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GEOLOGICAL REPORT ON THE COSTERFIELD GOLD-ANTIMONY MINE.

by

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Plan folded in Drawer
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1942/29A

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TABLE OF CONTENTS.

ACCOMPANYING PLAN. Mining

PLAN & SECTION OF THE COSTERFIELD GOLD-ANTIMONY REEFS IN FOUR SECTIONS - Scale 1" = 60'.

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INTRODUCTION.

Two reports on the Costerfield Gold-Antimony veins have been published. Bulletin No. 50 of the Victorian Geological Survey, by H.S. Whitelaw gives an account of the lodes and workings and of the history of the mine. An excellent description of the reefs and the mineralisation by Dr. F.L. Stillwell appeared in the proceedings of the Australasian Institute of Mining and Metallurgy, New Series, No. 48, 1922. In view of the existence of these publications, repetition of the details of Costerfield history, workings and geological features is avoided as much as possible in this report, and they are merely summarised in order to present the essential facts concerning the mineralised system.

The Costerfield Mining Company ceased operations in 1922 and the plant was subsequently sold by auction. In 1934 the property was taken up by Gold Exploration and Finance Limited, a subsidiary of Gold Mines of Australia, the mine was unwatered and a programme of exploration and mining carried out. The reserves indicated by Whitelaw (p.22) were found not to exist. It should be mentioned here that these reserves were apparently based on figures submitted some little time before the Costerfield Mining Company closed down, and that subsequent stoping and exploration in the lower levels and on the Costerfield Main Reef entirely failed to confirm these estimates. When the mine was re-opened by Gold Exploration and Finance Limited, it was found that practically all the developed ore had been stoped out and that the rich patches mentioned by Whitelaw as still existing had actually been pretty thoroughly gouged out before the mine filled up with water. This company tested possible extensions exhaustively by diamond drill from the underground workings, without success. Later, following a decision to explore along the flat northerly pitch of the lodes, the North Reef System was located by drilling. These lodes proved on development disappointing in average width (3 inches) and more particularly in length. A limited amount of stoping was carried out from 1936 to March 1939, for a total production of 1025 tons of concentrates, averaging 47.5% Sb. and 2 oz. 7 dwt. Au. per ton. Following a drop in the price of antimony, operations ceased in 1939, and the water was again allowed to rise in the mine, the property being eventually disposed of to Zinc Corporation Limited and subsequently abandoned. Machinery and headframe have since been removed and the main shaft, which was not in good condition, is thought to have caved round about the No. 6 level for a hundred feet or so.

Useful information with regard to the reefs was obtained from Mr. Gudgeon, Mine Manager at Costerfield for Gold Exploration and Finance Limited and from Mr. V.E. Edquist of Bewick Moreing Limited and others. The geology was discussed with H.J.C. Connolly, Geologist to the mining group operating the property, and considerable use has been made of a memorandum from him to Mr. G. Lindesay Clark stating the position of the mine in February, 1939, before the close of operations. Mr. J.D. Campbell, who did the geological mapping at Costerfield provided most valuable detailed information regarding the reefs and the ore structures, and was instrumental in obtaining on loan from Zinc Corporation Limited a complete set of the geological plans of the mine prepared by him. These plans have been used extensively in the preparation of this report, and details of the geology presented in the accompanying block diagram, which is an attempt to illustrate in one plan all the structural features involved in the Costerfield Reef System, have been taken directly from them. The block diagram has been constructed on a scale of 60 feet to inch, in cabinet projection, split into four sections in order to show the cross-sectional structure at intervals along the strike. The Nos. 4 and 6 levels are shown in plan for the greater part of the Main Reef and Kendal Systems, and the No. 6 level for the Bombay reef. The outline of the ore-bearing areas and of the high-grade sections are shown projected horizontally onto the North-South vertical faces of the diagram. The 100' coordinates adopted by Gold Exploration and

Finance Limited are measured from the Main Shaft in directions 19° West of north ("Costerfield North") and along corresponding bearings east, south and west. The vertical faces of the block diagram, in which this coordinate system is used, are aligned along these directions.

