient native openings, are crushed, inaccessible, and have been long abandoned.

We have never before seen a spot so scantily sprinkled with ore, and offering in our judgment so small a prospect of improvement, so extensively and perseveringly worked.

We visited and carefully examined the *Nowta* (or *Nota*), the *Thala*, the *Danda*, and the *Tulapoongla* mines, but nothing has been done in either of them or in the *Khurpa* mine, since Mr. Commissioner Lushington reported on them.* Their situations offer many facilities for mining operations, but the indications they present are so small, and so unencouraging, that we have no recommendation to submit in their favor.

At *Al Agur*, near Lohba,† a bed of quartz of about 6 feet in thickness, but from enclosing many masses of the adjoining rock affecting a veined structure, crops out at about 25 fathoms from the foot in the face of a steep escarpment of bluish-green quartzose chlorite slate conforming to its bedding, which bears nearly S. E. and N. W. and dips towards the S. W. perhaps 30°. Native miners have explored both parts of this bed, but the opening on one of them has been abandoned and is now inaccessible; on the other a pit has

* *Journal of the Asiatic Society*, No. CXXXVIII., N. S. (1843), p. 461—3.

† Mr. Deputy Beckett's Report—*Selections from the Records of Government*, N. W. P. Part XIII. (1853), p. 73.

been sunk about 15 fathoms on its line of dip, and the portions which are separate at the surface, re-unite at the bottom. The chief ingredient of this formation is quartz, occasionally mixed with a yellowish-brown iron ore, somewhat, but not exactly, resembling the "gossan" of the Cornish miner, and much stained with the green carbonate of copper. Lines of vitreous and of purple copper ore of exceeding thinness traverse many parts of the quartz, and when touching the ferruginous portions, they commonly increase to perhaps a quarter of an inch in thickness. Their length seldom exceeds half an inch, and usually they are much smaller. The portion of this formation now visible, though very far from being a rich one, is not without some encouraging characters, and we concur in thinking it deserves more examination than it has yet received. Wood and water sufficient for every purpose are at hand.

The rocks near *Dhumpoore* * are chiefly quartzose slate, but occasionally they contain much lime also: their structure is usually massive, but sometimes it is thick lamellar.

The schistose calcareo-siliceous rock is divided by a bed of highly siliceous limestone, holding on the whole a nearly horizontal position, but presenting many undulations: its ordinary thickness is perhaps a foot, but under special circumstances, to be presently mentioned, it is several feet. Two series of divisional planes, which may be more properly called structural joints than veins, traverse the limestone as well as the slate rocks above and below it; the prevailing direction of one set being from N. and S. to 10° — 15° E. of N. and W. of S, and of the other nearly E. and W. Ordinarily they are nearly vertical, but they sometimes have a slight inclination indifferently to either side. At a distance from their intersections, there is little to distinguish these lines from those of structure common to all rocks, for they coincide with the joints in

* Capt. Herbert, *Asiatic Researches*, Part I. (1829), p. 241, and *Journal of the Asiatic Society*, No. CXXVI. *Supplement* (1842), p. 99; Mr. Commissioner Lushington, *Ibid*, No. CXXXVIII, N.^o S. (1843), p. 464; Mr. Reckendorf, *Ibid*, N. S., (1845), p. 474.

position, differ little or nothing from the formations they traverse in mineral composition, except that they sometimes enclose small lumps and thin laminæ (so^o to speak) of purple copper ore and specks of copper pyrites and of vitreous copper ore.

The respective directions of the two systems of joints and the position of the bed of siliceous limestone by their intersections necessarily give birth to obtuse rhomboidal masses of rock. It is at the intersections of these planes, that the object of pursuit, the copper ore, is most abundant. At these points both the joints and the bed usually enlarge, sometimes to a thickness of several feet; the copper ore at the same time becomes much more plentiful, and the rocky mass is thickly spotted and traversed in all directions by veins,—which are sometimes as much as 6 inches in width*—of copper ore, chiefly of the purple variety. The calcareo-siliceous character, sometimes associated with a little brown iron ore, usually extends on the line of each of the three intersecting planes to some distance from their actual contact, and copper ore still prevails in all for many, sometimes 10, 15 or even 20 feet. Gradually, however, it disappears, the intersecting bodies collapse to their original dimensions, and poverty at the same time returns. This striking increase in richness does not however occur at every intersection, although the difference in character between those which are enriched, and those which are not, is by no means obvious.

It is supposed that the bed of rock thus occasionally productive at *Dhunpoore* on the North extends to *Dhobree* † on the South of the mountain in which both are worked; but at the time we examined the former, it was covered with snow to a depth of 18 inches or 2 feet, and the path to the latter was impassable.

Ample forests abound in the neighbourhood and water sufficient for every probable demand is not far distant.

* Mr. Wilkins mentions a vein of copper ore of a foot in thickness. Mr. Lushington, *Journal of the Asiatic Society*, No. CXXXVIII, N. S. (1843), p. 464.

† Mr. Lushington, *Ibid*, p. 465; Mr. Reckendorf, *Ibid*, No. CLXIII, N. S. (1845) p. 475.

At *Tarag-ke-Tal*, about two miles East of Gunnai, the face of a precipitous cliff of siliceous limestone is penetrated by a cavern some 6 fathoms in length and about 4 or 5 fathoms in width and height, and from it a gallery has been extended about 12 fathoms further into the mountain. The bedding of the rock, which has a thick lamellar structure, bears S. E. and N. W., and dips S. W. about 30°. Small stalactites appear here and there, and some parts of the walls are incrustated with stalagmites, which, as well as portions of the rock, are tinged with the green carbonate of copper. This prevails more on a bed of 8 or 9 feet in thickness than on any other part, and in this mass of rock a few minute specks of copper pyrites may be detected.

A fine stream from a marsh, which, in time of rain, is a small lake above, falls below the mouth of the cavern. The neighbourhood is thinly wooded.

At *Kurrye** near Bagesur, a gallery which had been formerly opened has recently fallen in : operations which are on a very small scale are, therefore, now confined to an open cutting across the strata of about 30 fathoms long in a N. E. and S. W. direction. The formation consists of alternating beds of white talcose slate and a calcareo-siliceous rock, which bear S. E. and N. W. and dip S. W. 35°—45°, though in this respect they are subject to many variations. The metalliferous deposit seems chiefly confined to the beds of talcose slate, and in that to a portion of only from 5 to 8 fathoms on the *strike* of the beds, all of them being to that extent slightly productive on the line of the open cutting.† These beds enclose small kidney-shaped lumps, composed for the most part of quartz, but carbonate of lime also enters, though more rarely, into their constitution. The quartzose portions are sometimes thinly spotted and striped with narrow veins of copper pyrites, and more rarely with purple copper ore : sometimes they are coated with small quantities of the green carbonate of copper. In the richer

* Mr. Commissioner Batten, *Official Reports on the Province of Kumaon*, p. 813.

† "The lodes in almost every district are productive on similar lines taken at right angles to their bearings."—*Cornwall Royal Geol. Trans.*, V., p. 215.

portions the quartz is softer than in the poorer, and it is transfused with earthy-brown iron ore. The mass of rock probably contains minute portions of copper pyrites, as the sand brought down by the rains is washed, because it is found slightly metalliferous.

* Abundance of fine wood grows immediately on the mine, but water is not plentiful.

We saw nothing in the mine which would warrant more extended operations.

At *Rai*,* in Gungolee, two openings formerly existed, at no great distance from each other, but both have been abandoned, and are now inaccessible. In the Eastern or upper of them there were two galleries, one of them scarcely 6 feet above the other; both have been for some time ruinous; and ill-directed attempts to re-open them have been unsuccessful; we were therefore unable to examine the formation *in place*. The rubbish brought to the surface is quartzose talc-slate, mixed with calcareous matter, amongst which we were unable to find a single trace of copper ore.

Two galleries also were extended into the mountain at the lower or Western mine, but they united within: these have likewise fallen in and are inaccessible, and as an open cutting outside the lower of them is faced with stone-work, the rock as it stands is effectually concealed. We were told that the metalliferous formation had a direction about 35° N. of E. and S. of W. and that its dip was towards the N. The refuse matter from the mine is chiefly white talc-slate, but some specimens of calcareous spar are mixed with it, and in a few of these there are small lumps and short, narrow veins of copper pyrites.

There is not much water within convenient distance, but the neighbouring mountains are clothed with magnificent forests.

At *Belar*, as at *Rai*, two galleries are wrought from the surface, and unite within the mine. The upper of them is 12 and the lower about 20 fathoms in length we were informed, and one is

* Capt. Drummond, *Journal of the Asiatic Society*, No. LXXXIII. (1833) p. 935.

3 fathoms above the other. Their direction is said to be about N. and S., and the dip of the formation they penetrate is towards the E. A mass of quartz about 4 feet wide appears at the entrance of the lower gallery, and the metalliferous rock is reported to vary in width from 6 to 18 inches. The mouths of both the galleries are crushed, we were therefore unable to enter the mine; but the rubbish extracted from it is chiefly talc slate, occasionally rather quartzose, amongst which we saw some lumps of blende (the sulphuret of zinc) of at least 3 or 4 inches square, and a few specks of copper pyrites.*

Water is not abundant within convenient distance of the mine, but noble forests cover the mountains.

Neither at *Rai*, nor at *Belar*, had we a sight of any thing whatever on which to found an opinion regarding the prospects of success in working, or of the propriety of doing so.

