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AUSTRALIAN CONSOLIDATED INDUSTRIES LIMITED

MINERAL RESOURCES DIVISION

THE GEOLOGY OF THE CLUMP PROSPECT, BALFOUR, NORTHWEST TASMANIA

by

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SUMMARY

The Clump Prospect near Balfour northwest Tasmania, was mapped in detail to provide a geological framework for the present diamond drilling programme which is testing the economic potential of a stratabound cupriferous dolomite quartzite. The depositional environments and the structural history of the folded succession were determined and a genetic model for the cupriferous mineralisation, was constructed.

The succession was divided into three lithological facies; an older sandstone-shale facies representing deposition of mature quartz sand and silt within a deeper sub-littoral environment, and a dolomitic quartzite facies, which is the host rock to the cupriferous mineralisation, representing autochthonous carbonate and silica deposition in a locally euxinic sub-littoral environment.

The succession was gently folded during the Tabberabberan orogeny and now forms part of the eastern limb of a large anticlinorium; post-orogenic faulting and shearing especially adjacent to the mineralised zone, complicates the structural picture.

The cupriferous mineralisation was formed by diagenetic and microbiochemical sulphurisation of copper compounds synsedimentarily deposited with the carbonate and silica. The source of the copper is unknown. Tectonic remobilisation has locally concentrated the disseminated chalcopyrite.

1. INTRODUCTION

Detailed geological mapping on a scale of 1:1000 was carried out at the Clump Prospect as part of the 1971-1972 mineral exploration programme of Australian Consolidated Industries Ltd. on Exploration Licence 16/68. The mapping was carried out to provide a detailed geological background to the present diamond drilling programme which is aimed at proving the existence of economic copper mineralisation at the Clump Prospect. This report gives the stratigraphical and structural interpretation of the geology of the area, as ascertained by field work during March 1972, and provides a model for the genesis of the cupriferous mineralisation.

1.1 Location and access

The prospect is situated at a latitude and longitude of 41° 12'S and 144° 53'E respectively, some nine kilometres NNW of the old township of Balfour, and some forty kilometres SSW of Smithton. The prospect takes its name from a prominent clump of heavy timber situated on a Tertiary basalt residual in the western part of the area. Access to the area is by a bulldozed track from Balfour. Within the area the numerous drillsite access roads, and the gently rolling button grass plain facilitate access to all parts of the mapped area. Rock exposure is less than 0.1 per cent, due to the thick peat cover over the area. Natural rock outcrop is best developed along the low ridge which defines the mineralised zone, and is supplemented along this ridge by old prospecting trenches, and by a series of costeans that were constructed during the present exploration programme.

1.2 Previous investigations

The prospect was first explored between 1900 and 1910 during the exploration boom in the Mt. Balfour mining field. Exploration was carried out by trenching and pitting along quartzose ridges, with a few shafts and adits driven in those parts of the area considered to have the highest potential. The most extensive investigations of the Clump Prospect during this period were carried out by the Mt. Balfour Copper Mines N.L. and consisted of an adit, shaft and associated drives and crosscuts. Although high grade cupriferous material was intersected in these workings, no ore was shipped.

The first geological investigations in the area were carried out by Ward (1911) who had all the exploratory workings and trenches available for study; Ward produced a detailed report on the results of the early investigations and underground exploration.

No further investigations were carried out after the failure of the Balfour mining field until the middle 1960's, when an induced polarisation survey was carried out for a local syndicate. After 1968, as part of the A.C.I. exploration programme, a further induced polarisation survey, a magnetometric survey and some geological investigations were carried out at the Clump Prospect. The geological investigations were limited to mapping and sampling of costeans and old workings, and mapping along the ridge in which the mineralised zone is located. The results of these investigations were considered to be sufficiently encouraging to warrant detailed investigations, and diamond drilling of the mineralised zone commenced in June 1970. To date eight diamond drill holes have been collared at this prospect.

1.3 General geology of the area

The rock succession in the area comprises three lithological facies; a lower thick sandstone-shale facies, and an upper thick siltstone-shale facies which contains a thin formation of a dolomitic quartzite facies. The succession strikes about north-west, dipping and younging to the north-east. The older sandstone-shale facies grades gently and conformably upwards into the younger siltstone-shale facies, but the dolomitic quartzite facies has sharp, possibly locally unconformable, contacts with the enclosing siltstone-shale facies rocks. The only igneous rocks in the area are dissected basaltic lava flows of Tertiary age.

The succession in the area appears to form part of the eastern limb of a large northwest-southwest striking anticlinorium which was formed by a single period of folding during the Devonian Tabberabberan orogenic movements. Two generations of post-orogenic major faults cut the succession, an older group of northwest striking strike-slip shears with dextral movement, which were active in, and immediately adjacent to, the dolomitic quartzite facies, and a later group of northeast trending shears with sinistral movement. The regional metamorphism accompanying the folding reached only the lowest greenschist facies grade.

Finely disseminated pyrite is ubiquitous in the carbonaceous shale and siltstone units of the siltstone-shale facies, but is concentrated in those units adjacent to, and intercalated with, the dolomitic quartzite facies formation, which itself contains finely disseminated chalcopyrite and locally concentrated coarsely disseminated pyrite.

The age of the rock succession of the area has not been definitely established. The succession had previously been placed in the Younger Precambrian on lithological and structural grounds, and in the apparent absence of fossiliferous strata. During the course of the present field investigations, some pyritic replacements of brachiopods which are provisionally identified as Lingula sp. were noted in siltstones outcropping in the banks of the Frankland River at 460450'N 310500'E. The presence of these fossils only indicates that the youngest units of the siltstone-shale facies present in the area are of Lower Cambrian age, or younger.

2. STRATIGRAPHY

The three lithological facies are described in detail mainly from their field appearance as thin sections are not available except from drill core.

2.1 Sandstone-shale facies

Rocks of the sandstone-shale facies underlie the western part of the area. This facies consists of quartz sandstone and ferruginous sandstone units, with a few thin black carbonaceous shale bands intercalated with the arenaceous rocks. The grain size of the arenaceous rocks decreases, and the proportions of shale increases, gradually up the sequence, to the point where this facies has graded into the siltstone-shale facies.

Exposures of the sandstone-shale facies are very rare, with only shale bands exposed in road cuttings. The sandstone members outcrop rarely but along the crests of the low hills, very extensive sandstone float occurs. The quartz sandstones and ferruginous sandstones have been intensely leached by humic acids, with the result that all the float consists of blocks of porous white quartz sand with a silica cement, whereas the unweathered sandstones are massive, almost non-porous rocks, cemented by silica, iron oxides and minor carbonate in the ferruginous sandstones, and by silica and carbonate in the quartz sandstones.

The ferruginous sandstones and quartz sandstones form units from 10 cm to 10 m. thick, the thinner units consisting mainly of ferruginous sandstone, and the thicker units consisting mainly of quartzites. The positions of the quartz sandstones are very easily recognised in the field as they tend to form long northwest-southeast trending ridges. The shales vary in thickness, from one centimetre partings between sandstones, to units greater than ten metres thick. In general, the units are 3 to 4 metres thick.

The quartz sandstones are generally featureless due to their siliceous cement obscuring internal structures and only a few examples of cross-bedding were noted. The ferruginous sandstones, however, exhibit oscillation ripple-marks, current-bedding, cross-bedding and graded bedding. The incidence of graded bedding in the ferruginous sandstone units increases eastwards, whereas the incidence of the traction current sedimentary structure decreases eastwards.

The quartz sandstones consist of sub-angular to rounded clear quartz grains in the 0.2 to 1.0 mm. size range, the mean size of grains decreases up the sequence. The grains have diagenetic silica overgrowths and are cemented by silica. The ferruginous sandstones are identical to the quartz sandstones except that iron oxides and carbonate as well as silica form the overgrowths and cement. Heavy and resistate mineral content is very minor, only a few grains of apatite, tourmaline, rutile, magnetite and zircon? were noted. The shales consist of fine silt and clay-size fractions composed of about 80 per cent rounded quartz, the remaining 20 per cent being made up of sericite, clay minerals, iron oxides and carbonaceous material. The shales do not exhibit any sedimentary structures apart from a distinct lamination.

The rocks of the sandstone-shale facies appear to have been deposited sub-aqueously in a littoral environment, mainly within the zone of wave action, with the increase in the incidence of graded bedding and decrease in the incidence of traction current structures eastwards, being indicative of gradually increasing water depth. These rocks represent the products of the deposition of mature, reworked quartz sand and silt in a strand-line environment, which gradually deepened to a sub-littoral environment on an unstable shelf. Sediment transport was by current and wave action, with the depositional processes of gravitational slumping and settling becoming more important with increasing water depth.

