

*On the Minerals of the Rio Tinto Mines.*

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THE great pyrites masses of the Sierra Morena, of which those worked at Rio Tinto are by far the most extensive, may be briefly described as contact deposits, which differ from such as are ordinarily met with only in size; and from ordinary fissure veins only in the circumstance that the cavities in which the minerals occur are bounded by dissimilar rocks.

The deposits in question extend for more than a mile in length in a direction about 20° to the N. of W.; *i.e.* in the line of strike of the slates; they vary in width from a mere line or the filling of a joint up to more than a hundred metres, and they extend to an unknown depth. On one side they are bounded by palæozoic slates which are nearly vertical, and on the other by felspar porphyries. Three distinct lodes are known. These overlap each other somewhat "en echelon," the "valley lode" (hitherto not worked) extending farthest to the west—the "South" and "San Dionisio" lode occupying an intermediate position, and the "North lode" extending farthest to the east.

The filling of these ancient "lenticular"\* cavities consists essentially of iron-pyrites, very rarely showing signs of distinct crystallisation and always more or less cupriferous. The copper occasionally exists as separate veins of yellow or grey ore, or as films of various rich cupriferous minerals lining joints in the main masses of pyrites, but usually it is disseminated throughout in almost indistinguishable particles. Other minerals occur occasionally under precisely similar conditions, as blende and galena. Both the country rocks also are found very frequently charged more or less with cupriferous pyrites; and sometimes the boundary between pyritous deposit and containing rock can only be determined by economic conditions; frequently, however, the boundary is quite sharp and distinct, especially as regards the porphyry.

The pyrites near the surface is more or less completely decomposed, yielding masses of slightly cellular but tolerably pure hematite iron ore,

\* They are frequently spoken of as lenticular, but their form is far from resembling that of a lens, even in horizontal cross-section.

and this again is capped in parts by horizontal deposits of iron ore of very similar character but of subsequent origin.\*

It is not at present my intention to discuss in detail the mode of origin of these important deposits, which some have regarded as igneous eruptions, but in which I can see nothing but aqueous agency posterior to the eruption of the porphyry.

Considering the great extent of the deposits, and of the works in connection with them, the number (and variety) of the mineral species met with from time to time is extremely small. The following list includes all that I have seen or heard of on what appears to be satisfactory authority.

*a. Native Elements.*

COPPER occurs in joints of the slate both at the south and north Lodes, according to Messrs. N. Kennedy and James Osborne. I have one specimen in which the copper occurs in very thin flakes between the laminae of the slate, as if reduced from percolating cupreous solutions by some organic matter there present. I have also specimens of oak and firwood from the mine, given me by Mr. Osborne, in which a similar action appears to have taken place, as the tissues of the wood are permeated by metallic copper.

SULPHUR occurred in 1881 in beautiful brilliant crystals, very highly modified, in cavities of the ore raised at San Dionisio and given to me by Mr. W. H. Davy and Mr. F. Johnson. The latter gentleman was the first to detect their real nature, which was by no means obvious owing to their minuteness.

*b. Sulphides, &c.*

PYRITES.—Usually contains from two to three per cent. of copper in an intimate state of mixture. This mineral is now being extracted at the rate of more than a million tons per annum. Crystals are rarely seen except in the slate or the porphyry, and then they are usually very small—either cubes or pentagonal dodecahedrons, or else the well-known combination of these two latter forms.

The portion of mineral which is exported, about one-third of the whole production of the mine, is neither the richest nor the poorest of the mass; these are reserved for local treatment; consequently the "export mineral,"

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\* For a description of some of these horizontal deposits of iron ore, see a paper by J. A. Phillips, F.R.S., *Quart. Journ. Geol. Soc.*

while somewhat richer in copper than the average of the whole mass, is at the same time much more even in composition.\*

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| Sulphur ... ..   | 48.98  |
| Arsenic ... ..   | 1.00   |
| Antimony ... ..  | 0.06   |
| Copper ... ..  | 8.06   |
| „ Sulphate ... ..  | 0.12   |
| „ Oxide .. ...   | 0.50   |
| Lead ... ..  | 1.47   |
| Iron ... ..  | 41.91  |
| „ Sulphate ... ..  | 0.50   |
| Zinc ... ..  | 0.62   |
| Cobalt ... ..  | 0.02   |
| Lime ... ..  | 0.10   |
| Moisture ... ..  | 0.65   |
| Bismuth, Selenium, Thal-<br>lium, Nickel, Silver, Gold,<br>Silica, Alumina and loss } ... .. | 1.01   |
| ... ..   | 100.00 |

Silver about  $1\frac{1}{2}$  ounces per ton ; Gold about 10 grains.

Selected specimens of the pyrites taken from portions which are as free as possible from copper contain no more than 0.5 per cent. of copper, and scarcely anything else except sulphur and iron. The crystals from the porphyry and slate contain still less copper—sometimes no more than a trace ; but I have never met with any absolutely free from copper.

Much of the export ore has a thin coating of Brochantite on it—a lining of the original joints of the pyritous mass. Without materially altering the average copper contents, this often gives special cargoes a very rich appearance which is by no means borne out by analyses.