At *Seera** the rock at a little distance from the metalliferous deposit is clay-slate, sometimes blue, sometimes of a pale buff colour: its cleavage planes bear E. and W. and dip N. about 50°. The formation in immediate contact with the copper-bearing bed is however talc slate, which encloses occasional deposits of massive talc. On entering the low, ill-made, and unventilated hole—the only access to the mine—we found it crushed and closed at about 30 fathoms from the mouth, our pine torches were soon extinguished by foul air: and it was therefore impossible to reach and inspect the part last wrought. Our information is consequently derived from examining the ore and rubbish lying at the surface, and from the workmen. Most of the stone we examined seems to have been long broken; it is chiefly quartz, but is more or less mixed with calcareous matter, and includes occasionally masses of calcareous spar, the mass being tra-

* Mr. Commissioner Traill, *Asiatic Researches*, No. XVI. (1828), p. 137; Capt. Herbert, *Ibid*, Part I. (1829), p. 243, and *Journal of the Asiatic Society*, No. CXXVI. Supplement (1842), p. 119; Mr. Commissioner Lushington, *Ibid*, No. CXXXVIII. (1843), p. 468, Note; Mr. Commissioner Batten, *Official Reports on the Province of Kumaon*, p. 17; Capt. Drummond; *Journal of the Asiatic Society*, No. LXXXIII. (1838), p. 936.

versed by thin curved joints lined with talc. Numerous spots and short narrow veins of copper pyrites are irregularly dispersed through this matrix, which, taken as a whole, is by no means rich. Many lumps of this copper-bearing formation of more than a foot square had been extracted; it may therefore be inferred that it is a large one—the only fact of favorable significance we observed in the mine.

Water enough for washing the ore flows through the gallery we entered, and a pretty rivulet passes within half a mile. The neighbourhood is in general very scantily wooded.

At *Goron* we picked a few small pieces of copper pyrites, and some stones stained with the green carbonate of copper, from amongst the *debris* at the base of a low cliff, in which some mining operations are reported to have been formerly carried on; but all traces of the openings, if any existed in time past, have been obliterated by fallen rubbish, which now covers the ground. The rock is talc-slate, usually of a pale brown hue, its beds bearing 5° — 10° S. of E. and N. of W. and dipping N. 38° — 45° . Enormous beds of siliceous limestone, traversed by numerous minute veins of quartz, interlie the talc-slate; but neither in one nor other of them is there trace of metalliferous bed or vein. The neighbourhood may be considered, for practical purposes, destitute both of wood and of water, nor does there seem a single inducement to the institution of further examination.

At *Agur* and at *Sahloo*, near Dhoola Devi, in the iron district of Chowgurhka, traces of copper pyrites, purple copper ore, and the green arseniate of copper were observed, but in quantities far too small to be of economic importance. Their mode of occurrence will be described hereafter.

6. The Southern slopes of the lower mountain range adjoining the Bhabur are composed of sand-stone,* for
 Iron ores. the most part very siliceous and of ordinary

* Capt. Herbert, *Journal of the Asiatic Society*, No. CXXVI. Supplement (1842), p. 133.

texture, but sometimes it contains layers of quartzose conglomerate, and occasionally beds of clay occur. Its general hue is pale buff passing into grey, but portions of it are red, and there are numerous patches of various tints of brown.

We were conducted to four localities on this formation, namely, *Loha Bhabur* and *Dechowree* near Kaleedoongee, and *Bejapoore* and *Jham* near Huldwanee.

At *Loha Bhabur* we saw two beds of clayey sand-stone, tinged in some places deeply with brown iron ore; one of these was about 10 and the other about 12 feet in width; one was visible in a ravine only, and the other in a few ill-directed openings, which had been recently made; sufficient to found a judgment on, was not exposed in either of them. In the neighbourhood loose stones of iron ore, some of them rich in metal, occur amongst the earth at the surface, but the parent rock of any of these had not been found *in situ*. Little or nothing had been done at *Dechowree* at the period of our visit; our information was therefore derived from inspection of the sides of two ravines only. In one of these a mass of greyish sand-stone, much impregnated with earthy and scaly red iron ore, was visible, for perhaps 4 or 5 fathoms in width on one side of the glen—on the opposite side it was covered with earth and vegetation. The second gully is about a quarter of a mile from the first; the iron-stained sand-stone bed is visible in it also, but its width could not be ascertained there, nor were the portions shown us of much, if of any, commercial value. As at *Loha Bhabur*, we picked a few stones of good ore out of the vegetable mould, but could find nothing like them *in place*. Three openings had been made into the mountain side, within a distance of 16 fathoms, at *Bejapoore*, and had intersected a bed of talcose clay, without, in either case, ascertaining its breadth, which however may be estimated at 20 feet at least. This clay bed is every where much traversed by joints, which are *faced* with earthy-red iron ore. Through the body of the clay are irregularly dispersed small kidney-shaped nodules of red iron ore, frequently not larger than a pea, but sometimes nearly as large as an egg: the greater number

however are perhaps about the size of a filbert. In the central part of the clay they are scarcely as numerous as they are near the sides, but this is not without exceptions. Although the ore is of excellent quality, and the earthy matter with which it is associated is not objectionable to the smelter, it is scarcely rich enough, as a whole, to be profitably employed alone : as a mixture, however to assist the fusion of richer ores, it would be valuable. Nothing had been ascertained of its length, except the 16 fathoms already mentioned, but an opening had been made about 10 fathoms farther East, in which, when we left the district, ferruginous stains only had presented themselves.

At *Jham* two openings had been made in a bed of clay, similar to that at *Bejapoore* ; its width in the deeper spot was 15 feet, and we estimated that from one-half to two-thirds of it, consisted of the kernels of red iron ore already mentioned. The numerous joints were in like manner full of ferruginous clay. The upper opening, about 6 fathoms higher, had not developed the width of the bed, but a vein of red iron ore, of from 3 to 4 feet wide, had been intersected.

The direction of the formation could not be ascertained at *Loha Bhabur* ; at *Dechowree* and at *Bejapoore* it seemed about S. E. and N. W., and at *Jham* it appeared to be about 10° N. of E. and S. of W. : the dip observed was always towards the S. or S. W. except at *Bejapoore* where it is N. Generally the bearing and dip seem to have some relation to the directions & slopes of the neighbouring mountains.

As so little has been done on this formation, and that little scarcely directed to the determination of the points of economic importance, nothing certain can be yet stated regarding the extent of the deposit in each place. We satisfied ourselves by the examination of several glens, transverse to the generally observed direction of the iron formation, that it is not continuous through the whole district from *Kaleedongee* to *Jham*, a distance however of perhaps twenty-seven miles. Assuredly, enough has not been yet ascertained respecting the iron ores of the *Bhabur* to warrant any expensive experiment on them, but we saw sufficient to convince us

that the district was worthy of further examination. A fact of some significance is however that but few and trifling traces of the labours of native iron smelters occur in any part of it, although they are numerous enough in every other mining field we have examined.

Limestone is quarried for use within four or five miles of Huldwanee; water-power to almost an unlimited amount may be obtained in the immediate neighbourhood, and fuel sufficient for experimental purposes, during perhaps seven years, is at hand; but the district does not afford enough for the permanent supply of a large blast furnace. During the cold season the climate is a healthy one, but as the heat and rain approach, it is disagreeable and dangerous; and even the natives, who work there in the winter, retire to the upper country as summer advances.

The Dhuniakote* district comprises the *Ujowlee*, *Kyrna*, *Kyroolee*, *Patol*, *Khuloagar*, *Hurchinolee*, and *Tutyle* mines, and others of smaller importance, all which are situate in the valley of the Cosila and its tributary glens, but they are so separated from one another, that if any connexion subsist between them, it is not easily traced.

Khuloagar, *Hurchinolee*, and some smaller mines are so ruinous, that, as facilities for the extraction of ore, they may almost be said to have ceased to exist. The rubbish at the surface is for the most part blue calcareous slate, amongst which we found at *Hurchinolee* some small pieces of specular iron ore mixed with lime. *Ujowlee* was wrought near the top, and in the face of a steep cliff, which rises perhaps 3,000 feet above the Cosila, in limestone, which, at not very distant spots, varies much in appearance, but is always siliceous. The beds are rather thin and irregular; they bear about S. E. and N. W., and at varying angles (50°—70°) dip. N. E. They enclose vein-like masses, generally of specular, but sometimes also of brown iron ore, which are rarely more than a few feet, often inches only, in length, or exceed a few inches in width: in this

* Capt. Herbert, *Asiatic Researches*, Part I. (1829) p. 254; Mr. Commissioner Batten, *Official Reports on the Province of Kumaon*, p. 300.

respect, too, they are most irregular, appearing, enlarging, dwindling, re-opening, dying out, and re-appearing, capriciously within very short distances.

The neighbouring forest is not extensive, but the oaks in it are of magnificent size. The banks of the Cosila abound in furnace material, and the stream within sight is a larger one than will supply all the wants of this mine.

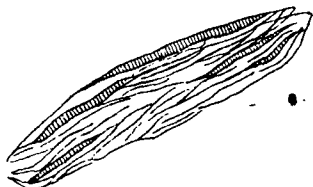
A mass of quartz many fathoms in width, bearing N. and S. and dipping E. 52° — 60° , appears in the Southern bank of the Cosila, within half a mile of the Kyrna suspension-bridge. Great part of it is ferruginous, but none is sufficiently so to make it an object of importance.