2.2 Siltstone-shale facies

Rocks of this facies outcrop throughout the eastern part of the area, and consist of laminated quartz siltstones, massive siltstones, ferruginous siltstones, carbonaceous shales and minor ferruginous sandstone beds. Outcrop of the less competent shales and siltstones is rare except in costeans. The more massive siltstones do outcrop.

Attempts have been made to correlate individual beds along strike but apart from a few thin-bedded quartz siltstones that outcrop intermittently for strike lengths exceeding 300 m., no correlation of individual units is possible due to the very rapid lateral and vertical lithological changes in this facies.

Three marker bands are useful in determining the extent of folding and faulting; these are the pyritic siltstones outcropping as limonitic siltstones, in the immediate footwall of the dolomitic quartzite facies, the finely laminated carbonaceous shales and siltstones forming the hanging-wall of the dolomitic quartzite facies and a pyritic siltstone bed (marked Gossan on Map) some 100 metres in the hanging-wall of the dolomitic quartzite formation.

Rocks of the siltstone-shale facies outcrop from the top of the sandstone-shale facies sequence eastwards to the Frankland River, with little across-strike variation in lithological type and grain sizes. In general the proportion of fine carbonaceous shales in the sequence increases from the sandstone-shale facies boundary up to the dolomitic quartzite facies, and then decreases eastwards. Major ferruginous sandstone intercalations are restricted to the southwest part of the area, where a sandstone lens some 10 m. thick lies about 20 m. in the hanging-wall of the dolomitic quartzite formation, from 456300'N 313000'E to 459250'N 311100'E. No quartz sandstone units have been recognised in this facies.

In the field, the shales are dark grey to black in colour, well laminated and contain a little fine-grained disseminated pyrite. The siltstones vary in colour from black to grey and brown, depending upon their carbonaceous and limonitic content. Soem coarse quartz siltstones have been leached by humic acids, with the result that they now consist of white silt-size quartz grains loosely cemented by silica.

None of the siltstones or shales exposed on the surface appear to contain any volcanoclastic fragments or debris. The siltstones and shales intersected in the drill-holes do contain small indistinct chloritic bands, and one possibly tuffaceous siltstone containing coarsely disseminated pyrite is present in core from DDH 3, 4, 9 and 27, so a possibility exists that some siltstones do contain volcanoclastic material.

In general the sequence of the rocks in this facies appears to be typical flysch deposits. Shale bands range in thickness from 5 mm. laminae, between siltstone bands, to greater than 15 m., but are generally 10 to 25 cm. thick. Their only internal structure is an indistinct graded bedding in the finely laminated shales. The graded beds ranging in thickness from 5 mm. to 5 cm.

The siltstone bands range in thickness from a few centimetres to greater than ten metres, the mean thickness being about two metres; the units making up the siltstone bands range in thickness from 2 mm. to greater than one metre. Siltstone units show well-developed graded bedding and some cross-bedding, with slump structures, micro-unconformities between units, intraformational microfaulting and some double graded bedding over groups of several units. Clastic dykes on the mesoscopic and microscopic scales have been recognised.

One important feature not easily seen in outcrop, but obvious in drill core is that in graded units the coarse basal part of the bed is a light grey quartz siltstone, and the fine upper part of the unit is a black carbonaceous shale or siltstone. As these graded units make up over 80 per cent of the drill core, it is reasonable to suggest that most of the rocks of this facies outcropping in this area are of a similar nature.

The shales and siltstones are composed of fine-grained rounded to sub-angular quartz, fine-grained euhedral pyrite, amorphous flakes of carbonaceous material, detrital minerals, iron oxides, carbonate sericite and clay minerals. Chloritic bands are present, but chlorite is only a minor constituent of the normal siltstones and shales.

Quartz content increases with grain size. The typical siltstone contains greater than 85 per cent quartz, with the remainder made up of detrital minerals, silica-iron oxides - carbonate cement, and 1 to 2 per cent clay minerals, chlorite and sericite, whereas the typical black shale contains about 75 per cent fine-grained quartz cemented by silica, iron oxides and carbonate, with commonly over 10 per cent carbonaceous material with the remainder made up of pyrite, sericite, chlorite and clay minerals.

Pyrite grains are ubiquitous throughout all rocks of the facies, and are concentrated within any one bed in the coarse siltstones at the base of a graded unit, and in the massive coarse siltstones as a whole.

Attention has been given to the presence of leucoxene "porphyroblasts" in the siltstones, with the inference that these grains represent remnant volcanic sedimentary material. It is considered that these are the alteration products of detrital rutile and ilmenite, the original source of which, however, may have been sub-aerially eroded basic igneous rocks.

The siltstone-shale facies was deposited sub-aqeously below the zone of wave action. The close similarity in mineralogy between these rocks and rocks of the sandstone-shale facies indicates a similar source for the majority of the quartz grains and other minerals. The presence of a great amount of carbonaceous material that is a minor rock-forming constituent in the shale bands indicates a relatively shallow maximum depth of deposition. As mentioned before, probable fossil remains of Lingula sp. were discovered in the uppermost beds in the sequence, the presence of this fossil suggesting that bottom conditions during deposition were poorly oxygenated waters, with low pH and negative Eh, i.e. a low energy environment. Transport of material was by slumping down the gentle sub-littoral slope, and by current action. Periods of a relatively high rate of sediment transport and deposition are represented by thick coarse quartz siltstone beds, massive siltstones and sandstones, whereas periods of a low rate of sediment transport and deposition are represented by the carbonaceous shales. The immediate source of the sediment was mature reworked fine quartz sand carried out to sea from a strand-line by current and wave action, and deposited in a sub-littoral environment on an unstable shelf with a transgressive shore-line.

2.3 Dolomitic quartzite facies

The focal point of interest in the Clump Prospect is the occurrence of chalcopyrite in a rock consisting of dolomite, quartz, pyrite and very minor chlorite and other silicates. Chalcopyrite occurs only within this rock and in no case has chalcopyrite been recognised in siltstone and shales, although some quartz veins in the shale that forms the hanging-wall to the dolomitic quartzite formation do contain some tectonically remobilized chalcopyrite. On the surface, this formation consists almost entirely of quartz as the circulating acidic groundwaters (humic and sulphurous) have leached out all the sulphides and carbonate, and only in the drill-hole intersections of the formation can dolomite and sulphides be recognised.

Previously, a great deal of discussion has been made as to whether the dolomitic quartzite formation is a sedimentary rock or a quartz-dolomite vein system. It is considered here for the following reasons that the formation is a sedimentary rock :-

a) The dolomitic quartzite formation acts as an integral part of the sedimentary sequence, and is deformed in the same manner and style as the whole sequence.

b) The dolomitic quartzite formation extends over two kilometres strike length, with no apparent deviation from the structural trends in the enclosing siltstone-shale facies.

c) The dolomitic quartzite formation does not exhibit any geological features consistent with a hydrothermal origin that cannot be readily explained as due to modification of original sedimentary features by the relatively intense post-orogenic shearing within, and adjacent to, the formation.

The dolomitic quartzite facies is exposed in the area as an anastomosing bed expressed on the surface by low ridges of massive but shattered quartz fragments, fragments of cavernous friable quartz and common iron-stained quartzose fragments. These ridges which extend from 456250'N 313000'E to 462000'N 307500'E are covered by a thin sheet of colluvial and eluvial quartz fragments.

Where the formation is exposed in the costeans, it consists of barren quartz and quartzose fragments set within a friable quartz sand matrix. The dolomitic quartzite formation contains many intercalations of siltstone and carbonaceous shale due to local variations in the depositional environment but giving the erroneous impression that the formation has been repeated by folding.

The dolomitic quartzite formation varies in thickness from 2 m. to greater than 15 m. Where intercalations of siltstone-shale facies rock occur, the total thickness of the formation exceeds 25 metres.

In drill-hole intersections, the dolomitic quartzite formation consists of coarsely crystallized dolomite and quartz occurring together in all proportions. Pure dolomite and massive quartz are common but the usual proportions are dolomite:quartz = 60:40. Accessory minerals are pyrite and chalcopyrite with minor chlorite, carbonaceous material and tremolitic amphiboles. Pyrite content of the rock is up to 50 per cent and occurs as coarsely disseminated euhedral grains together with finely disseminated grains. Chalcopyrite occurs as finely disseminated grains and a few coarse randomly distributed clusters of grains.

