II.—*Report on the Copper mines of Kumaon. By Capt.* H. DRUMMOND, *3rd, B. L. C.*

Many of our readers will be aware, that Capt. DRUMMOND of the 3rd Light Cavalry, brought with him to this country when he returned about two years ago from furlough, a practical miner from Cornwall, and that, upon his application, the sanction of Government was given to the employment of this person, under Capt. DRUMMOND'S superintendence, in the examination of the capabilities of the mines of copper in *Kumaon*, with a view to the introduction eventually of a better method of working them. These mines were reported upon at length by Capt. HERBERT ten years ago, but as the observations of a practical workman upon their present condition, and upon the methods of extracting the ore which are in use, cannot be without interest, the Government has permitted the following report by Capt. DRUMMOND of his proceedings to be printed in these pages.

*Mines of copper in the eastern districts of Kumaon.*

Of the mines of copper situated in the eastern division of this province only two are now worked, one at *Rye* in the pergunnah of *Gungowly*, the other at *Sheera* in *Barrabeesy*, the rest, namely, *Belar*, *Shore*, *Goorung*, and *Chincacolee*, have all fallen in, and been abandoned, and are consequently inaccessible at the present moment.

The mines of *Rye* and of *Sheera* have been worked nearly to the extent available, that is to say, available so far as native mining (or rather burrowing) can accomplish; not that the resources of these mines are by any means exhausted, but only that part, which being near the surface, can be obtained without the aid of skill and capital.

From the length of time that these mines have been worked, the appearance of the ground about them could not be expected to be very different from the condition in which it was found, but their poor state at present is no argument, why they should not become very profitable when prosecuted to a greater depth.

In other countries it seldom happens, I believe, that mines of copper are found to be productive near the surface, and in Cornwall few of them ever yield a return till a considerable depth underneath is reached, as much as 30 or 40 fathoms. And the greater part of this distance consists generally of little else than the mere ferruginous substance, termed gossan, which covers the ore, whilst scarcely any of the latter can be discerned. By analogy therefore the same may be expected here, and this is so far confirmed by the native miners, as well as by the present and former lessees of the mines, who assert

that the quantity of ore increases considerably in the downward direction. In no instance have I yet learned of a mine having been given up on account of deficiency of copper ore: all concur in the belief that there is no want of ore, but a great want of the means for extracting it.

*Rye mine—Pergunah of Gungowlee.*

This mine is opened on the eastern side of a hill of moderate elevation. The rock formation is composed of dolomite and talc. The dolomite* occurs compact, slaty and crystalline, and might frequently be mistaken for common primary limestone, but its feeble effervescence in acids readily distinguishes it as a magnesian carbonate of lime. The talc occurs in beds, both indurated and slaty (the soapy killas of Cornwall); and it is in these beds that the ores of copper are found in numerous strings, having every appearance of being leaders, as they are called, to solid ore, and maintaining a distinct course, which I shall accordingly denominate lode, agreeably to the term used in mining. The strike, or direction, of the strata, is nearly W. N. W. and E. S. E. dipping at an angle of about 45° to the N. N. E.

The present entrance is by an adit or passage, which serves as a drain. The adit is driven on the course of one of these lodes, which continues west about 10 fathoms, when it falls in with another lode, that alters its direction to 15°, and afterwards to 30° north, inclining nearly 50° to the east of north. At the time I penetrated to the working part of the mine, it was then about 58 fathoms from the entrance. The lode had been taken away from underneath, as deep as the miners could manage to excavate, and its place filled up with rubbish. Above also they had taken it away as high as it was found to be productive; and, when I saw them at work, they were then extending their operations in the same westerly direction, the lode being about two feet wide, and containing good yellow copper ore, but with a large proportion of its talcous matrix, 20 per cent. only being metalliferous.

The passage varies from two to four feet in height, and from two to two and a half in width; the superincumbent hard dolomitic rock not allowing the labourers to make it higher, without having recourse to blasting, with which they are totally unacquainted. A short distance above the entrance is an old adit, which has been carried on the course of the same lode, and is now kept open for the purpose of ventilation.