Immediately at the Western end of that bridge, the face of the cliff presents the outcrop of a ferruginous bed, of about 5 fathoms in width, which bears 15° S. of E., and N. of W., and dips 40° S. The mass of it consists only of iron-stained quartz, but fibrous, compact, and earthy-red iron ores are irregularly distributed through it, as isolated lumps, or short veins, seldom exceeding 3 or 4 inches in thickness. Much the larger portion of the formation is too refractory for the native smelters; but, following the more fusible ores, they have worked holes as much as 5 fathoms into the precipice, over an extent probably 8 fathoms in height. The same bed has been traced on the opposite side of the river S. E. and N. W. in the mountain above; but the openings of the miners are now crushed and deserted. Furnace-materials, lime, and water-power in excess of any possible demand, exist in the immediate vicinity; but wood is not plentiful.

A bed of brown iron ore, much mixed with quartz and abounding in drusy cavities, lined with incrustations of lime, of about 4 or 5 feet in thickness, bears about S. E. and N. W., and though occasionally horizontal, has a slight prevailing dip. S. W., has been wrought to a depth of about 4 fathoms, and a width of perhaps 3, in the face of a cliff which rises probably 2,000 feet above the river at *Patol*; and at *Kyroolee*, about 20 fathoms beneath, there are traces of a similar, but perhaps a richer bed, of ore having been

formerly mixed ; but a land-slip has nearly obliterated all traces of the openings. From time to time a few stones of ore are picked from the ruins, to supply the single small native smelting furnace of the district, which still exists at *Khuloagar*.

In the Northern of the two yet existing excavations at *Tutyle* has been wrought to some extent a bed of brown iron ore, similar in nature to that of *Patol*. Its thickness is about 4 or 5 feet, dip 30° — 36° N. and bearing nearly E. and W. The rock near it is a blue and buff-coloured calcareous slate, coincident with the ore in position. A second series of operations was formerly carried on about a mile Southward—upward in a calcareo-siliceous rock, but below in a greenish blue talcose slate, of which the cleavage planes bear about 10° E. of N. and W. of S. and dip 35° — 40° W.



Thin beds of micaceous specular iron ore, frequently of but the fraction of an inch in thickness and only a few inches in length, interlie the slaty laminae ; but the extent of the formation is not ascertainable, as the excavations are crushed, ruinous, and inaccessible. Until recently there was a third series of openings in this neighbourhood, but a land-slip has destroyed them all.

These mines are naturally furnished with lime, and copious streams flow within convenient distances of them, but fuel is very scarce.

Although this district is not so rich in iron ore as some of those of which we have to speak hereafter, we have still seen it in abundance. Limestone, furnace materials, and motive power exist in excess of any probable demand for them. Fuel however may be said to be entirely wanting. In spite therefore of its natural advantages, and of its vicinity to the plains, the deficiency of fuel has doubtless occasioned the abandonment of the *Dhuniakote* district, and the retirement of the iron miners and smelters from it to the, at least equally, valuable iron fields of the interior, which are better furnished with fire-wood.

The characteristic, if not the only, feature of the *Agur* or *Ramgurh** district is a large and rich bed of iron ore, which has been traced at short intervals in a S. E. and N. W. direction from beyond *Purturburà* to the valley South of *Pewrah*, a distance of probably seven miles. Whether the ore formerly wrought at *Pahlee*, near the *Ramgurh* suspension bridge, may be a branch of this extensive deposit or an independent and separate formation, we have at present no means of determining.

The ferruginous bed at *Pahlee*, like the larger one before alluded to, bears about S. E. and N. W. and dips towards the N. E. Three galleries, about 3 fathoms apart, have been extended into the mountain side one above another, and the iron ore (the micaceous specular variety) is represented to have been 3 feet wide in the upper and 2 feet in the two lower of them. These openings are much damaged, it is therefore impossible to go far enough into either of them, to get a sight of the ore.

The most extensively wrought, and therefore the best known, formation of iron ore in the district, is traced from *Shealgar*, about two miles North of the *Ramgurh* valley, beyond *Purturburà*, fully five miles South of it, through the mines of *Shealgar*, *Guarocoolce*, *Lusghancee*, *Nutoa Kanh*, *Gallà*, *Dhoora Kanhi* (1), *Capuà*, *Currocoolee*, *Bhoomkake*, *Bunnà*, *Chocootà*, *Purturburà*, *Udarke-Kanh* and *Dhoora Kanhi* (2). Although there are flexures, in which it takes an E. and W. direction, the general bearing is S. E. and N. W., and its dip is towards the N. E. 30°—50°. All the mines enumerated are on the outcrop of the formation and at considerable elevations, except *Bhoomkake* and *Bunnà*, which are on the dip of the bed below *Capuà* and *Currocoolee* and *Purturburà*, which is wrought as well on the slope as on the crest of the mountain. *Shealgar*, *Guarocoolce*, *Bunnà* and *Udarke-Kanh* seem to have been worked open to the day, and *Capuà* to some extent in the same manner: all of them are however now full of rubbish, and an inspection of them affords but little information indeed of *Udarke-*

* Capt. Herbert, *Asiatic Researches*, Part I. (1829), p. 254.

Kanki and *Dhoora Kanki* (2) scarcely even traces remain. *Lusghanee*, *Nutoa Kanh*, *Gallà*, *Dhoorà Kanki* (1), *Chocootà* and *Purturburà* were wrought by means of shafts,* and many of them, although the wooden supports are in a state of decay, and the rocky sides crushed and cracked, are still open. The ruinous condition of every mine in the district limits our information, concerning them in great measure to the statements of the workmen in their respective neighbourhoods, except of the nature of the ores and this was derived from searching the heaps of rubbish and of ore broken too small for the use of the native smelter, of which we found great quantities at the surface.

<i>Mine.</i>	<i>Description of ore.</i>	<i>Thickness of the bed of ore.</i>
<i>Guarocooloc</i> ,	Oxydulated and brown iron ore with oxide of manganese,	A few inches.
<i>Lusghanee</i> ,	Micaceous iron ore,	6—8 feet.
<i>Nutoa Kanh</i> ,	Micaceous iron ore,	7—9 feet.
<i>Gallà</i> ,	Micaceous iron ore,	7 feet.
<i>Dhoora Kanki</i> (1),	Micaceous and brown iron ores,	4 feet.
<i>Capud</i> ,	Micaceous brown and oxydulated iron ores,	1—3 feet.
<i>Chocootà</i> ,	Brown iron ore and carbonate of iron,	4 feet.
<i>Bunnà</i> ,	Brown iron ore,	Unknown.
<i>Purturburà</i> ,	Brown iron ore,	10—12 feet.

The particulars contained in these columns show so far as can be, without the personal inspection, (which has been seen to have

* The shattered condition of the shafts, and except two only, their having been unentered for some years, and these two not lately, the absence of workmen, and the detection of foul air in one of them, prevented our descent. At *Purturburà* we were informed that all the interior of the mine was crushed and inaccessible, and that the ladders and wood-work which propped the sides of the shaft had been removed only a few days before our arrival there. A rope was brought to lower us into the workings, but this, considering the reported state of the mine, we declined. The lease of the tenant expired in about a week after our visit.

been impossible,) the very great abundance of iron ores of various kinds in this district.

It is remarkable, that whilst specular iron ore prevails in the mines of the Ramgurh valley, the brown and oxydulated ores abound in the same bed both North and South of it. Near Ramgurh the rock is a talcose slate, and this is also the case at Chocootā and *Purturburā*. In all the other mines it is clay slate, chiefly of a blue colour, but a buff tint sometimes prevails, and in rare instances it is red; still talc is everywhere more or less visible.

Traces of limestone occur near *Nutoa Kanh*, and though the country is rather an impracticable one, the lime of the *Cosila* is not very distant. Materials for furnaces are abundant in every part of the district. The *Kyrna*, where it joins the *Cosila*, is a considerable stream, but in the Ramgurh valley it is but a small rivulet, and it flows through a cleft in the mountains, so deep and so narrow as to materially diminish, if not to destroy, its utility as a motive power, for a considerable distance from the mines.

A small forest of fine oaks occurs within about three miles of *Nutoa Kanh* and five or six of *Purturburā*, but with this exception the district is destitute of fuel. The few noble trees near *Ujovlee*, in *Dhuniakote*, are perhaps not more than six miles from *Lusghance* and *Nutoa Kanh*; but the whole of the wood in the three districts already described will not feed one large blast furnace for seven years.

This valuable bed of iron ore bears obliquely to the mountain range which it traverses—the mines are therefore sometimes on the crests, sometimes at the foot of the hills—a circumstance opposing many difficulties to the making one road common to them all.

Here, as in *Dhuniakote*, the mines are entirely deserted, the miners betaking themselves to the productive and more actively wrought tracts on the banks of the Ramgunga. The exceeding scarcity of fuel in *Agur* is an obvious cause of this migration, but many of the people are also employed on the extensive Government works now in progress for irrigating the *Bhabur*;* when

* Mr. Commissioner Batten, *Official Reports on the Province of Kumaon*, p. 304.

driven thence by the heat, they return home; but even in the Ramgurh valley and in Dhuniakote the summer is very oppressive.