In 1881 a quantity of dark sandy-looking material was brought up from a deep bore-hole at the “North Lode,” which proved to be minute crystals of pyrites coated very thinly with galena. All the pyrites contains small quantities of silver and traces of thallium, selenium, and gold.

CHALCOPYRITE occurs in veins and patches in the general mass of pyrites. The finest specimens I have seen were raised from the part of

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\* This is an analysis of a fair sample of ore exported in 1878, made by a friend. The ore exported at present is slightly richer, but the composition of the mineral does not materially differ.

the mine known as San Dionisio. Here it occurs in considerable quantities; I have never seen it in crystals, but I have found pieces so pure as to contain upwards of 80 per cent. of copper.

**ERUBESCITE.**—This occurs occasionally in veins with the chalcopyrite. I have never seen crystals.

**CHALCOCITE.**—As erubescite.

**COVELLITE.**—Occurs occasionally as thin films lining joints in the pyrites. No crystals seen.

**MELACONITE.**—As Covellite.

**BLLENDE.**—As erubescite and chalcocite; also in small brilliant crystals at San Dionisio. Also disseminated with galena.

**GALENA.**—Occurs massive; granular and disseminated, and occasionally in small modified cubes—the latter more frequent at San Dionisio. All the galena is more or less argentiferous, yielding a lead containing about 40 ounces of silver to the ton. In the North Lode heading a few years since some argentiferous galena was met with which contained 120 ounces of silver to the ton.

**PYRARGYRITE.**—Occurred in a small vein which was cut in the North Lode heading about 1879, and was analysed by Mr. F. Bawden at the time.

### *c. Oxides.*

**HEMATITE.**—Abundant as a capping several metres in depth on the hill known as Mesa de los Pinos; also on the hills known as the Cerro de los Vacas, Cerro Colorado, and Cerro Salomon. It is frequently botryoidal and beautifully iridescent, but I have never met with it in crystals.

**LIMONITE** is associated with hematite at all the localities, but seldom in large quantities or in characteristic forms.

**PYROLUSITE.**—In bedded veins running with the strike of the rocks at Los Planes and on the Zalamea road beyond Bella-vista.

**PSILOMELANE.**—As Pyrolusite.

**WAD.**—As Pyrolusite. Also as small patches or “eyes” in the slates near to the veins of Pyrolusite, especially at the second-mentioned locality. It is often cobaltiferous and nickeliferous.

**QUARTZ.**—In veins almost everywhere, but not very abundant in the immediate neighbourhood of the mines, and very rarely as crystals.

**JASPER.**—Abundant, both green and red, in the neighbourhood of the manganese veins, but not elsewhere.

**OPAL.**—As Müller’s glass has been met with occasionally in fissures and cavities of the iron ore on the Mesa de los Pinos.

*d. Spathoids.*

**BARYTES.**—In north and south fissures crossing the South Lode between the great open-cast and San Dionisio—mostly in tabular crystals and associated with galena. Has also been met with at San Dionisio, the north lode, and on the hill above Gangosa.

**ANGLESITE.**—In brilliant crystals with galena in the Tunnel and the South Lode. Occasionally acicular according to Mr. Bawden.

**CERUSSITE.**—As Anglesite. Some needles have been seen two or more inches long.

**CHESSYLITE.**—In soft clay at Los Planes. Also in fissures and cavities in decomposing clay slate.

**MALACHITE.**—As Chessylite.

**MELANTERITE.**—This is not uncommon as a secondary formation in the open spaces of the mine—a result of the decomposition of the ores. It occurs both in crystals and in stalactites. They are almost always cupriférous and zinciferous, and their composition is, as might be supposed, extremely variable. Some varieties contain more copper than iron, but all the crystals I have as yet seen, whether small or large, have the form of Melanterite, and not of Cyanosite.

**CYANOSITE.**—This occurs occasionally in stalactitic forms, but not, I believe, in crystals.

**BROCHANTITE.**—This occurs as a thin coating or film in joints of the pyrites; it sometimes exhibits crystalline facets, but I have never seen measurable crystals, and it is usually amorphous.

**CHRYSOCOLLA.**—This is met with under the same conditions as Brochantite, but very rarely, and in small quantity only.

**VIVIANITE.**—Occurs in brilliant dark-blue crystals in the cavities of human bones taken out of a supposed Roman well, and given to me by Mr. James Osborne in 1881. I have never seen it in ore raised from the mines.

The following have only been met with as results of the industrial operations carried on at the mines:—

**REALGAR.**—As an incrustation on the top and upper portion of the sides of the heaps of burning mineral (teleras).

**ORPIMENT.**—As Realgar.

**ARSENOLITE.**—As Realgar; often in very beautiful octahedrons—occasionally as much as half an inch in the side.

**CLAUDETITE.**—Occurs in fine pearly flakes in the “chimneys” of the “teleras,” where the supply of oxygen is more limited than on the tops of the teleras. This mineral is said to have occurred in fissures

of the pyrites at San Domingo, but nothing of the kind has ever been seen at Rio Tinto, except in connection with industrial operations (calcination of ore, &c.).

In concluding these brief notes, I have to acknowledge my obligations to the following members of the Rio Tinto staff for information given at various times on this subject, viz. Messrs. N. Kennedy, Jas. Osborne, F. Bawden, H. B. Fulton, F. Johnson, W. H. Davy, and John James.