SUMMARY OF GEOLOGICAL FEATURES.

GENERAL ENVIRONMENT. The country rock of the Costerfield reef is a uniformly fine-grained mudstone of Silurian age. No noticeable variation in character was observed to the greatest depth operated. It is folded into broad anticlines and synclines which strike slightly west of north and which pitch generally at a low angle to the north. Lesser subsidiary folds are often developed on the flanks or near the axes of the anticlines. Superimposed on the main north-south folds are a series of cross-folds whose axes are aligned in a northwest-southeast direction, so that the pitch of the main folds varies from north to south according to the cross-folding. The axes of the mainfolds are more or less vertical or dipping east near the surface, but trend to the westward in depth. Axes of the cross-folds dip south-west at varying angles and these folds tend to die out in depth, below the main faults.

FAULTING. The most important faults are a flat dipping series, which strike N.N.E. - S.S.W. and dip west at angles seldom exceeding 25°. These faults cross the crests of the folds and on the flanks they often become conformable with the attitude of the strata and merge into the bedding planes. For this reason they were referred to by the last operating company as backs and this nomenclature is retained in the present report. The principal ones are the Whitelaw Back and the No. 3 Back, which run parallel for almost the whole length of the workings. No. 3 Back marks the bottom of the ore. Others are Medhurst's, Mason's, and Plowright's.

Another series of faults is developed parallel and often coincident with the axes of the northwest-southeast cross-folds. These dip southwest at usually 50 - 60 degrees.

In addition the reef fissures themselves are to some extent fault planes which often continue beyond the limits of the mineralised section.

Practically the whole of the faulting took place prior to mineralisation and is probably related to the deforming stresses which produced the folding. Almost all the faults are normal in character, thrusting being confined to occasional very minor faults.

Application of the strain ellipsoid and Hartmann's Law to the system of folds and fractures induced at Costerfield indicates that the principal shearing force was directed from a point in depth to the S.S.E.

REEFS. Stillwell classified the reefs into -

(1) Quartz-stibnite and stibnite-quartz veins.
(2) Quartz-veins uniformly unproductive of antimony or gold.

The valueless quartz reefs occur either in fault planes, where they may be as much as 3 feet wide, or as laminated quartz veins, generally small, parallel to the bedding.

The ore veins strike on the average 20° west of north, parallel to the axes of the main folds, and dip very steeply. Their average stoping width is from 4 to 6 inches, though bulges occur. The Costerfield Main Reef is said to have been up to 21 feet in width but in such cases it consisted of a great number of thin veins close enough together to justify mining the lot.

The vein material is quartz and stibnite in varying proportions, with gold. Towards the extremities of the veins, both horizontally and vertically, the relative proportion of quartz increases and eventually they become too poor to work, either because of this or because they dwindle in size. In this way the lodes may grade laterally into quartz reefs along faults, as for instance the Central Fault on No.4 level occupies a continuation of the channels of the Kendal and branch lodes.

The principal sequence of events at Costerfield has been: folding, accompanied and followed by cross-folding and faulting and formation of the reef fissures. Mineral solutions ascended along fault and joint planes and deposited first the laminated quartz veins, then the auriferous quartz-stibnite veins, with the stibnite being precipitated more readily than the quartz, which penetrated farther afield to form the quartz extensions to the veins, and finally the barren fault reefs.

RELATION OF ORE BODIES TO GEOLOGICAL STRUCTURE.