In thin section, the dolomite is recrystallized, and unstrained; the quartz is recrystallized but strained, with undulose extinction and pressure solution sutured intergranular boundaries modifying an earlier mosaic texture. Both quartz and dolomite and to a lesser extent, the chlorite emphibole, corrode both pyrite and chalcopyrite.

Although sedimentary structures are absent, there is a crude banding parallel to bedding planes, caused by large variations in dolomite:quartz proportions.

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The dolomitic quartzite formation has sharp concordant contacts with the rocks of the siltstone-shale facies and only sheared contacts appear to be discordant. It is evident that this relatively competent formation has been fractured and locally brecciated by the shearing in the incompetent shale in the hanging-wall, and in the shale bands within the formation. The pyrite content of the surrounding siltstones and shales increases markedly towards the dolomitic quartzite formation, in both the footwall and hanging-wall. The shearing of the formation has permitted access by acid ground-waters, which have leached out dolomite and sulphides to depths well below sea-level.

Certain features of the environment in which the dolomitic quartzite facies accumulated are evident due to its presence within the siltstone-shale facies. The facies represents a sub-aqueous sub-littoral depositional environment below the zone of wave action, on an unstable shelf. Dolomitisation was a diagenetic process, obscuring the nature of the original carbonate-silica rock. The source of the carbonate is not known, but was probably chemical precipitation, from sea-water concentrations of calcium carbonate. The environment was certainly one of low energy, representing both a period of low intermittent sediment transport and influx, and high carbonate precipitation, with restricted bottom circulation. The silica content of the rock may be due to incoming quartz sand and silt deposited with the carbonate, or chemical precipitation of chert. On the available evidence, neither possibility can be dismissed, and it is possible that both sources were active. Thus the dolomitic quartzite represents a thin, probably blanket micrite, carbonate sheet that accumulated by mainly chemical precipitation of carbonate, in a sub-littoral euxinic environment during a period of low sediment transport and deposition, the carbonate being diluted by locally important and gravitational sedimentation of siltstone-shale facies material, and by chemical precipitation of silica. The high pyrite content of the facies is indicative of the euxinic nature of the environment. Diagenetic dolomitisation destroyed the original textures and nature of the carbonate.

2.4 Igneous rocks

The only igneous rock known in the area is the Tertiary basalt that forms the small circular residual known as the "Clump". This residual is a remnant of basaltic lava flows extruded during the Tertiary. No basalt is exposed at the "Clump", as weathering has been extensive, but a few boulders remain within

3. STRUCTURE AND METAMORPHISM

3.1 Introduction

After the deposition of the sediments, the succession was deformed and slightly metamorphosed, probably during the Devonian Tabberabberan orogenic period. The deformation and metamorphism was restricted to a single period of gentle folding. Two generations of post-orogenic faulting cut the folded succession, their age is not established beyond the time range Upper Paleozoic-Mesozoic. Dynamic metamorphism along shear zones was locally active during the first period of faulting.

The fold structure of the area was studied in detail using bedding plane minor folds and joint orientations.

3.2 Mesoscopic structures

a) Initial structures

Bedding planes (S_0) are present in the rocks throughout the succession, apart from the massive sandstone units. By plotting the poles to bedding planes on a Schmidt net a mean bedding surface striking 140° and dipping 71° east is defined (Fig. 1). Sedimentary structures, especially graded bedding, are common and are locally useful for determining the direction of younging. Inversions of dip are rare, except in the highly contorted siltstones and shales immediately adjacent to the dolomitic quartzite formation and in no case was dip inversion traceable beyond a single outcrop along strike.

b) Group-I structures

A poorly developed cleavage, (S_1) in the fine grained carbonaceous shales is defined by the parallel orientation of sericite flakes. The orientation of S_1 planes has been controlled in the thin-bedded alternating shales and siltstones by S_0, and thus S_1 readings in such beds are of little apparent value. Only in the thick shale beds in the immediate hanging-wall of the dolomitic quartzite formation are axial plane cleavage planes developed, but as these have been folded and sheared by S_2 shear faulting in this band, the reading of S_1 in this bed are also of little value. In general, S_1 planes dip a few degrees steeper than S_0 planes in any particular bed, and the strikes of S_0 and S_1 are almost coincidental.

Minor folds in S_0 are common throughout the finer-grained units in the sequence. These folds are apparently more

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common in and around the mineralized zone, but it is considered that this picture is erroneous and due simply to the greater exposure around the mineralized zone. By plotting the axial planes and the plunge directions of the minor folds in S_0 on a Schmidt net, two groups of minor folds are defined:- the first group has axial planes parallel to the mean bedding plane direction, and the plunge lineations lie about a plane striking 141° and dipping 50° east (See Fig.1). This first group undoubtedly consists of minor folds formed during the period of folding. The second group of folds has almost random axial plane and plunge direction orientations, and are minor folds related to strike faulting of the S_2 period o faulting.

c) <u>Group-II structure</u>

These consist of shear faults (S_2) along 140° trends which are located within, and adjacent to, the dolomitic quartzite formation. A few other minor faults with 140° trends are present away from the mineralised zone. All the shears have moved dextrally; the displacements o each shear are impossible to ascertain. Much of the displacement along each shear plane has been taken up by bedding plane slip in the carbonaceous shales, the actual shear planes being defined by a veneer of graphite. Shear joints parallel to the shear planes are very common, are always infilled by quartz-carbonate stringers, and are the acial planes of drag folds that occur along the major shear planes. It is these drag folds which have been cited as evidence of greater folding complexity in and around the mineralised zone.

d) <u>Group III structures</u>

These consist of the major shear faults (S_3) along 060° trends. These faults displace the sequence in a sinistral sense and are related to a major set of quartz-infilled shear joints present throughout the area. That these faults are younger than the Group II faults is demonstrated by their displacing the 140° trending faults (S_2) and also in that the 060° S_3 shear joints displace the 140° S_2 joint set sinistrally.

e) <u>Joints</u>

Joint orientations were measured at five stations in the area (Fig. 2).

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contoured.

The 000° and 090° joint sets are shear joints related to folding, their angular separation and distribution indicating angular folding of large amplitude and low frequency; the 040° set are a-c tension joints parallel to the major direction of compression; the 140° set are shear joints belonging to the S_2 period of deformation, and the 060° set are shear joints belonging to the S_3 period of deformation, (see Fig. 2).

FIGURE ONE

1. Poles to S_0, sandstone-shale facies, 28 readings.

2. Poles to S_0, siltstone-shale facies west of the ridge that contains the mineralised zone, 111 readings.

3. Poles to S_0, siltstone-shale facies on ridge that contains the mineralised zone, 302 readings.

4. Poles to S_0, siltstone-shale facies east of ridge that contains the mineralised zone, 43 readings.

5. Poles to axial planes of minor folds in S_0, 40 readings.

6. Plunge of axial planes of minor folds in S_0, 40 readings.

Contour interval 1%, 5%, 10%, 15%, 20%, 25%.