The mine of *Mungla Lekh*,* in Kalee Kumaon, is worked in clay slate, occasionally of a dull blue colour and thick lamellar structure, although it is mostly somewhat fissile, with an uneven cleavage, and is of a dead pale blue hue, with glossy spots of dark blue. Its lamination bears E. and W. and dips 18° — 25° — 40° N. Four beds of ore, coincident in position with the structure of the adjoining rock, occur in the accessible parts of the mine: the principal deposit averages about 6 feet in width, and the smaller ones perhaps 2, varying from $1\frac{1}{2}$ to 3 feet: they are separated from each other by beds of slate of from 2 to 5 feet in thickness. The ore is for the most part the micaceous variety of specular iron ore; in some parts indeed it is exclusively so, in others however laminae of brown iron ore interlie those of the micaceous kind, and sometimes masses of the former are imbedded in the latter. In these cases irregularly crystallized groups of oxydulated iron ore, slightly magnetic, are included by the brown ore. We examined four different excavations, of which two are on the ore *in place* and two were ancient openings in course of preparation for being re-wrought. It is impossible to enumerate the pits and holes within an area of half a mile square: there are probably scores of them, which, although unwrought at present, give evidence of the activity of former operations. Of the shafts we entered, the first two are about 7 fathoms deep and the others about 4 and 15 fathoms respectively. Two horizontal galleries (*adits*) extend from the surface to the bottom of the mine, and through these it is effectually drained, a means we had seen nowhere else, probably because the other mines afforded no water.

Materials, of which furnaces may be made, are found in the mine. A fine river flows within about a mile and a half, but at perhaps 1,500 or 2,000 feet beneath it. We neither found nor could learn that lime existed in the neighbourhood. Wood is scarce in the

* *Ibid*, p 288.

immediate vicinity, but sufficient for present purposes occurs within four or five miles. The mines of Chowgurahka* are so isolated that it is impossible to treat of them in connexion. If any relation exist between them it is unknown, and there are at present no means of detecting it.

At *Pahlee*, on one of the tributaries near the head of the Punaar valley, the rock is in general a blue clay slate, but portions of it are brownish, many of its beds are quartzose, and thin siliceous laminae interlie the slate. The beds are not uniform in direction, as they conform in some respect to the outline of the mountain in some places, therefore they bear about 15° N. of E. and S. of W. and in others N. E. and S. W.; their dip is towards the N. W. 18° — 20° ; and the iron formation corresponds with the slaty structure both in strike and inclination. The ore is of the massive brown variety, everywhere mixed with some quartz and a little slaty matter, and its thickness varies from $1\frac{1}{2}$ foot to 3 feet, the average being probably rather more than 2'. Operations are at present confined to the vicinity of two shafts about 5 fathoms apart, and about 12 fathoms deep; but there are still many ancient shafts open, though now unwrought in the mountain side, and many more have been filled up, and are still being so, to give place to cultivation. The smelter here, as in very few other places in Kumaon, calcines his ore previously to smelting it.

As usual elsewhere, the neighbourhood of the mine has been closely shorn, but plenty of fine fuel still remains at the head of the Punaar valley, in which the river affords more than ample motive power within quarter of a mile of the ore. Ingredients for fire-bricks abound, but we could neither discover nor learn the presence of lime.

The *Bunna* mine, near Ockelgurh, in the valley of the Punaar, is wrought for about 15 fathoms in length and 40 to 50 in depth, from four different openings, one above another in the mountain. The rock is a thick lamellar talc slate of a pale buff hue; its beds

* *Ibid*, p. 300.

bear 20° S. of E. and N. of W. and dip S. 40° — 70° . The ore is the micaceous variety of specular iron of remarkable purity in general, though the central portion of it is occasionally a little mixed with talc and quartz: it varies a little in width, but is on an average about 10 feet in breadth. Beside the shafts whence the mine is now worked, there are two others, one of which is full of rubbish and the other has not yet reached the ore.

Lime occurs at Kumolna, about 5 miles from the mine; a bed of excellent furnace materials occurs within a few fathoms of the iron ore, but beneath it, in the same series of rocks. The Punaar river flows within quarter of a mile of the mine; more water power than can be required for many years is therefore at hand. In the immediate neighbourhood of *Bunna*, wood is not plentiful, but would become so within a few years, if protected from the wasteful ravages of the natives; at present the mountains which bound the Punaar valley afford pine forests sufficient to supply every demand.

Near Dhoola Devi, the *Schloo* mine has been wrought open to the day on a bed composed for the most part of compact brown mixed with earthy-brown and yellow iron ore, generally sprinkled with a small proportion of quartz, which is rather more plentiful in the middle than at the sides. Towards the lower *wall*, there are a few small lumps of copper pyrites, purple copper ore, and green arseniate of copper; but altogether the quantity of copper ore is too small to affect the general quality of the iron deposit. The direction of the bed is about N. and S., its inclination 50° E. and for an extent of 6 or 7 fathoms long a width of about 10 feet of ore has been wrought; but this does not comprehend the whole, the size of which has not been ascertained. Here, as at *Pahlee*, the ore is calcined before it is smelted. The rock adjoining the ore is talcose and its structure massive.

For present purposes the wood in the neighbourhood is sufficient, but the forests are not extensive. Fire-stone is found in the vicinity, but we found no lime nearer than Kumolna. Water is scarce.

There are many traces of ancient mining at *Agur*, but one mine only is now wrought there. The rock is a pale brown talc slate, of which the beds bear nearly S. E. and N. W. and the dip is S. W. 16°. The metalliferous deposit is of compact earthy-brown and earthy-yellow iron ore, the *gossan** of the Cornish miner, in a matrix of talc in about equal proportions of earthy matter and of ore, and is about 2 feet in thickness. An extent of only 7 fathoms in length and 5 feet on the inclination of the bed has been wrought.

Two other spots, within about half a mile, were formerly *worked* to a trifling extent, but they have been for some time abandoned. Some excellent, though rather small, specimens of copper pyrites were obtained from amongst the rubbish at the surface of one of them, dispersed through a matrix of cellular yellowish-brown iron ore, mixed with a little quartz, which is in most places considered a congenial one to copper ore. The quantity of ore is however so small, that it will scarcely attract the attention or stimulate the hopes of the copper miner.

Materials for the construction of furnaces are plentiful in the district, but wood is not abundant, and water is scarce.

The climate of the Punaar valley, like that of the Bhabur, drives the inhabitants to the higher grounds during the warm weather; for about half the year therefore the mines remain unwrought.

All these mines are in remote situations and are accessible with difficulty.

The Kotelar and Khetsaree valleys† empty their streams into the Ramgunga at Gunnai; the former from the South, the latter from the North. They thus form, as it were, one continuous vale of about

* Cornwall Royal Geol. Soc. Trans. V., p. 204.

† Capt. Herbert, *Asiatic Researches*, Part I, (1829), p. 255, and *Journal of the Asiatic Society*, No. CXXVI. Supplement (1842), p. 103; Lieut. Glasford, *Ibid*, No. LXXXIII, (1838), p. 473; Mr. Commissioner Lushington, *Ibid*, No. CXXXVIII. (1843), p. 469. By far the best and most practical account of these mines however is that of Mr. Deputy Collector Beckett, *Selections from the Records of Government, N. W. P.* Part XIII (1853), p. 67.

fifteen miles in length, from near Dwarra Hath on the South to the pass of the Simul-khet in Gurhwal on the North; lowest about the middle and rising towards both extremities. On the East the Kotelar and Khetsaree valleys are bounded by a range of mountains which bear nearly N. and S., intersected by numerous deep glens and rocky ravines nearly at right angles, of which the chief forms the bed of the Ramgunga. Much the larger formation of this district is clay state, occasionally fissile, but more commonly of thick lamellar structure; its texture is usually homogeneous, and its hues are pale blue, buff, brown and purple. The *strike* of its beds is nearly parallel to the axis of the range, and the dip is towards the East, for the most part at a low angle, but subject to many variations and occasional contortions by thin strings of quartz, which are numerous. Masses of green-stone, of flinty slate, and of common jasper are not uncommon; rocks of coarse quartzose conglomerate abound at the base of the mountains, having probably fallen from the summit; and a schistose calcareo-siliceous rock, sufficiently rich in lime for the iron smelter's purpose, is abundant throughout the district.

At *Soongaree*, a tributary which empties its waters into the Khetsaree valley, a few stones of specular iron ore have been picked out of the rubbish which has fallen from a cliff above and covered some ancient mining works. Small quantities of similar ore occur in a quartzose vein of about 18 inches in width, which traverses the clay slate formation in a direction 15° E. of N. and W. of S., dipping about 20° W. About a furlong from this locality, an ancient, but now ruinous, gallery has been cut in the river's bank, but nothing can be learnt from it at present. Nothing indicates that this spot was ever a productive one, nor does any thing offer a prospect of its becoming so.

A trivial opening was made some years since at *Baroollee*, on the Western side, and near the head of the Khetsaree valley. A few small bits of specular iron ore were found amongst the rubbish at the surface, but neither they nor the rock offer encouragement to further examination.

On the way to the, *Nowta* mine, about a mile and a half N. W. of *Pokree*, some specular iron ore, enclosing small crystalline lumps of oxydulated iron ore, were obtained. The requirements of the district are few, and when ore sufficient for them had been extracted, the opening was abandoned, and is now closed.

The summit of the Beanssee mountain affords some compact and earthy-red iron ore, but it has not been traced. Whether it may have relation to either of the trifling deposits just enumerated, whether they may be connected with one another, or whether there may be any mutual dependence between them and the great and characteristic iron formation of the district, is at present unknown.