* Dolomite is not a rock producing copper in England, but it is known in other countries to contain ores of this metal and of iron. The rich mines of Cuba are said to be in it.

The yellow sulphuret of copper, or copper pyrites, in its perfectly pure state yields about 30 per cent. of metallic copper; and though not a rich ore, is the most important of any from its abundance, and from being generally more to be depended on for continuance than the richer varieties*. In England, more copper is obtained from it than from all the other ores together; and, should this mine be prosecuted to a greater depth, I have no doubt, that the strings of ore above mentioned, will be found to lead eventually to solid ore, when data as to the actual capabilities of the mine may with certainty be obtained.

In the event of an experimental mine being established here, a new adit, 80 fathoms in length, will require to be brought in lower down the hill, so as to reach the present mine 10 fathoms below the entrance, and drain the whole of it, along with a considerable quantity of new ground, which the natives report to be very rich, but say they cannot work it on account of the accumulation of water.

About a couple of hundred yards to the north, and in the same hill, is another deposit of copper. This is laid open to the surface during the rainy season, and allowed to fall together again, as soon as the water, employed by the natives to carry off the talcous mud from the ore, ceases to be plentiful. An awkward attempt had been made by the present *teekadar* (lessee of the mine), to mine this with timber, but without success; and it was at the time I visited the spot abandoned, and the works lying full of water. To have an effective mine here, it will be necessary to sink a perpendicular shaft of 12 fathoms, and to bring in an adit about 50 fathoms in length, so as to come under the works above described about eight fathoms, and lay open a space of ground, also believed to contain a considerable quantity of ore.

*Sheera mine—Pergunah of Barrabesry.*

The mine of *Sheera* is situated on the northern side of a hill, somewhat higher than the one at *Rye*, and is entered by an adit, which is driven south in the course of an evidently non-metallic vein, (no traces of copper being found in it:) and this the natives must have made use of, to assist them in penetrating the dolomite rock, which, with beds of talc, constitutes here likewise the formation where in the ores of copper are discovered. Nearly 33 fathoms from the entrance, the adit strikes a copper lode, on which a level passage is driven, that continues westward, its course being about 10° south of west, and dip northerly from 45 to 50°. Scarcely any thing could be seen of this lode, which has been all taken away, and its place supplied with timber, until I arrived at the end of the level, (18 fathoms in length,) where it seems to inter-

* Extensive beds of copper pyrites occur in the mining districts of Sweden.

sect another lode, running in a northwest and southeasterly direction, which is poor at this particular locality. The former lode resembles the ore at *Rye*, but the ore is harder and more contaminated with iron pyrites.

The adit is also continued south from the strike of this lode a few feet, when it enters a confused mass of timbering and stones, having the appearance as if ore had been excavated in every direction; it then runs 15° west of south, and is about 10 fathoms in length. At the end of this passage, a pit is sunk (said to be 35 feet deep) on a lode running 5° north of west. When I penetrated to the spot, it was half full of water, which six men were constantly employed in lifting up in small buckets, to prevent the flooding of the working part of the mine, with which there is a communication, as is evident from the currents of water and air that come from that quarter.

The *teekadar* reports the lode at the bottom of the pit to be very rich, but complains of deficiency of hands to work it. Should the passage of the mine be enlarged, men of a different caste from the miners might be employed to draw off the water, and the whole of the miners set to work at the ores. There is no want of ventilation, as the air is constantly circulating from the works to the pit, and from thence to the strike of the first lode, not far from which are two holes brought down from an old adit, formerly the drainage of the mine. The appearance of this mine warrants the repairing and enlarging of the adit, which is the first thing to be done: more satisfactory data will then be obtained as to the character and number of the lodes, than can be hoped for in its present wretched state: the bringing in of a new adit may then be taken into consideration.

I shall now offer a few practical observations by my mining assistant, contrasting the modes of working here with what he has been accustomed to witness in Cornwall.

1. "The mode of excavation.—This is performed with a very indifferent kind of pick-axe; the handle being made of a piece of wood with a knob at one end, into which a piece of hard iron is thrust and sharpened at the point. This, with a miserable iron hammer, wedge and crowbar, constitutes all the apparatus that the native miner has to depend upon. It is plain that with such tools no hard rocks can be penetrated, nor can the softer ones be worked with much facility; and to this fact may be attributed the universal smallness of the passages throughout the mines; as the native miner can have his passage no larger, than the rock which encloses the ore and its matrix will admit of.