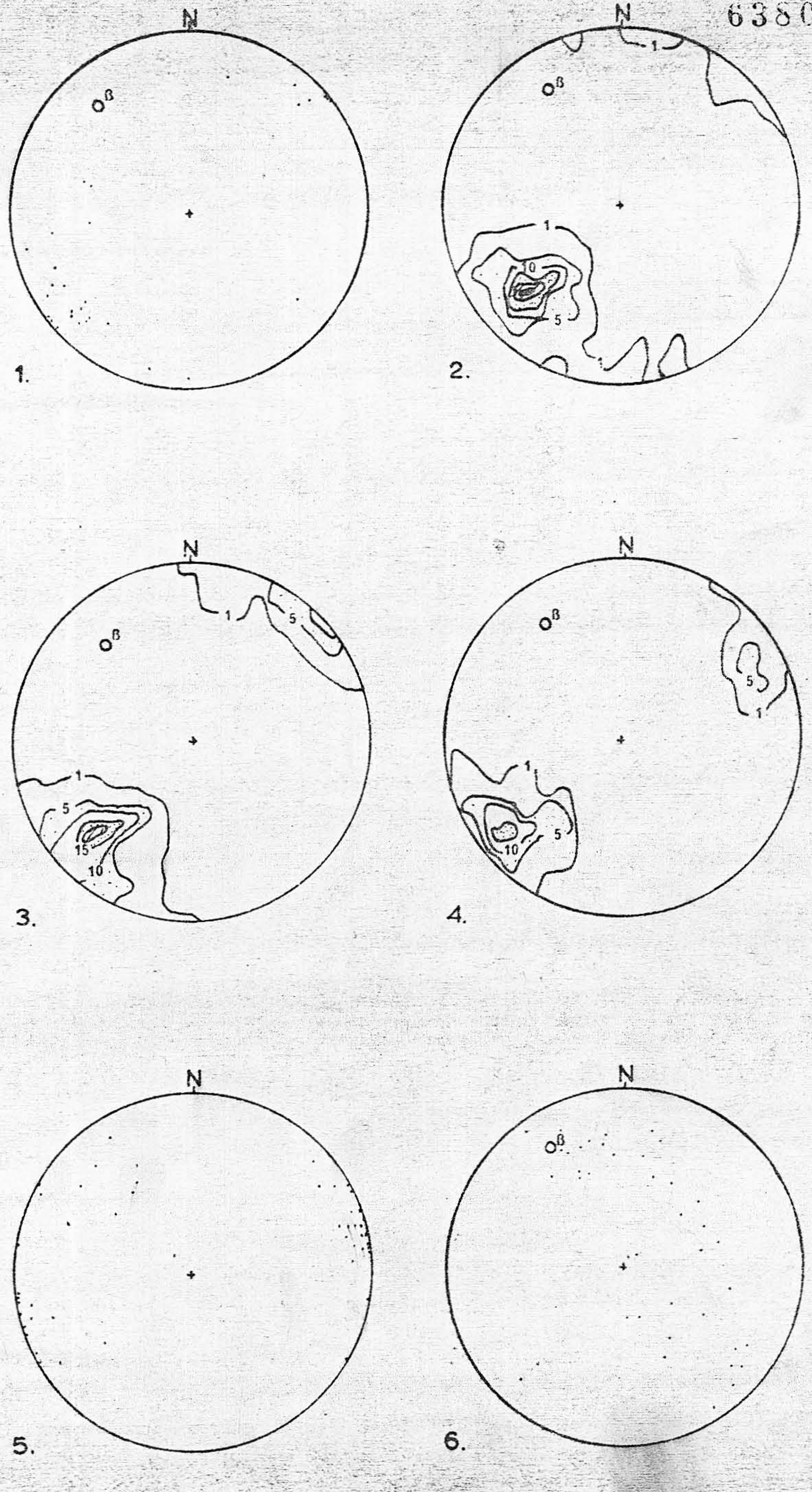

FIGURE ONE

FIGURE TWO

1. Poles to joints, Station 1 (460120N 309250E), 90 readings.

2. Poles to joints, Station 2 (459000N 310450E), 90 readings.

3. Poles to joints, Station 3 (457900N 309350E), 90 readings.

4. Poles to joints, Station 4 (461150N 309250E), 90 readings.

5. Poles to joints, Station 5 (460650N 309250E), 90 readings.

Contour interval - 1%, 2.5%, 5%, 7.5%, 10%.

6. Joint orientation/frequency interpretation diagram.

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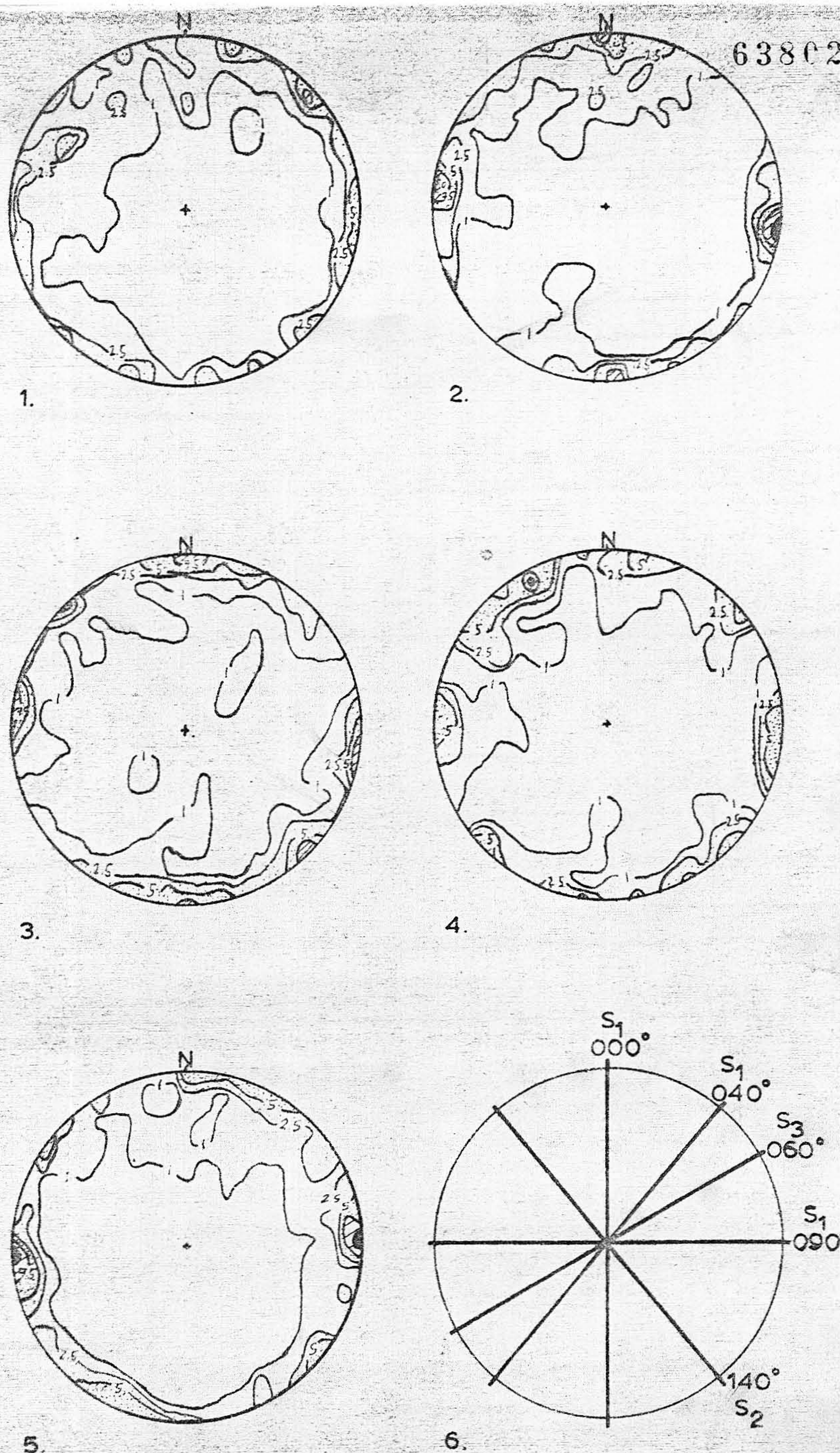

FIGURE TWO

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3.3 Macroscopic structures

From the plots of poles to S_0 planes, the axial trace of the major folds (Beta) was determined. From the plots o plunges of axial planes of minor folds, the mean inclination and orientation of the axial plane of the major folding was determined. From these two determinations, the orientation, inclination and plunge of the major fold axial planes was determined to be 140°, dipping 50° east, and plunging 20° north (see Fig. 1).

The distribution of poles to S_0 indicates that the folding was angular with much overturning of the minor limbs. Field observations on folds in this area are precluded by the lack of marker horizons. The lack of well-developed S_1 planes in the sequence indicates that folding was relatively gentle, and that the structure is by no means locked.

The structural history of the area appears to be one of gentle but angular folding of a Younger Precambrian to Lower Cambrian sequence of clastic sediments along 140° trends, during the early stages of the Tabberabberan orogenic period. Folding was followed by shear faulting along 000° and 140° trends, indicating that north-south compression was active in the area during the Upper Paleozoic and/or Mezozoic.

3.4 Metamorphism

Metamorphic effects upon the rock types exposed in the area have been slight. Regional metamorphism affected the entire sequence, and dynamic metamorphism was locally active within and adjacent to the mineralised zone.

a) Regional metamorphism

O'Toole (1971) reported that the whole district had been subjected to upper greenschist facies regional metamorphism, and in certain areas to the highest greenschist facies grade - the albite-epidote-almandine-hornblende sub-facies. The present fieldwork and a study of the thin sections available from the Clump Prospect, indicates, for the following reasons, that the area has not undergone regional metamorphism above the lowest greenschist facies grade, i.e. the albite-epidote-chlorite-sericite subfacies:-

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(i) Notwithstanding the fact that the rocks contain over 70% quartz, in no shale outcrop is epidote present or even suspected, neither do major amounts of chlorite occur even though clay minerals are present in sufficient quantities to allow the formation of these minerals under regional metamorphism.

(ii) Relatively little sericite is present in the shales and siltstones, even though there are sufficient quantities of clay minerals to provide the chemical constitutents of sericite.