That formation, far the richest, largest, and most extensively wrought in Kumaon and Gurhwal, bears nearly parallel to the valleys of Kotelar and Khetsaree, and to the *strike* and dip of the clay slates which compose the mountains which form their Eastern slopes. It is traced from near Dwarra, Hath, on the South, beyond the pass of Simul-khet on the North, through the mines of *Tilpoora*, *Chitalee*, *Burrulgaon*, *Khetsaree* and *Simul-khet*, all now actively wrought, as well as through the abandoned mines of *Siroolce*, *Godee*, *Boneegurh* and *Rampoore*. Parallel to the valleys, its dip is *from* them, and *into* the body of the mountain chain; its outcrop is for the most part from one-half to two-thirds of the way up their sides. Thus, though its inclination forbids the best possible position, it is very conveniently situated for mining operations. In width this formation, like that of every other metalliferous deposit, is variable—at *Tilpoora* it was not more than about 2 feet, at *Burrulgaon* it is 4 or 5 feet, at *Khetsaree* 18 feet, whilst at *Simul-khet* we saw more than 30 feet, but without reaching either of the sides (*walls*.) The positions of the mines, as well as our own examinations, lead to the belief that, like as in every other ore bearing formation, there are alternations of poverty and riches; the richer *bunches* in *Simul-khet* at least having a northerly inclination (*shoot*) in the vein, a position with regard to

the nearest granitic formation at Dwarra Hath, which exhibits a perfect similarity to every other district I have explored.*

The prevailing ore is compact red iron ore, much penetrated by irregular masses of earthy-red iron ore, and affording occasional stones of the same mineral exhibiting a fibrous structure. Quartz in greater or less abundance occurs amongst most of the compact ore, and jaspery iron ore is not uncommon. The whole formation exhibits numerous small drusy cavities, which are frequently lined with incrustations of the carbonate of lime.†

The lime dispersed through the iron formation is, considering the admirable quality of the ore, probably sufficient for the smelter's purpose, but an extensive deposit of a siliceous limestone occurs at *Burrulgaon*. Materials for the manufacture of fire-bricks are found in abundance both at *Simul-khet* and within three miles of Gunnai, of unsurpassed quality.

The rapid fall and powerful stream of the Ramgunga offer every facility for the erection of machinery, and afford means of supplying blast for furnaces to almost any extent, without the necessity for costly or complicated apparatus. Excepting on their summits, the mountains both E. and W. of Kotelar and Khetsaree are but slightly clothed with wood; but some parts of the Tarag-ke-Tal glen, portions of the banks of the Ramgunga towards Kala-bun, and spots on the Western slope of the Jorassee range, afford a tolerable sprinkling of timber, within about six or eight miles of Gunnai; the fine oak forests beyond Lobha are not above ten miles distant, and are scarcely six miles from *Simul-khet*. To this subject I must necessarily revert. The great road from Almorah to the interior is within half a mile of the iron formation to which it runs parallel.

* Cornwall Royal Geol. Soc. Trans., V., p. 193.

† A second, but a much smaller, bed of iron ore occurs West of the principal one at Khetsaree, but it has been little noticed; it is therefore not known whether it is a mere branch of the great formation or a separate deposit. Northward the small opening at *Baroollee* is not far off its line of bearing.

7. Having thus, as far as practical purposes seem to require, described the localities, products, and peculiarities of the several mines to which we were directed, it is necessary, as a matter of economic importance, to mention the manner in which they are wrought by the natives.

Operations of the native miners.

Although the miners in Kumaon and Gurhwal use both *picks* and *wedges* ("gads"), the rude and clumsy implements they employ scarcely resemble, but in name and object, those used for similar purposes in England. With rocks, too hard for these tools, elsewhere blasted with gunpowder, the native method is softening by the application of heat, an operation which, in their small and scarcely ventilated openings, is of but small utility to him who employs it, whilst the smoke and foul air generated by it effectually stop the work of every other person in the mine at the time. The imperfection of his means, his ignorance of the advantages derivable from ventilation, and from economy of labour in extracting the broken ore through larger passages, as well as the smelter's inability to encounter successfully any but the richest and most fusible ores, therefore render it an object of paramount importance in the view of the native miner, to avoid by every possible device the opening of large galleries. In the iron mines of Agur, *Mungta Lekh*, Chowgurhka, and Khetsarce, as well as in the copper mines of Gungolee and *Dhunpoore*, in every district in fact, excepting that of *Pokree*, the same slow, inefficient, and wasteful mode of working prevails. The softer and more fusible ores, being far less abundant than those which are too refractory for the native smelting furnace, and being so intimately mixed that it is impossible to extract the requisite quantity of the former without breaking the latter also, in order to obtain the needful supply, it becomes necessary to make large excavations. A selection of the ores, therefore, as far as circumstances permit, is made in the mine, that which is unsuitable being heaped up within to such an extent as scarcely to allow the unimpeded work of the miner, and to preserve the smallest passage available for his exit and the removal of the ore. The

ordinary mode of extraction is in small bags made of skins, dragged over the rough floor of the opening by a person "crawling on *all four*," but in many places the aperture is too strait even for this, permitting passage only in a prostrate position, the sufferer propelling himself only by writhing, and by aid of his toes on the floor and his elbows on the sides of the hole. At *Seera*, the low, wet, unventilated, and ill-propped entrance to the mine is so small in every part, except that wrought under Goorkha rule, that children only of perhaps from 10 to 14 years are employed on the difficult and dangerous task of re-opening a hole through fallen rubbish, ill supported by small and half-rotten wooden props. Occasionally of course the galleries are larger, but it is rarely that the person passing them can rise even to a sitting posture—seldom indeed that he can advance stooping; walking erect is out of the question.*

I have however peculiar gratification in recording one remarkable exception to this rude, painful, wasteful, and unsystematic mode of mining, at *Pokree*.† We found Mr. Wilkins's valuable practical lessons still gratefully remembered, and his injunctions still observed by the natives. The galleries are of convenient dimensions, and they are kept in good repair, the wooden props employed in them being set up, if not in the very best, at least in a workman-like and efficient manner.

At *Simul-khet* the bed of ore is of such enormous dimensions as to admit sufficient ventilation, and of a far more efficient and economical mode of working than in any other of the mines, wrought by the untaught native operator; still even there it is susceptible of great improvement.

It is obvious that much valuable ore, easily convertible by European methods of smelting, are heaped up within the mines, in a manner so rude and insecure that it must frequently fall and prevent further access to them. The openings are so small, that

* Capt. Herbert, *Asiatic Researches*, Part I. (1829), p. 244; Mr. Deputy Collector Beckett, *Selections from the Records of Government, N. W. P.*, Part XIII., p. 69.

† Capt. Drummond, *Journal of the Asiatic Society*, No. LXXXIII. (1838), p. 934; Mr. Commissioner Lushington, *Ibid.*, No. CXXXVIII. (1843) p. 454.

it is very difficult, if not quite impossible, to re-open them. The miner therefore abandons them when thus closed and opens on another part of the formation. Thus the mines are stopped by the accumulation of ore within them, and not by natural impediments, or in consequence of exhaustion, which are elsewhere the causes of abandonment. But all ore brought to the surface is not within the native smelter's means; that which he is able to appropriate is therefore separated and taken to the furnace, whilst the rest is left as rubbish at the pit's mouth. Many thousand tons of rich ore thus lie neglected at idle mines.

It is plain that this dangerous and wasteful mode of working has already filled many mines in such a manner as to render them inaccessible and worthless to the natives. A similar fate hangs over every mine at present wrought, and it is clear that if a better and more systematic mode of operation be not adopted, the manufacture of iron by the inhabitants must at no remote period entirely cease.

Eight hours per day is about the usual duration of the miner's labour under ground.

We were informed at *Burrulgaon*, that two miners working together, break from 2 to 6 maunds (160 to 480 lbs.) of ore each per day, the average being about 5 maunds (400 lbs.) As the entrance to that mine is long and very small, this is probably rather below the mean of the district. At *Simul-khet*, where the excavations are longer and afford greater facilities to the workmen, Mr. Deputy Collector Beckett* states the day's work at from 8 to 12 maunds (640 to 960 lbs.) but this is perhaps considerably above the average. In other districts we found the daily labour of each miner sufficed to extract about 6 maunds (480 lbs.) of ore. The mean is probably under rather than over 500 lbs. of ore per day. Four coolies (labourers) are employed to draw out of the mine the ore broken by two miners, an

* " *Selections from the Records of Government, N. W. P., Part XIII.* (1853), p. 69.

operation which, with a wheel-barrow and through large and commodious galleries, one boy would accomplish with ease in the mines of Cornwall. The wear of each person's tools is supposed to be covered by about 8 annas (a shilling) per month. It is not easy to ascertain the earnings of the various classes employed in the mines. We were informed* that those of the miners averaged about 8 Rupees (16 shillings,) and of the coolies (labourers) 5 or 6 Rupees (10 or 12 shillings) per month each. In fact the various parties employed receive each a proportion of the iron manufactured, no wages being paid to any of them. No weekly day of worship or of rest breaks their constant daily toil; thirty days of labour may therefore be reckoned in each month, and each miner's ore in that time, at about 6 tons, of which the estimated cost is 28 shillings, or about four shillings and eight pence per ton.

