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(INCORPORATED).

(PROCEEDINGS. NEW SERIES, No. 51. 1923.)

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(Communicated by P. G. Morgan.)

WHEN the writer resided at Zeehan, on the West Coast of Tasmania, some years ago, he took a keen interest in the geology of the district, and availed himself of the opportunity to investigate occurrences of the varied minerals in which the field abounds. The following notes were compiled as a result of one of his periodical visits to the outlying mining districts, when an examination was made of the Lindsay Reward tin-mining property, which has an area of 140 acres. This is most easily reached from Renison Bell, the centre of the North Dundas tin-fields, on the Emu Bay railway, about eight miles north-east of Zeehan. Thence a pack track some 14 miles long connects with the mine, crossing the Pieman River by a fine suspension bridge. The mine itself is situated on the main south leading spur of the Parson's Hood Range, at an altitude of some 1600 ft. above sea level. The Parson's Hood Range is composed of granite, and is an extension of the rugged Meredith Range. A remarkable feature is the uniform topography of the surrounding country when viewed from the peaks. Except where dissected by the rivers and creeks, the surface is practically level, and, indeed, affords a striking illustration of an ancient uplifted peneplain.

The mine has been opened by means of trenches and adits, and the ore-body proved to extend for a length of 30 chains, with an average width of about 100 ft. Its general trend is west-north-west, and its dip, which is steep, corresponds to that of the country-rocks. These latter, which are of sedimentary origin and generally regarded as of pre-Silurian age, have been tilted at high angles, consequent, no doubt, on the crustal movements produced by the intrusion of the huge granitic masses which now form the high ranges in the vicinity. It may be here remarked that it is not within the scope of this paper to deal with the sequence of events leading to the geological structure

as now existing in this district. That has since been very ably investigated by Mr. L. L. Waterhouse, of the Tasmanian Geological Survey. The original stratification of the rocks, which is very regular, has been remarkably well preserved. They are, for the most part, fine-grained slates, sandstones, and tuffs, considerably altered, however, by the proximity of plutonic masses, in places becoming extremely hard. The ore-body itself is striking in that it is stratified or banded in a similar manner to that of the enclosing country-rocks, the banding becoming the more noticeable as the walls are approached. This structure at once gives a clue to the mode of origin of the deposit, which will be discussed further on.

The adits have been driven approximately along the centre of the ore-body, with crosscuts at intervals to the walls, or, more correctly, to the boundaries of the mineralized channel. The lowest adit, some 20 ft. above the level of Tulloch Creek, which runs through the property, shows the bulk of the gangue to consist of a mixture of dark tourmaline and biotite, heavily impregnated with pyrite, with cassiterite or tin oxide fairly uniformly distributed throughout, and for the most part payable. Quartz is fairly common, occurring in small acicular crystals or as glassy blebs. Chalcopyrite, pyrrhotite, and arsenopyrite occur in minor quantities, while various secondary minerals resulting from their decomposition, such as malachite and siderite, are also found. Calcite, garnet, fluorite, and other minerals can be distinguished. Near the walls the sulphides give place to limonite, which is somewhat siliceous, and presents a gossanous appearance. The limonite in turn merges into a clay, and passes insensibly into the country-rock. The next adit, some 70 ft. higher, shows the ore-body to consist almost wholly of massive pyrrhotite (magnetic iron pyrites) with splashes of chalcopyrite, carrying cassiterite. The pyrrhotite occurs in bands of varying thickness, replacing layers of country-rock. The uppermost adit, after passing through a few feet of clay, penetrates the ore-body, here mainly massive magnetite, presumably of primary formation. Magnetite also occurs in defined bands, replacing the country-rock, and carries a little tinstone in the form of black crystals. At the summit of the hill, which is somewhat flat, a shallow shaft has been sunk, and a series of trenches cut across the cap of the deposit, here fully 100 ft. wide. The ore consists of magnetite and limonite, with scattered

spangles of fine mica and clear blebs of quartz, the characteristic banded structure being well preserved. The western side of the hill slopes much more gently than the eastern side, and on it considerable quantities of oxidized material and clays have accumulated. An adit driven from this side of the hill carries limonite for most of its course, but when work was suspended pyrite had made its appearance in the face.