(iii) In the Clump Prospect area, none of the shales have been transformed into slates or phyllites, which would be expected if subjected to upper or middle greenschist facies regional metamorphism.

(iv) The large amounts of carbonaceous material within the shales have not been altered to graphite except by dynamic metamorphism along S_2 shears. Graphite forms at about 320°C, and the latest estimate of greenschist facies temperatures are 280°C, for the lowest sub-facies, and 420°C, for the upper greenschist facies.

It is considered that most of the "metamorphic" features displayed by the rocks are due to diagenesis, and that only very low grade greenschist facies metamorphism of the Barrovian metamorphis facies series was active during the period of folding. The metamorphic period corresponds to the period of folding and S_1 definition.

(b) Dynamic metamorphism

Dynamic metamorphic effects are restricted to the S_2 shear zone within, and adjacent to, the dolomitic quartzite formation. These effects include:-

(i) Formation of graphite from carbonaceous material along S_2 shear planes;

(ii) Very slight reorientation of the sericite flakes from an S_1 to S_2 orientation;

(iii) Formation of talc and talcose minerals, within the dolomitic quartzite formation in the extreme south of the area in Costean 5S; the talc may have formed from dolomite and quartz;

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(iv) Intense shearing, drag-folding and minor brecciation of the incompetent shales adjacent to the dolomitic quartzite formation;

(v) Local brecciation of the dolomitic quartzite formation.

4. MINERALISATION

4.1 Introduction

During the exploration of the Clump area in the first decade of this century, prospecting pits, trenches and shafts were excavated throughout the area on quartz and limonite shows. Three types of outcrop were prospected intensely - the dolomitic quartzite formation, a large quartz vein in the southern part of the area, and outcrops of limonitic and hematitic "gossan" developed upon pyritic sediments. Only the dolomitic quartzite formation proved to contain significant chalcopyritic mineralisation, and was tested by underground workings at the Clump mine (459100N, 310450E) and by two adits and a shaft to the north of the mine (co-ordinates are; shaft 459350 N, 309850 E; adits 461000 N, 308465 E; and 461450 N, 308750 E), as well as over thirty trenches and pits.

4.2 Mineralisation in the dolomitic quartzite facies

A small amount of chalcopyrite is finely disseminated throughout the dolomitic quartzite formation. To date the only large concentration of chalcopyrite known in this formation is that tested by the underground workings of the Clump mine, where chalcopyrite, secondary copper sulphides and pyrite form veins and disseminations in the dolomitic quartzite formation and in massive vein quartz, with certain samples containing over 10 per cent copper. The chalcopyrite has been remobilised and probably concentrated by, and into, S_2 shears throughout the mineralised dolomitic qaurtzite, and into quartz-dolomite veins extending into the surrounding sediments. The mineralisation is concordant with a very crude banding of sulphides in drill-core intersections. There are no indications of wall-rock alteration. The pyrite is an original rock constituent, and is corroded by quartz and dolomite.

4.3 Other mineralisation

Away from the outcrop of the dolomitic quartzite facies, some trenching was carried out on limonitic outcrops - at 460150 N, 309300 E; 461250 N, 308550 E; and along a quartz vein extending from 456500 N, 312000 E to 458200 N, 311500 E.

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The limonitic outcrops marked Gossan on map are developed from the weathering and oxidation of pyritic siltstones and shales. No chalcopyrite was discovered in the course of trenching, and in the adit at 461450 N, 308750 E, driven to intersect the dolomitic quartzite formation, the limonitic band at depth was found to be pyritic carbonaceous shales and siltstones.

The quartz vein in the southeastern part of the area that lies on or about the transitional boundary between the sandstone-shale facies and the siltstone-shale facies was prospected by trenching during the 1900-1910 exploration. The vein has a marked discordance with the fractured iron-stained sandstone and siltstone country rocks, and is composed of massive and slightly fractured quartz. No cupriferous material was discovered in any trench. This vein appears to be purely tectonic, and is probably a vein infilling of a fault plane.

No economic potential is attached to either the quartz vein or the pyritic siltstones.

4.4 Genesis of the cupriferous mineralisation throughout the sequence at the Clump Prospect is undoubtedly an original constituent of the rocks, the mode of formation, and age relationship of the chalcopyrite with other minerals are not so clear.

The pyrite formed by diagenetic and microbiochemical sulphurisation of syngenetic, synsedimentary iron hydroxides and oxides just below the sediment/water interface; it is not feasible to postulate a hydrothermal/epigenetic or detrital origin for the pyrite.

To determine the origin of the chalcopyrite, it is necessary to consider certain salient points :-

(i) Cupriferous mineralisation is restricted to rocks of the dolomitic quartzite facies, except where quartz-dolomite veinlets infilling faults in the foot- and hanging-wall sediments carry remobilised chalcopyrite, even though the carbonaceous shales would provide a more suitable host for any syngenetically deposited cupriferous material;

(ii) There is a total lack of hydrothermal wall-rock alteration around and within the cupriferous mineralisation;

(iii) Tuffaceous material forms a very minor constituent, if at all, of the country and host rocks, indicating that volcanoclastic material was not introduced into the environment during the deposition of the sequence, and that a pure volcanic source for the copper is unlikely;

(iv) Cupriferous mineralisation is restricted to a concordant stratiform sedimentary formation that has a strike length exceeding two kilometres at the Clump Prospect, and exceeding ten kilometres within the Balfour district as a whole;

(v) Within the host carbonate formation hydrothermal sulphide features are recognisable;

(vi) The mineralogy of the cupriferous mineralisation is restricted to pyrite-chalcopyrite secondary copper sulphides. No copper or copper-iron sulphides indicative of a high-temperature formation have been recognised.

Any theory postulating a hydrothermal/epigenetic genesis of the chalcopyrite is considered to be untenable. If the chalcopyrite was introduced during S_2 shearing, the major shear zone, which is located in the shales in the hanging-wall of the mineralised zone, would certainly have been mineralised.

A theory postulating diagenetic/microbiochemical sulphurisation of synsedimentarily deposited cupriferous material is considered to be the most viable. Cupriferous material in a non-sulphide form was synsedimentarily deposited with the carbonate and silica, and was diagenetically and microbiochemically sulphurised to chalcopyrite. Later tectonism mobilised and concentrated some of the disseminated chalcopyrite into quartz-carbonate-sulphide veinlets.

The source of the copper is unknown.

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GEOLOGY OF THE SPECIMEN HILL AREA, BALFOUR

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SUMMARY

The Specimen Hill-Tin Creek area, Balfour, was mapped in detail to provide a geological background to the exploration work presently being carried out at the Murrays Reward Prospect. Special attention was given to determining the depositional environments and the structural complexity of the folded succession.

The succession is divided into four lithological facies - the stratigraphically oldest sandstone-shale facies represents deposition of mature quartz sand in a shallow-water infralittoral environment; the overlying siltstone-shale facies representing finer-grained quartz silt and clay material deposited within the same environment. Thin sheet sand bodies intercalated within the siltstone-shale facies are represented by the quartz sandstone facies. The onset of gradually deepening water and low sediment supply conditions is represented by the stratigraphically youngest chloritic carbonaceous shale facies.

The succession is gently folded along steeply plunging axes, forming part of the eastern limb of a major anticlinorium, formed during the Tabberabberan orogenic period. Two generations of post-orogenic shearing complicate the structure of the area.

Hydrothermal cassiterite-wolframite-pyrite-quartz veins, alluvial cassiterite deposits and a hydrothermal chalcopyrite-galena-sphalerite-pyrite-bearing quartz vein, are the mineral deposits located within the area. None of these have any significant economic potential.

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GEOLOGY OF THE SPECIMEN HILL AREA, BALFOUR

1. INTRODUCTION

Detailed geological mapping was carried out at a scale of 1:1000 on the area shown on Sheets 1 and 3 of the Australian Aerial Mapping photogrammetric map of the Murrays Reward Prospect, as part of the 1971-1972 mineral exploration programme of Australian Consolidated Industries Ltd. on Exploration Licence 16/68. The mapped area encompasses Specimen Hill and its environs, west ~~xxxxxxxxxxxxx~~ and north-north-east of the Tin Creek Valley. The mapping was carried out as part of a joint effort by Mr. M.H. McIntyre and the author, to give a detailed geological background to the present drilling programme at the Murrays Reward ~~xxxxxx~~ Prospect. This report gives the stratigraphical and structural interpretation of the geology of the area as ascertained by field work during April and May 1972.