The same disregard of method which has caused the relinquishment of so many iron mines prevails in the copper mines also; and taken in connexion with the poverty of the deposits has produced even more disastrous results, notwithstanding every particle of ore obtained is scrupulously preserved. For at *Kurrye* operations are confined to the surface, at *Seera* the gallery is choaked with rubbish, and but faint attempts are made to re-open it; whilst at *Agur* and *Dhutpoore* the straitness of the entrances, and the enormous heaps of carelessly piled refuse keep the lives of the workmen and the existence of the mines in constant peril. I need only mention the striking and advantageous contrast which *Pokree* presents to all the other mines.

8. Owing probably as much to the insignificance of native smelting operations on the small and scattered Condition of the forests. deposits of iron ore yet known, as to the unhealthy climate which prevails through the hot season, the lower slopes of

* By Kishna, our guide, lessee of the Government iron mines during several years past.

the mountains which adjoin the Bhabur afford fuel enough for the supply of such a small furnace as prudence dictates should precede a large smelting establishment in a new country. There is little or no pine amongst it, the greater part consisting of more slowly growing "*hard wood*," of a size rather large for being cheaply converted into charcoal, though in general small for mechanical purposes.

The Dhuniakote and the Agur districts may be said to be destitute of fuel; for the noble oaks, of which small tracts yet remain, are much too large to be advantageously used for the furnace.

At *Mungla Lekh* and in the district of Chowgurahka, although there is wood enough for present purposes, there is not sufficient in any single spot for the supply of even a small blast furnace; and the localities of the ore are so far apart, that the fuel of one can scarcely with advantage become auxiliary to another; still with economy the pine forests near the Punaar might, in a few years, become valuable.

The crests of the mountains which bound the Kotelar and Khetsaree valleys, the high grounds above the Ramgunga towards Kala-bun, the glen of Tarag-ke-Tal, and the Eastern and Western slopes of the Jorassee range, have all been pine forests; and though sorely wasted, their remains would supply sufficient fuel within six or eight miles of Gunnai for a small blast furnace, until the present shrubs, if immediately protected, would have grown to useful size. The fine oak forests beyond Lohba, in Gurhwal, probably exceed that distance, but within five or six miles of *Simul-khet* fuel of that description is abundant, although of a size too large to be cheaply available.*

In one of their operations the native iron smelters employ fuel scarcely more than an inch, and they rarely use any which exceeds three inches in diameter. To procure it of these dimensions, when

* Minute details of the condition of these forests in 1840-50 are given by Mr. Deputy Collector Beckett, *Selections from the Records of Government*, N. W. P. (1853), p. 78.

saplings are scarce, they do not hesitate to fell the finest trees, stripping them of their tops and branches only, and leaving, as we see by thousands, their magnificent trunks to decay.* This small charcoal is so light and so thoroughly burnt, that it is useless in a powerful blast, scarcely indeed sufficing for a smith-shop, where strong heats are required. Timber trees are by no means adapted for the smelter's use, for splitting them, that they may be thoroughly charred, adds enormously to the expense, whilst if burnt entire, the outside is almost consumed and rendered useless before the inside is properly carbonized. Trees of from 4 to 8 inches in diameter are perhaps of the size most convenient for the charcoal-burner; if smaller, the wood is often over-burnt; if larger, and it be charred entire, the objection already urged applies in full force.

The ravages committed on the forests by the natives attracted attention at least thirty years since.† Mr. Commissioner Lushington made strong representations on the subject,‡ which, has also been forcibly commented on by subsequent writers.§ Sometimes probably from unextinguished camp-fires, sometimes by sparks from the torches and pipes of travellers, but much more frequently intentionally, in order that the ashes of the dried herbage may manure the roots of the young grass, and thus provide pasture for their cattle, tracts of enormous extent are burnt by the natives. The largest trees do not wholly escape injury; saplings are so scorched and mutilated that their growth is almost stopped; and if they still live, it is only as stunted, deformed, and mutilated dwarfs: the younger shrubs are, of course, for the most part destroyed. The scarcity of trees in many districts, the crooked and ill-grown shrubs, and the almost entire absence of young trees, attest the extent of the mischief; whilst the blazing moun-

* Mr. Commissioner Lushington, *Journal of the Asiatic Soc.*, No. CXXXVIII. (1843), p. 469.

† Heber, *Indian Journal* (post 8vo., edit. 1840), I., p. 274.

‡ *Journal of the Asiatic Society*, No. CXXXVIII. (1843), p. 469.

§ Mr. Deputy Collector Beckett, *Selections from the Records of Government*, N. W. P. (1833), p. 71—5.

tain sides which we have so often seen prove that the work of destruction is still in progress. Thus, whilst the ravages of the charcoal-burner destroy the older and larger trees, the fires of the neatherd and of the traveller prevent the renewal of the forests. Repeating therefore, that whilst the neighbourhood of the Ramgunga, near Gunnai, and perhaps also the vicinity of the Bhabur (if iron ore enough were discovered there,) afford fuel sufficient to feed a small blast furnace, such as would be recommended by a prudent regard to the difficulty and expense of large and rapid erections in a new country unaccustomed to them, to the want of skilful workmen at wages low enough to make their labour remunerative to their employer, and to the present absence of roads; I am bound to say that we have, in no district we have examined, seen forests sufficient to supply *at present a large* blast furnace within practicable distance of the iron ore.

Throughout Kumaon and Gurhwal the average price of charcoal delivered at the furnace from forests within four miles is about three annas ($4\frac{1}{2}$ pence) for 30 seers (60 lbs.) or about fourteen shillings and eight pence per ton (of 21 cwt.)

SUGGESTIONS OF IMPROVED MINING OPERATIONS.

9. The foregoing details have shown the existence of copper ores sparingly dispersed through many localities, and of iron ores of the richest description in inexhaustible abundance through various parts of these provinces, our next enquiry is how they may be most cheaply and speedily rendered to the smelter.

The present narrowness of the openings, and the abundance of ill-supported rubbish within the mines, render the access to them so slow and difficult as not only to impede the workman's operations, obstruct proper ventilation, and render extraction of the ore much more expensive than is necessary, but to endanger even the existence of the mines and the lives of the miners.

An alteration, most imperatively demanded, is the opening in each mine a gallery (*level*,) high and wide enough to permit the

labourer's entrance in an erect attitude, and to admit of his using the wheel-barrow through it. If not perfectly horizontal, it should decline at the mouth,* merely sufficiently to allow the free escape of any water which might fall within.† The use of the wheel-barrow should be everywhere introduced, and the employment of the English-made mining tools, which we have brought out, should be taught, and their far greater efficiency, than that of the implements at present used by the natives, should be carefully and continually pointed out to them. Any prejudice of country or caste, which may exist, can be readily obviated, I presume, by the employment in each locality of some of the native miners who were taught to a great extent the use of all these improved appliances by Mr. Wilkins at *Pokree*.

The expiration of all the mining leases at the end of April leaves nothing to prevent the immediate introduction of all these improvements. Whether, if sanctioned by Government, they should be introduced at the public expense, a higher royalty being charged on the mines, as soon as they become available to the native workmen, in order to re-imburse the outlay : or whether they should, under competent supervision, be carried out by the native miners themselves, a lower rate of *dues* being receivable from them whilst penetrating the less productive parts of the iron deposit and whilst unskilfulness in the use of unaccustomed tools interfered with the extraction of ore, is a question which can probably be best decided by the local authorities, who have an acquaintance with the habits, feelings and prejudices of the people, to which we do not pretend.‡ In whatever manner the tempo-

* The mouths of most of the native galleries are higher than their interior.

† Although the water escapes through an *adit* at Mungla Lekh, the ore is brought to the surface over the sloping side of the formation, at perhaps four times the labour which would have taken it through the gallery.

‡ It is to be feared, that the poverty of the people will not permit them to undertake anything not immediately remunerative, and therefore that the improvement must be made at the expense of Government in the first instance.

rary deficiency of revenue is to be arranged, the operations should be under the entire direction of the Government mining agents, who should be *practical* miners: a mere theorist without experience would probably, if possible, render what is bad now still worse.

In all the many mining districts it has been my lot to examine, the proprietor of the land, whether public or private property, employs a competent person to inspect the operations of his lessee,—the miner, whose lease binds him, under penalty of fine or forfeiture, to conduct his researches on the best and most approved system of mining; a measure which assures the proprietor that his property is fairly wrought and yields sufficient return, without unduly exhausting the richer parts, or leaving unworked the poorer parts necessarily to be pierced, in order to reach productive ground beyond them, which occur with greater or less frequency in every metalliferous deposit. Such an office has not yet existed in this part of India, but I respectfully submit the necessity for its immediate creation. Thus, for his own ultimate advantage, no less than for that of Government, compelled to work under official supervision, the miner would doubtless, and with reason, demand a longer term of lease than one year, in order that he might in the latter part derive advantages from the less productive labour expended at the commencement of his tenancy. In Cornwall mining leases are commonly for twenty-one years; but a shorter period, perhaps for five, seven, or at most ten years, might, for obvious reasons, at the commencement of a new system, be most convenient for both parties.

SUGGESTED PRESERVATION OF THE FORESTS.