"I would therefore suggest that proper pickaxes and steel gads

(wedges) be substituted instead of the inefficient tools in use, and when blasting may be required the necessary materials should be provided. On the other hand, where timber may be requisite, sawn wood should be used to render the passages permanent and secure, in place of the branches of trees now employed for that purpose; and I judge from experience, that a man accustomed to work under these improved circumstances will excavate and extend a large and commodious passage in a less time by one-third, than that occupied for the same distance in excavating the miserable holes under the native mode of working.

2. "The conveying the ores and refuse from the mine.—This is performed by boys, who pick up the stuff with their hands, and put it into skins, which they drag along the floor to the entrance of the mine. In place of this method, wheel-barrows and shovels should be used, when the passages are enlarged; and a boy might then easily discharge *four times* as much as he can at present.

3. "The pulverizing of the ores.—This is performed by women: a large hard stone being placed on the ground on which they lay the ores; they then either with a stone, or hammer, more frequently the former, proceed to pulverize them and to pick out the impurities: in this manner a woman may manage from one to two maunds per day, according to the hardness of the ores. In Cornwall, a woman will pulverize from 10 to 15 hundredweight per day, according, as in the former case, to the nature of the ores. The method in practice there is, first to dispense with the picking:—secondly, to have the ores elevated, so as to enable the individual to stand while working, and to have a plate of iron about a foot square and two inches thick on which the ores are broken with a broad flat hammer: the impurities are then finally separated by a peculiar mode of dressing the ores with a sieve, by which a boy gets through with from one and a half to two tons per day. The ores are conveyed to the women, and from them to the boys by a man who attends for that purpose.

4. "The washing and cleansing of the poorer ores from slime and other impurities.—This also is performed by women, who carry the stuff from the entrance of the mine to a stream in baskets, where they contrive, by dabbling with their hands, to wash off the mud and finer particles of earth. They then proceed to pick out all the pieces of ore they can get hold of; or in the case of what may be submitted to the water in a comminuted state, they work this against the stream, so as to gather it clean at the head of a small pit by handfulls; but, from the bad construction of the pits, it is with difficulty that this is performed. After picking up any larger pieces of ore, which may have gone back

with the stream, they scoop out the refuse with their hands, and then proceed with another charge. In Cornwall, one woman provided with a wheel-barrow and shovel for the conveying and washing of the ores, and a boy with a sieve for dressing them, as formerly mentioned, would accomplish an equal task to that of ten women on the system described.

5. "The drainage of the mine.—In the first place, this is managed in a proper manner by an adit. But whenever any attempt is made to go below it, as is the case in most, if not all the mines, the water is then raised in wooden buckets handed from one man to another, until they reach the adit into which they are emptied. In this manner six, ten or even more men may be employed, whilst only an inferior number can be spared for excavating the ores. At the *Sheera* mine, for instance, six men are constantly engaged in lifting up the water, and there are only two at the ores: the water raised by these six men, could be effected with a hand-pump by one man: but, in order to keep the pump constantly going, two men might be required, and the remaining four added to the number of those who are excavating.

Lastly.—"To obtain sawn wood for rendering the passages permanent and secure, the art of sawing, which is entirely unknown to the people here, ought to be introduced."—

The foregoing remarks having reference simply to the rude and inefficient mode of work now actually in practice in this province, the rectifying of them will form the first stage of improvement. No allusion has hitherto been made, to the vast results from machinery, which in England may be witnessed in almost every mine; nor have the important processes of reducing the ore to the metallic state, been yet adverted to, though these are on a parallel with what has been said on the subject of extraction*. However, from the statements which have been made, it may be seen, that notwithstanding the mountaineer receives but a very slight remuneration for his labor, yet considering the extravagant manner in which that labor is expended, an exorbitant rate is paid for the really serviceable work performed. Thus it is not so much the grinding avarice of the *teekadar*, that oppresses the miner, as the system upon which he works, that cannot admit of his being much better paid. To relieve this class of people, therefore, and raise their condition, it is much to be desired, that a new management should be adopted; while, on the other hand, were the mines equal to the very best in Cornwall, no great profit could ever accrue from them, worked as they are at present.