MAIN LODE SYSTEM. The Costerfield Main Lode, worked over a length of more than 1500 feet, is easily the largest individual lode in the series. From the surface to about 160 feet depth it dips vertically or very steeply east. Below that depth it dips 60° east, still more or less following or slightly west of the crest of the main Costerfield anticline. Below about 400 feet from the surface it cuts across the anticline, which begins to trend to the west, and passes into the bedding on the eastern flank. One of the most prominent characteristics of the Costerfield reefs is their marked aversion to the bedding planes, apparently because of the resistance offered to vein formation by the weight of overlying strata, compared with the comparative ease with which crystal growth could force apart the walls of the vertical fissures whose original formation was concerned with the relief of strain within the rock system. Consequently no further ore can be looked for in the Costerfield Main Reef after it passes into the bedding and it has been completely worked out down to this level.

Of the same type as the Main Reef are the Minerva and the less important Macdonald Reef, and probably the Bombay also, as far as can be ascertained from the available records of the geology of this section. The relation of these reefs to the anticlinal structure is shown in the east-west sections through the block diagram.

KENDAL SYSTEM. The Kendal reefs form a branching system, of which Kendal's is the principal one, with several others - Plowrights, Eastern, Norris's Teague's, etc., diverging from it or from each other. They lie more or less directly beneath the upper part of the Costerfield Main Lode, and their vertical extent is from about or just below the No. 3 level down to the principal fault, the No.3 Back. In the upper portion they are nearly vertical but lower down dip steeply west. Throughout most of their payable extent they lie a little to the east of the crest of a subsidiary north-south fold developed just to the west of the main Costerfield anticline. The individual reefs are much smaller than the Costerfield main reef, but the whole system has produced about an equal quantity of concentrates.

The structures which govern the location of ore shoots and of the orebody as a whole for the Kendal system are much more complicated than for the Main Reef System. The upper limit of the system as well as the lateral limits and breaks in the mineralisation are related to the cross-folding, and the ore-bodies bottom in the vicinity of the main flat dipping faults, particularly the No. 3 Back. The commercial sections of the lodes occur on the northern pitch of the folding, while the south-pitching portions appear to be unreceptive to mineralisation. The underlying cause of this resolves itself into a mechanical problem similar in essentials to the reason for the veins of the Main Reef type dying out when they become bedded. On the southwest flanks of

the northwest-southeast cross-anticlines which are principally developed east of the main Coster field North-South anticlinal axis - that is, where the beds in the plane of the lode pitch south, the bedding is parallel to the direction from which the stresses originated, with the result that the strain has been partly taken up along the bedding planes and has inhibited the development of fractures which could be readily opened up by the mineralising solutions. On the north-east side of the crossfolds, where the beds pitch north, the forces acted more or less at right angles to the bedding planes, with the formation of more readily permeable fissuring. In this connection special reference is made to Mr. Stillwell's remarks on the formation of the veins, Section 5 of his paper, pp. 374-376, particularly with regard to greater ease of penetration of quartz and the foreign sulphides compared to the stibnite.

Near the top of the Kendal system (refer to Block Diagram), the cross folding is particularly strong and the payable mineralisation is divided into several sections along the No. 4 level. Below No. 4 this cross-folding tends to die out as it approaches the main flat fault system and on Nos. 5 and 6 levels ore in the Kendal system was continuous. The Whitelaw back displaces the veins varying distances to the west and below it the fissuring is apparently dying out, for the mineralisation weakens perceptibly and completely plays out on and above the No. 5 Back, below which no reef system has been found. The southern limit of the Kendal system is also marked by south-pitching beds, which revert to north pitch in the Bombay area, and then again presumably pitch south. Whitelaw records that in the Alison mine one mile further south the beds pitch north once more.

At its northern end the Kendal system finished on a crossfold which is very strong above No. 6 level and which has been referred to by Conolly as the "Brick Wall", for obvious reasons. Gold Exploration and Finance Limited directed exploration to the north of this interference on the grounds that the known Costerfield ore systems showed a flat northerly pitch as well as a steep southerly pitch, and that the former direction might provide a repetition. The North System of lodes was located on the other side of the "Brick Wall", again on a northerly pitch but were found to be a weak development of ore, with no great length, and playing out to the north on the reversal of the crossfolding. (See Block Diagram - Northern Section).