1.1. Location and Access

The mapped area is situated at a latitude and longitude of 41° 16' S. and 144° 52' E. respectively, about one kilometre west of ~~t~~ the Balfour township, and about 53 km. south-south-west of Smithton. Access throughout the area is excellent with many costeans and bulldozed tracks, driven during earlier prospecting campaigns. Natural rock outcrop is almost nil, however, tin-sluicing operations and extensive costeaning have provided excellent exposure in several parts of the area.

1.2. Previous Investigations

The tin and wolfram-bearing veins of Specimen Hill were worked in the late nineteenth and early twentieth centuries, as were the alluvial tin placers in the valleys, by a series of companies, the records of which none survive. Ward (1911) mentions the extent of the workings. Several local prospecting syndicates investigated the area after 1910, but the first intensive prospecting ca[illegible] the period 1965-1967, consisting of extensive costeaning, a gravity survey and a limited diamond d illing campaign. To date, several small mining leases are still held in the area by private individuals, who are working the outcropping tin veins of Specimen Hill. The interest of A.C.I. in the area is basically to determine its geology in order to provide a greater understanding of the geology of the Murrays Reward Prospect as a whole.

2. STRATIGRAPHY AND STRUCTURE

2.1. General geology

The rock succession in the area is comprised of four lithological facies. The stratigraphically oldest is the sandstone-shale facies exposed in the hills to the west of the Tin Creek valley, which grades vertically upwards into the siltstone-shale facies that forms the Tin Creek valley and Specimen Hill. The siltstone-shale facies sequence contains rocks of the quartz sandstone facies - these are exposed in the ridges north of Tin Creek, and on the eastern flank of Specimen Hill. The stratigraphically youngest facies is the chloritic carbonaceous shale facies exposed in the far north-west of the area. No igneous rocks are exposed in the area.

The succession in the area forms part of a large anticlinorium which was formed by a single period of deformation during the Devonian Tabberabberan orogenic period. The anticlinorium strikes about north-west - south-east throughout the Balfour district. Two generations of post-orogenic major faults cut the succession.

The mineralisation in the Specimen Hill-Tin Creek area is restricted to hydrothermal cassiterite-wolframite-pyrite veins, alluvial tin deposits and hydrothermal copper-lead-zinc mineralisation in a quartz vein. No syngenetic cupriferous mineralisation as found at Murrays Reward, is developed in the area.

The age of the rock succession of the area has not been reliably ascertained. By analogy withthe Clump Prospect (Jackamn 1972) where Lower Cambrian fossil remains were noted, and considereing that worm burrows are very common in graded beds of the siltstone-shale facies, an Upper PreCambrian to Lower Cambrian age is assigned to the succession.

2.2. Stratigraphy

The four lithological facies are described in detail in the following sections, from the study of their field relationships, structure and characteristics, together with microscopic mineralogical study.

2.2.1. Sandstone-shale facies

The far western part of the area is underlain by rocks of this facies, making up the hills to the west of the Tin Creek valley and Specimen Hill. The facies consists of theick quartz sandstone and ferruginous sandstone units with a few intercalated bhack carbonaceous shale bands. This facies sequence is overlain by that of the siltstone-shale facies, the upper one hundred metres of the sandstone-shale facies is a transitional zone in which the arenaceous rocks grain size decreases rapidly upwards, and the proportion of shale in the sequence increases up to about fifty percent.

Exposures of theis facies are rare within and outside the area, with shale bands only exposed in road cuttings and in areas where tin-sluicing has been carried out. The sandstones ~~xxxxxxxxxxxxxxx~~ very rarely outcrop naturally, their presence is indicated by ~~flat~~ float; except where water-races were constructed by the tin-sluicers, exposing bedrock, natural exposure is limited to stream beds. In common with the Clump Prospect (Jackaman 1972) the weathered sandstone float consists of porous white quartz sand with a sparse silica cement, whereas unweathered ferruginous sandstones and quartz sandstones are massive, almost non-porous sandstones cemented by silica, iron oxides and minor carbonate.

Quartz sandstones comprise only a small proportion of the facies sequence exposed in the area, in marked contrast to the sandstone-shale facies sequence at the Clump Prospect (Jackaman 1972). They form thick units exceeding ten metres in thickness, extending for many hundreds of metres along strike. In unweathered outcrop, their internal structures are partially obscured by the siliceous cement, a marked cross-bedding is the only evident sedimentary structure. The rock is comprised of sub-angular to rounded clear quartz grains in the 0.2-0.6 mm size range, cemented by a diagenetic silica cement in the form of silica overgrowths on the grains. The heavy resistate mineral content of the quartz sandstone -s appears to be limited to a few sparse magnetite, zircon and rutile grains.

The ferruginous sandstones form units between 50 cm and 10 metres in thickness, the majority of units lying in the thickness range five to eight metres; units apparently extend laterally over a hundred metres along strike. Sedimentary structures noted in these units are oscillation ripple-marks, graded bedding, cross-bedding, current-bedding and associated traction-current structures. Graded bedding is the dominant sedimentary structure in the ferruginous sandstones of the upper 250 metres of the facies sequence. In grain size and mineralogy, the ferruginous sandstones are identical to the quartz sandstones except that they have a silica/iron oxide/carbonate cement.

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The black shales form individual units of between one millimetre and 25 metres in thickness; the shales in the bulk of the sequence are simple one to ten millimetre laminar partings between sandstone units; only in the one hundred metre transitional zone at the top of the facies sequence do thick shale units exist. The shales do not exhibit any sedimentary structures apart ffom an indistinct lamination. They consist of fine silt and clay fraction sized rounded quartz grains with minor sericite, iron oxides, carbonaceous material, chlorite and clay minerals.

The above features indicate that the rocks of the sandstone-shale facies sequence were deposited sub-aqueously in an infralittoral environment.

Apart from the upper one hundred metres of the facies sequence, the rocks of this facies were deposited within the zone of wave action, mature reworked quartz sand and silt being transported by wave and current action from a strand-line environment into an infra-littoral environment on a relatively stable shelf. In view of the infra-littoral depositional environment of the overlying siltstone-shale facies sequence, the upper one hundred metres of the sandstone-shale facies sequence must represent a major change in sediment size and nature supply, and not a major depth of deposition change.

2.2.2. Siltstone-shale facies

Rocks of the siltstone-shale facies outcrop throughout the central part of the area. The sequence consists of laminated quartz and ferruginous siltstones, massive quartz and ferruginous siltstones, carbonaceous shale and minor ferruginous sandstone bands, together with graded siltstones and shales. Natural outcrop of this facies is almost non-existent, only the extensive tin-sluicing operations and the costeans constructed by B.H.P. on Specimen Hill provided outcrop for study. The only individual units correlatable along strike in this facies are the intercalated sandstone-shale facies bands on Specimen Hill, and the quartz sandstone facies bands in the eastern half of the area. Any correlation of individual units within the siltstone-shale facies sequence itself was found to be impossible due to the very rapid lateral and vertical lithological changes in this facies, coupled with the patchy nature of the manmade exposure.

There appears to be little overall variation in lithological types and grain size in the facies sequence from the top of the underlying sandstone-shale facies sequence to the bottom of the overlying chloritic carbonaceous shale facies sequence, apart from a concentration of graded siltstones and shales in the middle of the sequence. The intercalated sandstone-shale facies and quartz sandstone facies rocks are considered separately.

In the field, the siltstones vary in colour from grey to brown and black, depending upon their iron oxide and carbonaceous material content. The siltstone units range from two centimetres to over ten metres in thickness, most units lying in the five ~~cent~~ to fifty centimetre thickness range. Units exhibit well-developed graded bedding and some cross-bedding, with slump structures, micro-unconformities, intraformational micro-faulting, wash-out structures, and doubly graded bedding between units. Clastic dykes have been noted.

The siltstones consist of fine sub-angular to rounded quartz grains, together with very minor iron oxides, euhedral pyrite, and amorphous carbonaceous material, cemented by diagenetic silica/iron oxide/carbonate overgrowths. Detrital resistate minerals are present, notably grains of rutile and ilmenite, some of which have altered to leucoxene, producing the leucoxene "porphyroblasts" which are a common feature of the siltstone-shale facies of the Balfour district.

The shales are black in colour due to their high carbonaceous material content. They are well-laminated, forming units ranging in thickness from two millimetre laminae between siltstone units, to major 25 metre beds, most units falling into the thickness range one to ten centimetres. Sedimentary structures are restricted to an indistinct grading extending over the whole thickness of the thinner units. Shales consist of very fine silt and clay fraction size rounded to sub-angular quartz grains, fine amorphous carbonaceous material, sericite, clay-minerals, and very minor fine pyrite, iron oxides and carbonate. Quartz contents range ~~xxx~~ between 75 and 90 percent.