* The charcoal smelting furnaces of Sweden appear to me to be the best suited for these mountains.

The almost inaccessible state of these mines, and the great difficulty of making any observations at all in such places, as well as the interruption alluded to heretofore, namely, the illness of my assistant whom I was obliged to bring back to cantonments in a very precarious state of health, have prevented me from making this report so full as I should have wished. It appeared to me desirable to take, in the first instance, merely a rapid glance at the whole of the copper mines throughout the province, before the setting in of the rains, (when they become inaccessible,) with the view of determining the most eligible locality for bringing the question of their productiveness to the test of experiment. The mines of the western purgunahs, which, by all accounts, are the richest, I have not yet had an opportunity of examining; but though my plans have been frustrated in that respect, I can nevertheless recommend a trial of one of those I have already visited; to wit, the *Rye* mine. It is unfavorably situated for a new adit; but from the appearance of the ground, and the probability of cutting new lodes underneath by traverses from the one now worked, the superior quality of the ore, together with what information I have been able to gather from the natives, as to the character of the lode at a greater depth, I consider it in every way the best suited for an experiment, an estimate of the probable expense of which is herewith annexed*. Should the government deem it expedient to authorize the work being commenced, my mining assistant, Mr. WILKIN, is fully competent to carry on the detail; and Lieut. GLASFORD, executive engineer of *Kumaon*, has offered his services to superintend, as far as his other duties in the province will permit, and to further the undertaking by every means in his power.

I shall now conclude with a summary of the different points of inquiry, upon which I should wish to ground my next report of the mines of copper in this province.

Some account of the rocks, considered in an economical point of view.

The ores seem to be of the usual varieties, and need merely to be specified. Assays from selected specimens hardly give a correct estimate of produce†.

The important thing to be noticed is, the quantity that may be obtained. This will depend principally on the width of the lodes, and

* It is estimated by Capt. D., that the cost of the proposed new adit at Rye will be above 2400 rupees.

† The working ore I have hitherto seen has been copper pyrites, grey copper ore, and the green carbonate I have met with, but in too inconsiderable quantity to deserve notice.

how far that width is occupied by solid ore, or how much it is intermixed with spar, talc and other matters*. Also, on the continuity of branches of ore to a reasonable extent, or, on the other hand, on their being short and occurring at considerable intervals.

Again, the character of the lodes will have to be described,—whether beds conforming with the stratification of the country, or veins traversing the same.—Whether numerous, parallel to each other, or crossing.—What their direction usually is by the compass.—Whether vertical, or at what angle they deviate from being vertical.—Whether they are rich at particular places, as where veins intersect each other.—What is the character of the mineral matter, filling the lode where ore is deficient.—Whether this character is different, when near the surface, or when observed at greater depths.—What proportion of the lode appears to be metalliferous, and what barren.

*Facilities for working.*

Many considerations come under this head—character and habits of the natives—rate of payment for labor—state of roads and means of transport—supply of timber and other articles required—means of drainage, such as levels for obtaining adits—falls of water for machinery—streams whether constant and sufficient. As no mining operations upon an extended scale can be carried on without a command of cheap and good iron, I shall next advert to the mines and manufacture of this metal, and point out the peculiar advantages possessed by these mountains, over other parts of India, for improvements in that valuable branch of the natural resources of the country.

*September*, 1838.

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III.—*Observations on six new species of Cyprinidæ, with an outline of a new classification of the family.* By J. McClelland, *Esq.*, *Bengal Medical Establishment.*

It is almost unnecessary to refer to the following passage which is inserted under the head of European correspondence, page 110, volume I. of this Journal, but it is so apposite to my subject that I must be excused for quoting it as it stands. "I spent some time in *Paris* this summer and saw a good deal of M. Cuvier. I used the freedom of mentioning your name to him and your desire of taking

* In the western pergunahs, Captain Herbert, in his geological report particularises grey, purple, and vitrious copper ore.