PROSPECTS.

A reading of Whitelaw's report gives the impression that many faces of payable antimony exist in the Costerfield Mine. It should be remembered, however, that before the final abandonment of the property by the Costerfield Mining Company, the rich patches were fairly thoroughly worked out. The several other possibilities were examined by Gold Exploration and Finance Limited, who had competent and experienced technical staff available, and it was found that the payable reefs had all been followed to their termination, that is, to a point where they narrowed down, or the proportion of quartz increased, to such an extent that further exploration was not justified. A small amount of ore was obtained from one or two sections, but nearly all their production came from the North System. A little ore may remain here (Conolly estimated a possible 400 tons of concentrates a month or so before production ceased) particularly in the Donald Lode above and below No. 5 level, but certainly not enough to justify re-opening the mine. During their operations a total of 12 underground drill holes were put out from Nos. 4, 5, 6, 7 and 8 levels, but no encouraging results were obtained at the south end, under the Kendal system.

The possibility of further important ore-bodies at Costerfield would appear to be restricted to -

(1) The development of a downward extension or repetition of the Kendal system underneath the main "backs".

(2) The possible existence of a "Kendal System" in the Bombay area, bearing the same relationship to the Bombay reef as the Kendal and North lodes do to the Main Costerfield reef.

(3) Repetition of the lodes south or north of the Costerfield - Bombay mines.

The first possibility is of course highly speculative. There is little, if any, evidence as yet that the reef fractures persist in depth. Drilling on No. 7 and 8 levels has not revealed any ore. The only way to test the area would be by drilling a long inclined hole from the surface west of the lode 5-600 feet south of the main shaft, to cut the possible ore area some 200 feet below No. 8 level. This would involve a hole some 1600 feet in depth and could only be recommended as a last resort.

The possible existence of reefs in the footwall of the Bombay county could be tested more easily and would be the first work to be recommended in any attempt to recommence operations at Costerfield. Again recourse would be had to inclined surface drill holes from west of the lode, preferably about 150 feet north of the Bombay shaft, aiming to test the ore area between 500 and 600 feet depth. A disturbing factor in connection with this section of ground is the rise towards the south of the strong Whitelaw and No. 3 Backs (refer Block Diagram, Bombay Section), bringing them, if continuous to that extent, into the vital area under the Bombay Reef. On the other hand the deeper holes here would test the possibility of ore repetition below these faults at a lesser depth than would be necessary for the Kendal system.

If the antimony position becomes so desperate as to necessitate contemplating the re-opening of the Costerfield workings, exploration along the above lines should be carried out before incurring the heavy expense involved in dewatering and reconditioning the mine

With regard to repetition of the lodes beyond the limits of the Costerfield-Bombay workings, the strong development of ore in the Main and Kendal reefs suggests that the area south of the Main Shaft for a thousand feet or so has been the principal focus of mineralisation and that it would be optimistic to expect similar strong ore formations along the strike. North of the Main Shaft considerable prospecting has been done on the surface, and outcrops here are better than elsewhere along the lode, so that it is less likely that anything could have been missed. South of the Bombay, just one mile from the Bombay Shaft, the Alison mine has produced a certain amount of ore, of generally poorer grade than from the Costerfield Mine. Little is known of these and the other south workings. It may be assumed that the area between the Bombay and the Alison shafts was thoroughly prospected in the early days. Ore might be expected to occur where the main folds pitch north, as, for instance, the pitch would be expected to have reverted to the north perhaps 600 feet south of the Bombay shaft and at intervals between there and the Alison. That such occurrences exist is indicated on Whitelaw's Surface Plan, but as they were not followed up they were apparently unpayable. It would, however, be sound prospecting to examine this area by surface costeaning, bearing in mind that values are most likely to be associated with north-pitching beds in the vicinity of the anticline.

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