The graded units found concentrated in the middle of the sequence consist of both silt and shale, the coarser part of the unit consisting of grey to dark grey quartz siltstone, grading upwards into fine black carbonaceous shale. Units range from one centimetre to ten centimetres in thickness. Sedimentary structures exhibited are ubiquitous graded bedding, cross-bedding, current-bedding, current scour, ubiquitous wash-out structures, and other traction current structures, together with worm burrows into the shaly tops of individual units.

The siltstone-shale facies represents the sub-aqeous deposition of mature quartz sediment and clay material in an infra-littoral environment on a relatively stable shelf. Sediment size was a function of the sediment source and not of the transporting media. Most deposition was by gravitational settling within and just below the zone of wave action, as indicated by the presence of graded beds modified by traction current structures. The presence of worm burrows indicates a shallow depth of deposition. The presence of pure quartz arenite sheet sand lenses (the quartz sandstone facies) supports a shallow water depth. Sediment transport was by the agencies of wave and current action bringing sediment out from a strand-line environment and reworking previously deposited material.

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2.2.3. <u>Quartz sandstone facies</u>

Several thin beds of quartz sandstone intercalated within rocks of the siltstone-shale facies are exposed in the eastern part of the area. They form the crests of ridges extending from the east of the Tin Creek valley, southwards forming the eastern ridge of Specimen Hill. Exposure of the immediately adjacent siltstone-shale facies rocks is limited to Specimen Hill costeans, here it is seen that these enclosing rocks are normal siltstone-shale facies sequence rocks.

The quartz sandstone facies consists of several thin but laterally extensive, pure quartz-arenite beds. The beds range from two to ten metres in thickness, and from five hundred metres to over two kilometres in along strike length. Each bed is extremely homogeneous in nature and constituents along its strike exposure. The rock consists of rounded to sub-angular quartz grains in the size range 0.3 to 0.8 millimetres, cemented by diagenetic silica overgrowths. Only a very small amount of iron oxides and detrital minerals was noted. Sedimentary structure are limited to indistinct cross-bedding and indistinct current-bedding and wash-out structures. Several instances of ripple-marked bedding surfaces were noted.

The quartz sandstone facies sequence represents the sub-aqueous deposition of mature reworked quartz sand in an infra-littoral environment during a period of very low contaminating silt and clay material supply. Each band represents a period of relatively rapid quartz sand accumulation transport being by the agencies of wave and current action. Deposition was in very shallow water,

2.2.4. Chloritic carbonaceous shale facies

In the extreme north-west of the area are several exposures of chloritic carbonaceous shale, The rock appears to be homogeneous throughout its exposure, having few diagnostic features. The rock is very well laminated, with slight grading over two to five centimeter units. The rock appears to be the chloritic equivalent of the shale of the siltstone-shale facies, consisting of fine clay-fraction size quartz grains, amorphous carbonaceous material, clay minerals, chlorite and sericite. Siltstone bands appear to be absent.

This facies represents the sub-aqueous deposition of clay shales and organic material in an infralittoral to circalittoral environment on a relatively stable shelf. Sediment transport was by the agencies of wave and current action, deposition by gravitational settling. The absence of coarser sediment was a function of the depositional processes active in the environment.

All four lithological facies represented in the eastern half of the Murrays Reward-Specimen Hill area represent the products of shallow-water infra-littoral clastic depositional environments, with similar transport and depositional agencies active.

2.3 Structure and Metamorphism

2.3.1. Introduction

After the deposition of the sediments, the succession was subjected to a period of gentle folding and concomitant slight regional metamorphism during the Tabberabberan orogenic period, followed by two generations of post-orogenic shearing. The age of the shearing is not definable beyond the time range Upper Paleozoic to Mesozoic. Some slight dynamic metamorphism along shear zones occurred during both periods of shear faulting.

The structure of the area was studied in detail using data on bedding plane orientations, joint orientations and minor folds, the details of which are presented below.

2.3.2. Mesoscopic structures

a) Initial structures

Bedding planes (S_0) are present in rocks throughout the ~~area~~ sequence, apart from the massive sandstone units. From the contoured stereographic plots of poles to S_0, a mean bedding surface striking 008° and dipping 64°E., is defined. This mean bedding surface is purely statistical, in view of the observed major changes in S_0 strike orientation in the area. Sedimentary structures, especially graded bedding, are locally useful in determining fold limb inversions; inversions of dip direction are very rare, only found in shear zones.

b) Group-I structures

Defined by the parallelism and elongation of sericite flakes is an axial plane cleavage (S_1), that is only poorly developed, and only developed in the fine carbonaceous shales. The orientations of the S_1 planes have been controlled in the thin-bedded alternating shales and siltstones by S_0 planes, thus S_1 orientation data in such beds are of little value. In general, it can be stated that S_1 planes are oriented a few degrees steeper in dip than the S_0 planes in any one bed, and that the strikes of both planes are almost coincidental.

Minor folds in S_0 are common throughout the finer-grained units in the sequence. Minor folds in S_0 are more common in the sediments adjacent to major fault zones. This is demonstrated from Fig. 2-1, where the axial planes and the plunge directions of the minor folds are plotted on equal area stereographic projections. Two groups of minor folds are recognisable - the first group has axial planes parallel to the mean S_0 plane, with the plunge lineations all lying about a plane striking 168^o and dipping 72^oE.. The second group of folds has almost random axial plane and plunge lineation orientation, and are minor folds related to shear faulting of the post-orogenic periods of faulting.

c) Group-II structures

These consist of the major shear faults along 140^o-170^o trends, which displace the sequence dextrally. These major faults are marked by intense quartz veining and shearing of the adjacent country rocks. In the vicinity of Specimen Hill, some of these faults contain mineralisaed quartz veins.

Much of the displacement in these shears has been locally taken up by bedding plane slip in shales of the siltstone-shale facies. Shear joints paralleling the major shear faults are very common, these joints are always infilled by quartz stringers, the joints are the axial planes of minor drag folds that occur along the major shears.

d) Group-III structures

These consist of the major shear faults along 020°-060° trends which displace the sequence in a sinistral sense. These faults are related to a set of majot quartz-infilled shear joints that are present throughout the area. In the vicinity of Specimen Hill, some of these faults contain mineralised quartz veins

e) Joints

At three stations in the area, joint orientations and inclinations were measured. These measurements are plotted in the form of contoured equal-area stereographic projections in Fig. 2-2. The interpretation of the joint directions is basically simple. The 020° and 120° sets are shear joints related to folding, their distribution and angular separation indicate angular folding of low frequency. The 070° set are a-c tension joints paralleling the main compression direction. The very small 150° and 060° maxima represent Group-II and Group-III shear joints; that these joint sets are not more obvious is due to the wide angular variations in these sets lessening point maxima and that the other maxima obscure the sets. The major 160° set at Station 3 represents the major joint sets paralleling the stanniferous quartz veins exposed at that station.

2.3.3. <u>Macroscopic structures</u>

From the plots of poles to S_0 planes, the trace of the axial direction of the major folds was plotted. From the plots of plunges of axial planes of minor folds, the mean inclination and orientation of the axial planes of the major folds can be ascertained. From these two measurements, the orientation, inclination and plunge of the major fold axial planes was determined as 166°, dipping 74°E. and plunging between 40°S. and 47°S.. The distribution of poles to S_0 when considered in the context ofnthe steep plunges of the major fold structures, indicates that folding was on a broad scale of relatively angular style. Field observations on folds in the area are precluded by the lack of marker horizons to show repetition of beds by folding, and the broad scale of the folding The lack of defined S_1 planes in the sequence indicates that folding was relatively gentle. The major structure in the area is the plunging anticline that forms the western part of Specimen Hill, and in which all the known stanniferous quartz veins are located.

The structural history of the area appears to be gentle but angular folding along 165° trends of an Upper Pre-Cambrian - Lower Cambrian sequence of sandstones, siltstones and shales, along the eastern limb of a large anticlinorium formed during the early stages of the Tabberabberan orogenic period; folding was followed by shear faulting along 140°-170° and 020°-060° trends, indicating that some north-south compression was active in the area during the Upper Palaeozoic and/or Mesozoic.