No extensive exposures of granite or its derivatives are observable on the Lindsay Reward property, there being, in fact, but two small outcrops of igneous rocks. One is a small tongue of altered quartz-tourmaline rock occurring close to the ore-body. The other and larger outcrop, in the form of a dyke, is situated some distance away, and on examination is seen to be a fairly coarse-grained holocrystalline rock consisting of quartz and feldspar, but devoid of mica, which may be called quartz-porphyry. In places clusters of black tourmaline crystals are present on the outside, having perhaps segregated to the margin by a process of differentiation when the dyke was forming. Although the igneous dykes are not directly connected with the deposition of minerals to any extent, indirectly their connection with the underlying massive granites is of great import, since it is from the latter that the metallic vapours and solutions giving rise to the deposits emanated. The huge granite mass forming the Meredith Range and its outlying spurs represents the acidic or final phase in the differentiation of the molten magma which intruded the older sedimentaries, and it was at this period that the tin was deposited.

As already indicated, the intrusion of these plutonic masses has had a marked effect on the sedimentary strata, metamorphosing them for a certain distance beyond the contact zone, and converting the sandstones into quartzites and the slates into cherts. The aureole of metamorphism, however, as far as can be judged, is not extensive, nor does the action appear to have been of a violent nature, since the rocks have not been shattered to any appreciable extent, and the bedding planes are still clearly discernible. Of more influence as a determining factor was the role played by the bedding planes, as they provided the channels along which the mineral vapours and solutions emanating from the cooling magma were conveyed. As the magma cooled the metalliferous vapours would first be given off. These,

aided doubtless by superheated steam, extracted various metals from the magma and carried them into the channels afforded by the bedding planes. Their mineral contents would there be deposited, owing to reduction in pressure and temperature. Tin emanated as a volatile fluoride of tin, which at lower temperatures, in the presence of steam, was decomposed into oxide of tin (cassiterite) and hydrofluoric acid. The former was directly deposited in the parallel fissures or bedding planes, and so preserved the original banded structure of the strata. The hydrofluoric acid suffered a further reaction with the calcium compounds present, resulting in the deposition of fluorite. The association of these minerals (cassiterite and fluorspar) is characteristic of most tin fields. Quartz, which is almost invariably present, was simultaneously deposited by the action of superheated steam on the volatile compound, silicon fluoride. Although the cassiterite is regarded as having been deposited first, it is so intimately associated with the metallic sulphides as to suggest a practically contemporaneous origin. On the other hand, occasional rich veins of high-grade tin oxide are met with, which, since they cut obliquely across the sulphide bands, indicate that in such cases the introduction of the cassiterite is later than the deposition of the sulphides. It would appear that variations of this nature depend on the conditions prevailing at the time of mineralization. If from any cause these conditions alter, there is a corresponding change in the order of deposition of the minerals. When the conditions are intermediate the deposition of the tin oxide and the sulphides occurs simultaneously.

Metasomatic replacement has played a pronounced part in the formation of the ore-body, and adequately explains how whole bands of the country-rock have been completely replaced by mineral. The process can be seen in progressive stages, notably in the pyrrhotite bands. The action has proceeded simultaneously along a number of adjoining bedding planes, extending laterally until gradually the intervening layers are wholly replaced. The occurrence of tourmaline in the ore-body is interesting. Abundance of it can be seen occupying contraction cracks in the granite about the vicinity. The fissuring of the granite allowed the escape of boron vapours, which, reacting on the argillaceous sedimentary rocks, caused the formation of tourmaline. The effect of the various mineralizers extended some distance into the country-rock, and strictly the so-called walls of

the ore-body were determined by the distance so penetrated. The absence of any considerable quantity of detrital mineral in the neighbourhood of the deposit may be accounted for in either of two ways —viz., that the mineralization of the ore-body did not extend to the surface, or that the steep nature of the country and the fineness of the tinstone were unfavourable for its accumulation.

Active operations on the Lindsay Reward property have now ceased altogether, but the former company, working in a small way, did much useful work in opening up and proving the ore-body. Sufficient was done to demonstrate that a large quantity of payable ore could be won from the oxidized zone. This, however, is small in comparison with the large reserves of sulphide ore from which ultimately the main supply would be drawn. But the proposition, to be profitable, requires handling on a large scale, with the expenditure of considerable capital. There is plenty of fall in the ground to allow of the mine being operated from a main adit and rises. Systematic sampling and assaying are essential. The method of ore-treatment calls for close investigation. Roasting would doubtless have to be resorted to at some stage of the process, and the possibilities of electromagnetic separation for certain portions of the ore should be considered. Cheap mining and milling costs would be all-important. By using the waters of Wilson's River to operate turbines, 1000 h.p. could readily be obtained under normal conditions. The power would be transmitted to the mine electrically, and would be ample for all purposes.

In a somewhat cursory examination of this complex ore-body the author came to the conclusion that there were many interesting problems demanding further elucidation, and of such economic importance as to warrant a detailed geological survey.