10. But should the alterations in the management of mining property, which I have had the honor to submit, be sanctioned by Government, it will merely prolong, without ensuring, the continued existence of the mines, unless a supply of fuel to the smelter, which is now seriously threatened, be secured by preservation of the forests. This involves no privation, either of pasture or of fuel, to

the inhabitants, for there is ample room for both, and for the protection, from the trespasses of cattle, and from the ravages of fire, of wood land sufficient to satisfy the wants of the smelter. The land thus set apart for the use of the "iron" manufacturer should be guarded from all incursions of the farmers and of their cattle, and should be subject to the control of the Government Mineral Surveyor, without whose leave no timber should be felled by either miner or smelter. The same natural causes which existed when the largest pines were planted are still in operation, and would equally aid the growth of young trees at present. I therefore venture to submit the expediency, as well of founding a nursery, as of planting out young trees on the mountains and protecting those of larger growth. There are, I believe, in every village, local authorities who exercise some command or controul over their neighbours. Whether they might be usefully employed to a certain extent as foresters or wood-rangers, without any very material expense, is a question which, with many others relative to the same important subject, the resident officers of Government can discuss and arrange far more ably and easily than my necessary want of local experience will permit me to do, the only absolute necessity being that the protection should be perfect. Seven years of vigilance over a well-selected tract of the pine forests near Gunnai will secure ample supplies of charcoal for as large a blast furnace as prudence would dictate the erection there. Where oak and other "*hard wood*" occur, the protection must, of course, be a much longer one to ensure fuel of the same dimensions. An obvious duty of a Superintendent would be to furnish the Government with minute periodical Reports on the state of the forests, and the condition and prospects of the mines.

EXPERIMENTS IN MINING AND SMELTING.

11. Until a thorough examination of every locality had enabled us to select a spot which offered the greatest facilities for operations, and the best prospects of success, it was not thought desirable to commence the experiments authorized by Government. The con-

ditions which bear on this enquiry in each of the iron districts are briefly recapitulated in the following columns :—

Districts.	Situations of Mines.	Qualities and supplies of Ores.	Limestone.	Fuel.	Water.	Furnace Materials.	Means of Communication.
Bhabur, ..	Four openings; two near to, two far from each other, ..	As supply not yet developed. Red and brown ore scattered through clay, ..	Abundant within 4 or 5 miles, ..	No pine: "hard wood" sufficient for a small blast furnace, ..	Abundant in one spot, moderate in others,	On edge of the plains, roads very good.
Dhuniakote, ..	Scattered, ..	Chiefly brown; but some red and specular ore also. Ore abundant, ..	Abundant, ..	No wood fit for charcoal, small tracts of fine oaks, ..	Abundant, ..	Abundant, ..	Good road through district, paths from it very bad.
Agur, ..	Mines, or one large bed for miles in length, ..	Mostly brown, but a little oxydulated, and specular ore also. Ore in great abundance, ..	Little at hand, plenty 5 miles distant, ..	No wood suitable for charcoal, small quantities of fine oak timber, ..	Scanty and inconvenient, ..	Abundant, ..	A good road across district, side roads from it scarcely passable.
Chowgurb-ka, &c., ..	Scattered, ..	Brown, specular and oxydulated ore. Ore in great abundance, ..	In one locality, ..	Sufficient for no use. If protected enough for a small blast furnace, ..	Abundant, ..	Abundant, ..	District remote, roads very bad, some mines accessible with difficulty.
Rangunga, ..	One enormous bed of ore wrought for 15 miles in length, ..	Red, and a little brown and specular ore. Ore in inexhaustible abundance, ..	Abundant everywhere, ..	At present sufficient for a small blast furnace. If protected, enough for any purposes. Fine near, oak forests 5 or 6 miles distant, ..	Abundant and convenient, ..	Abundant, ..	High road from plains to interior within half a mile of every mine.

The quality and abundance of the ore, its advantageous position for cheap and efficient mining operations, the facility of access to every mine, the vicinity of limestone, the extent and convenience of water power, the present and prospective supply of suitable fuel, and the abundance and excellence of furnace materials in the neighbourhood, appear to my Mining Assistants, Messrs. Barratt and Gray, and to me conclusive that the Ramgunga district possesses collective advantages, which we found nowhere else, and which make it the fittest place for the experiment.*

12. A former division of the subject contains allusions to the mining operations we venture to propose, namely, to open on the *Burrulgaon* iron formation, at such a height as to admit of the ore being taken at once from the spot where it is broken to the furnace mouth, a gallery sufficiently high and wide for the use of a wheel-barrow at present, and large enough to admit of a small wooden tram-way being laid in it, if necessary hereafter. As operations advance, and ventilation is required, it may be conveniently obtained at first by communication with such of the native openings as may not have been crushed, and afterwards by means of a fall of water through a tube open at both ends, a method to be more particularly described hereafter. The use of better tools for breaking and removing the ore, and the employment of gunpowder when the hardness of the rock may need it, under European superintendence, at every stage, would render the ore at the furnace for half the present cost, small as it is, probably at a *labour charge* within two shillings per ton.

13. The native mode of smelting, on an almost open hearth, the fire being blown by bellows made of buffalo hides, worked by women, has been so well and so minutely described by Mr. Deputy Collector Beckett† that I need offer no description of my own.

* Mr. Davies does not concur in this conclusion ; but agrees with Lieut.-Colonel, Drummond in thinking the experiment can be best made in the yet undeveloped district and pestilent climate of the Bhabur.

† *Selections from the Records of Government, N. W. P., Part XIII. (1853), p. 67.*

In the experiment witnessed by him at *Simul-khet*, 1,860 lbs. of ore yielded 655 lbs. of *bloom*, and this afforded 163½ lbs. of marketable bar iron. In the first operation 680 lbs. of charcoal were employed, and 654 lbs. in the second.

Mr. Davies, my Metallurgic Assistant, saw at Burrulgaon 264 lbs. of ore give 80 lbs. of *bloom*, and this again 24 lbs. of bar iron. The first process expended 192 lbs. of charcoal and the last 84 lbs.

These results indicate that the reduction of a ton (21 cwt.) of iron ore afforded in the experiment of

Mr. Beckett 828 lbs. of bloom or 206 lbs. of bar iron, the first operation requiring 860 lbs. of charcoal and the last 826 lbs.

Mr. Davies, 712 lbs. of bloom or 213 lbs. of bar iron, the first operation requiring 1,710 lbs. of charcoal and the last 748 lbs.

Results so discrepant with ore of the same kind show that, after making every allowance for the greater or less purity of both the ingredients employed, there must have been a great difference in the mode of treatment and in the skill of the operators.*

Mr. Davies has devoted by far the larger part of his time and attention to watching the operations of the native smelters, on which he declares himself unable to make any improvement; compatible, I presume, with preservation of their principles of smelting. Nothing is therefore left us, in his opinion, but the introduction of the European method: touching which our first considerations are the dimensions of the furnace and the apparatus by which it is to be blown.

The foregoing part of this Memoir contains evidence, which will probably be deemed conclusive as to the fact of no iron-producing district in these provinces affording at present—within a distance which would render cheaply available—fuel enough to maintain a large blast furnace, although the remnants of the older forests and the condition of the young trees about Gunnai, in the Ram-

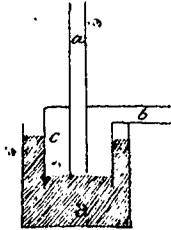
* Mr. Jacob obtained 22·84 per cent. of iron ("not in a marketable condition") from the iron ore of the Nerbudda Valley, at a cost of 104 per cent. of charcoal compared with the weight of ore.—*Report on the Baroda and Central India Railway Line* (1854), p. 46.

gunga district, would support a *small* one—until, by due protection, the wood-lands could be again brought to yield an efficient supply. There is no manufactory in the country in which the requisite machinery for a large blast could be made, and if there were, there are no roads—nor can there possibly be for some years to come—for its conveyance to either of the extensive iron deposits of Kumaon and Gurhwal. But even were fuel and machinery now on the spot, the native smelters are unable, until properly taught, to conduct operations with it. If Europeans are to be introduced to make the experiment, we at once set aside the question of cheap native labour, which has been the great recommendation to an attempt at manufacturing so far in the interior. There are other and scarcely minor considerations, sufficiently obvious to make further comment unnecessary; what has been already advanced being in my judgment conclusive on the propriety of commencing on a small rather than on a large scale.

14. We propose therefore erecting at *Burrulgaon* mine, on the Southern bank of the Ramgunga, near Gunnai, a Blast. blast furnace of about $3\frac{1}{2}$ feet in diameter within, and 12, 14 or at most 16 feet in height,* to be blown by means

* Previously to his engagement by the Honourable Court of Directors, Mr. Davies proposed to make the intended experiment with a small furnace heated by a "*fan blast*," such an one as is now used in the Mint at Calcutta. On being directed to execute his own proposition, he declared that a "*fan blast*" was insufficient for the purpose, and recommended in its stead "a furnace 8 feet in the *bosh* and 30 feet high for regular work, and one of 4 feet in diameter and 20 feet in height for trying experiments" to be worked by means "of four circular bellows driven by a water-wheel." In one of his proposals he states that 3 tons of charcoal would be requisite, in another 2 tons, for the manufacture of a ton of iron.

As furnaces of such size, and blowing apparatus of so large and costly a description, seem to me as well to exceed greatly the requirements of the experiments and the limits of expense wisely assigned us by Government,—as Mr. Davies's skill to plan and ability to execute, I have not recommended their erection; limiting my suggestions to those in the text, with the full and unreserved approval of Messrs. Barratt and Gray. Further detail on these, and on other differences of opinion which have arisen are to be found in my Monthly Reports of Progress.



a. Water fall tube.
b. Blast Tube.
c. Air Vessel.
a. Trough full of water.

of a fall of water into a pneumatic trough, through a wooden tube. The fall we recommend should not be less than 60 feet in height, the tube 18 inches square, and even larger, if the materials procurable in the neighbourhood admit of it. Messrs. Barratt and Gray have both seen the same apparatus in use; and in Brazil I have known it applied with perfect success to iron smelting* on a much larger scale than that

on which it seems to me prudent to commence in a new district, with limited supplies of fuel and with inexperienced workmen.

The same water-course, for which there are admirable natural facilities at *Burrulgaon*, would serve for bringing a stream to work any other machinery hereafter requisite.

If honored with the sanction of Government, the erection of this cheap and efficient blast apparatus will be undertaken by Messrs. Barratt and Gray, who, with such native assistance as they may be able to procure, will, during the rains, occupy themselves on portions of it at their residence (fixed by Mr. Commissioner Batten

* At the Government iron works of Neuberg, in Styria, the pressure of the blast is only equal to $2\frac{1}{2}$ inches of mercury, or little more than one pound on the square inch. From two cylinders of 45 inches in diameter and 4 feet stroke each, working at a rate of 12 strokes per minute, it enters the furnace at a temperature of about 500° F. The heating apparatus consists of 9 tubes, each 5 feet long and 6 inches in diameter.

The total height of the furnace is 36 feet, of which the bottom is 3 feet high, the width of that part is 2 feet 8 inches; the middle is 7 feet 10 inches, and the top $2\frac{1}{2}$ feet in diameter.

The ore smelted is the carbonate of iron, occasionally mixed with quartz and felspar, and being obtained from different mines, a proportion from each is used; the charge is 470 lbs. of ore, 50 lbs. of limestone, and 99 lbs. of large and 65 lbs. of smaller charcoal—5 lbs. of cinder-iron are added to two charges out of every three. All charcoal less than half an inch square is rejected.

The produce of this furnace is about 40 tons of iron per week.

at Hawulbaugh, about five miles from Almorah.) If Lieut.-Colonel Drummond's experiments on smelting shall have been completed, Mr. Davies might also co-operate with them in the wet season, employing himself, in making fire-bricks for the intended furnace, as soon as the dry season admits of out-door work. Messrs. Barratt and Gray would proceed to opening on the iron formation at a suitable altitude in *Burrulgaon*, to the construction of the water-course, and to the erection of the blast apparatus. Our limited sojourn in India, and entire inexperience amongst the artificers of Kumaon, require that an estimate of expense should be received with large allowance: we think, however, that one thousand pounds would pay for all the labour requisite in the works now suggested. Many implements and stores will be required, and when time is reckoned as an element of expense, we believe it will be found much cheaper and in every respect more desirable to employ an English mining carpenter and smith on these constructions than to rely exclusively on native labour.

Theoretically pure iron ores, of the varieties common to these provinces, may be taken to contain from 50 to 65 per cent. of metal. Instead of being absolutely pure, however, the ores are everywhere mixed more or less with foreign matters, and these, and the loss of metal in the slags in smelting, may be estimated at from one-third to one-half the chemically pure composition.

15. We shall not be accused therefore of too partial an estimate if we allow

4 tons of ore, at 2 shillings per ton for each ton of iron,	£ 0 8 0
And taking the mean of Mr. Davies's two state-	
ments, viz., 2½ tons of charcoal, at (say) 15 shillings	} 1 17 6
per ton for each ton of metal,	

We have therefore the materials necessary for one	} £ 2 5 6
ton of metal delivered at the furnace at a cost of	

to which must be added the expense of native smelting labourers, of European superintendence, and of waste and wear of materials

and machinery. In an estimate of profit and loss, the interest on invested capital too must not be disregarded.

16. It is scarcely probable, that a furnace of these dimensions would make more than a ton of iron per day. We cannot therefore calculate that the experiment, which must be considered only a preliminary one, whilst limited by the fuel and by the pupilage of the native workmen, conditions which are for a while unavoidable, can, as a commercial investment, be a very profitable one, until these early difficulties are vanquished.

17. The iron manufactured at *Barrulgaon* and *Simul-khet* sells at the rate of 28 seers for Rupees 5 (56 lbs. for 10 shillings,) or £20 per ton.

Native yield of iron. 18. The number of furnaces employed in the various districts, so far as we were able to learn, are—

		<i>Furnaces.</i>			
<i>Districts.</i>		<i>Smelting.</i>	<i>Refining.</i>	<i>Total.</i>	
Bhabur,	0	0	0	0	
Dhuniakote,	1	0	1	1	
Agur,	7	8	15	15	
Chowgurhka, &c.,	28	39	67	67	
Rangunga,	16	22	38	38	
Total,	52	69	121	121	

These numbers may not perhaps be perfectly accurate, but they are probably not very wide of the truth and are the closest approximation we were able to obtain.

The quantity of iron produced we have found no means of ascertaining.

The slight accompanying topographical sketch has been compiled principally from the large maps published by Government, corrected however in some instances by my own observations. It is perhaps not minutely accurate; but is probably a sufficient index to the various metalliferous districts we have examined.*

* The names of mines are printed in the italic character.

19. I thankfully bear testimony to the zeal and ability of Messrs. Barratt and Gray, who have accompanied me in every investigation and advised with me on every statement contained in the foregoing pages. • Mr.

Cordial co-operation of Government Officers.

Davies was our companion in the Bhabur, the Ramgunga and the Chowgurahka districts only, for possessing no knowledge of copper or of its ores, he was left at Gunnai to institute experiments on fire-bricks and other furnace-materials, an important part of duty connected with his own department, whilst we visited the copper districts of Gurhwal; and whilst we examined the copper mines of Gungolee, at the united request of Mr. Commissioner Batten and Lieut.-Colonel Drummond, he joined the latter in an excursion to the Bhabur. It was Mr. Batten's wish, no less than my own, that Lieut.-Colonel Drummond, and of course Mr. Davies, should have gone with us through the Agur and Dhuniakote districts, and to that end the former was duly advised of our movements. Reasons with which I am not acquainted prevented Mr. Davies's rejoining us, and Lieut.-Colonel Drummond visited us only during the very last hour of our labours in the field. We had not unnaturally expected much advice and assistance from him, but excepting in a few of our enquiries in the Bhabur—a district to which he has of late almost exclusively confined himself—neither his researches, local experience, advice, or assistance, have afforded us the slightest aid.

The absence of Lieut.-Colonel Drummond's co-operation has however been more than amply compensated to us by the kind, judicious and energetic assistance with which Mr. Commissioner Batten has honoured us. To his admirable itineraries, even more than to the guides he provided us, we owe our visits to important and interesting tracts, of even the existence of which we had no other means of knowledge, whilst the attendants (*chuprassies*) he sent with us procured every supply the scanty produce of some districts afforded. To him therefore, to his excellent Assistants, Captain Ramsay, Mr. B. W. Colvin, Mr. W. C. Watson, Mr. J. O'B. Beckett, and indeed to every officer of Government we have met;

our warmest thanks are most justly due for the kind aid which assisted every step of our enquiry.

We have visited and carefully examined every mine* of the existence of which we were aware : in doing so we have found several which, as we were informed, had never until then been seen by a servant of the Government : fair average samples of the ores and specimens of the rocks were obtained from them all, and are deposited with Mr. Commissioner Batten.

If the physical difficulties were overcome, which now prevent the erection of a *large* blast furnace, I believe that want of adaptation to the present wants and capabilities of the country would ensure its failure. To the immediate construction of a *small* one, however compatible with the present knowledge of the native workmen, state of the forests, means of communication, and other existing conditions of the provinces, to be enlarged hereafter by constructive means growing up within the establishment, as the labourers become more skilful, as the woods flourish, as roads are improved, and as demand increases, as it always does, with larger and cheaper supply, I equally believe there is no well-founded objection, but on the contrary fair inducement ; and although difficulties may perhaps beset its early progress, nothing shakes my confidence in its ultimate success.

Submitted with the greatest respect,

To the Most Noble the Governor General in Council,
by His Lordship's most faithful, humble Servant,

W. J. HENWOOD.

Nynce Tal, Kumaon, }
1855, May 26th.

POSTSCRIPT.

THE period assigned by Government to Lieut.-Colonel Drummond's labours on iron having arrived, in conformity with instructions from Cecil Beadon, Esquire, Secretary to the Govern-

* A depth of snow, as already stated, filled the path and prevented our reaching *Dhobree*.

ment of India, to him (No. 613, 11th May 1855,) we have examined what has been done from the end of January to the time when his workmen were driven by their labour by the heat.

At *Bejapoore* a gallery in the mountain-side has pierced several beds of clay impregnated with small nodular concretions of red iron ore,* which alternate with others of smaller size, almost exclusively of clay, for more than 60 feet in width.

The formation has been traced about 22 fathoms in length, but in several of the pits in which it is seen, it is small and poor.

Nothing worthy of special notice has been done in the interval at *Loha Bhabur*.

At *Dechowree* the ferruginous mass affects two distinct beds, respectively, about 25 and 40 feet wide at their broadest parts, which may be 120 to 130 fathoms long. Some short and thin lumps of good red iron ore are dispersed through the body, but particularly on the joints. The principal part of the formation, however, is whitish and greenish talcose matter, interspersed with small concretions of red iron ore, and is not rich.

Lieut.-Colonel Drummond informed us that he had conducted researches in other localities, but said that the climate would not admit of our visiting them now.

Nothing we have seen shakes the confidence already expressed, that *Burrulgaon* is by far the preferable locality for our experiment.

W. J. H.

Kaleedoongee, Kumaon, }
1855, June 30.

* Ante, p. 12.



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