2-3-4. Metamorphism

Metamorphic effects upon the rock types exposed in the area were slight. Dynamic metamorphism was locally active within and adjacent to shear zones, and regional metamorphism affected the entire sequence.

a). Regional metamorphism

As was found at the Clump Prospect (Jackaman 1972) the mineralogical and textural features exhibited by the rocks in the area indicate that greenschist facies metamorphism of the albite-epidote-chlorite-sericite subfacies affected the area concomitant with the period of folding and S_1 definition.

b) Dynamic metamorphism

Dynamic metamorphic effects are restricted to the rocks within and adjacent to Group-II and Group-III shear zones. The dynamic metamorphic mineralogical and textural changes are developed more in the fine-grained shales than in the coarser sandstones and siltstones. These ~~xxx~~ changes are :-

i) Formation of graphite from carbonaceous material along shear planes

ii) Very slight redefinition of the sericite flakes oriented along S_1 to orientations parallel to the shear planes.

iii) Intense shearing, drag-folding and minor brecciation of the more competent beds within and adjacent to the shear zones.

3. MINERALISATION

3.1. Introduction

To date, three types of mineralisation have been discovered in the area - hydrothermal cassiterite-wolframite-quartz-pyrite veins, alluvial stanniferous gravels and hydrothermal copper-lead-zinc mineralisation in a quartz vein. All three types were actively explored during the early stages of the Mt. Balfour mining field, the alluvial and hydrothermal vein tin deposits were exploited.

No mineralisation of the syngenetic cupriferous type located within rocks of the dolomitic quartzite facies (see Jackaman 1972) has been discovered in the area; the total absence of rocks of the dolomitic quartzite facies in the area suggests that syngenetic cupriferous mineralisation does not exist within the mapped area.

3.2. Hydrothermal tin-wolfram mineralisation

On the crest and Western slopes of Specimen Hill, numerous thin quartz veins carring cassiterite and wolframite are exposed. These veins were worked during the late nineteenth and early twentieth centuries for their tin and wolfram contents, by open-cutting down to the water-table, at which point the appreciable sulphide content of the veins below the zone of oxidation precluded further extraction due to the difficulties of separation. Certain of the veins had oxidised to a quartz and clay rock containing appreciable quantities of cassiterite, these were also worked, mainly by underground methods. The main workings are located at 434700'N. 317450'E.; 434650'N. 317850'E.; 433640'N. 318250'E.; and 433250'N. 318600'E..

The veins at surface consist of porous milky quartz with residual cassiterite and wolframite in places. These minerals are generally deposited on the margins of the veins, adjacent to the host rocks.

At depth, the veins consist of abundant pyrite and arsenopyrite, with minor cassiterite, wolframite and siderite, set in quartz gangue. The country rocks immediately adjacent to the major quartz veins have been slightly hydrothermally altered, the alteration being in the form of sericitisation and slight silicification. The veins are generally of minor thickness, between two and ten centimetres, with occasional veins up to thirthy centimetres; all veins have sharp boundaries with the country rocks.

The mineralisation appears to have been emplaced during or after the period of group-III fault generation. The orientation and inclination of the major quartz veins carrying cassiterite and wolframite mineralisation are plotted in Fig. . The mineralisation appears to have been emplaced within pre-existing faults and shear/tension joints, by hydrothermal mechanisms. The tin/wolfram contents of the veins varies erratically, as do the thicknesses and dips of the veins themselves.

The control to mineralisation seems to be pre-existing faults and joints within the small anticlinal flexure along the western side and crest of Specimen Hill and southwards, being exploited by rising hydrothermal solutions from a deep crustal source, probably granitic.

The economic potential of the stanniferous veins was investigated fully by B.H.P. in the course of their exploration programme. It is doubtful whether renewed investigations by A.C.I. would prove up an economic orebody, as the veins themselves are narrow and too sparsely spaced to constitute a stockwork.

3.3 Alluvial stanniferous gravels

In the Tin Creek valley and the subsidiary tributary valleys to Tin Creek, alluvial cassiterite deposits are located on bedrock, at the base of the alluvial valley gravels. These deposits have been intensively worked in the late nineteenth and early twentieth centuries by numerous companies, notably Balfour Pioneers N.L. (Ward 1911). The mining methods were sluicing the overburden away using channelled water-races, or hand removal of thick gravel overburden, with hand and launder picking of the cassiterite grains. The deeper valley deposits were apparently worked by trenching and backfilling so the real extent of the worked ground is unknown. It is extremely unlikely that these gravels represent an economic source of tin at the present time.

3.4. Copper-lead-zinc mineralisation south of Specimen Hill

Several prospect shafts mentioned in Ward (1911) were sunk during the period 1900-1910 on an outcropping quartz vein carrying base-metal sulphides; only one of these shafts lies within the mapped area, at 431700'N. 317430'E.. Chalcopyrite, sphalerite, pyrite and galena in a hydrothermal quartz vein were intersected at depth. The amount of sulphide-bearing material on the dump around the shaft collar indicate that the vein is neither richly mineralised, nor of great width. The quartz vein appears to be genetically correlatable with the Specimen Hill tin-tungsten mineralisation.

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SUMMARY REPORT ON REGIONAL GEOLOGICAL MAPPING IN

E.L. 16/68, BALFOUR, TASMANIA

SUMMARY

Regional geological mapping on a scale of 1 : 10,000 was completed over an area of 6,000 hectares between The Clump Prospect in the north and The South Balfour Prospect in the south.

An easterly dipping sequence of sandstone and shale in the west is successively overlain by carbonaceous shale and siltstone and chloritic siltstone. These rocks, which have been tentatively assigned a younger Precambrian to Lower Palaeozic age, have been intruded by Cambrian (?) diorite and are unconformably overlain by Tertiary conglomerate and basalt.

Several synclinal folds occur along NNW trending axes, particularly in the basal sandstone and shale. Quartz is widespread in the area.

Previously investigated occurrences of quartz - dolomite - pyrite - chalcopyrite mineralisation occur at the Clump, Gully, Blocks, Central and Murrays Reward Prospects.

South of Balfour, between the Pierpont Morgan and South Balfour Prospects, is a NNW trending zone of quartz-(dolomite ?) pyrite - chalcopyrite mineralisation identical to that at all other prospects. This mineralisation occurs along a ~~subdivided~~ subdued and discontinuous ridge and further investigations are warranted on at least two prospects, The Pierpont Morgan and Waratah.

Several costeans were constructed and sampled and a number of anomalous copper values were recorded, particularly at the Central Prospect in the vicinity of Emmetts Creek.

It is recommended that field work be continued in 1973, such work to include sampling and mapping of old adits, diamond drilling and geological mapping.

INTRODUCTION

During the two month period October to December 1972, regional geological mapping was carried out over an area about 19 kilometres long and 3 kilometres wide extending between The Clump Prospect in the north and The South Balfour Prospect in the south. The geology of this area has been plotted on four 1 ; 10,000 plans and one 1 : 20,000 plan.

GEOLOGY

Stratigraphy:

The geological succession in the area consists of :-

Tertiary	Basalt Conglomerate Unconformity
Cambrian (?)	Diorite
Younger Precambrian to Lower Palaeozoic	Quartzite Siltstone Chloritic Siltstone Carbonaceous shale Sandstone

These formations are described further as follows.

Sandstone

The oldest rocks in the area consist of numerous grey and

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white quartz sandstone and brown ferruginous quartz sandstone beds separated by carbonaceous shale. The sandstone beds are quartzitic in parts and although commonly have strike lengths exceeding two kilometres, are rarely greater than 10 metres thick. In situ exposure of the sandstone is uncommon although sandstone float occurs along many ridge crests.

The intervening carbonaceous shale consists of banded and laminated carbonaceous siltstone and quartz siltstone and is rarely exposed.

Chloritic quartzite and sandstone occurs as thin beds particularly between the Blocks and Murrays Reward Prospects. This rock type has generally been bleached white but reveals a medium to dark green chloritic colouration on fresh surfaces.

The sandstone formation is at least 1,500 metres thick.

Carbonaceous Shale

The carbonaceous shale is essentially identical to the carbonaceous rocks separating the sandstone beds but contains no appreciable sandstone.

The lithologies include carbonaceous siltstone, carbonaceous shale, pale grey quartzose siltstone and dark grey to black graphitic and carbonaceous shale, this latter lithology apparently being restricted to zones of faulting or shearing. Graded bedding occurs in parts under green tinge and in some areas reflects the presence of a minor ~~ambient~~ amount of chlorite.

This formation is about 800 metres thick.

Chloritic Siltstone

This formation occurs on the eastern margins of the area, particularly between The Blocks and Pierpont Morgan Prospects, and attains a maximum thickness of about 500 metres.

The main lithologics of this formation consist of chloritic siltstone, phyllite and slate. Boundaries between the carbonaceous shale and chloritic siltstone are commonly obscure, one formation merging imperceptibly with the other, and it appears probable that the chloritic siltstone is simply a chloritic version of the carbonaceous shale. To complicate matters further, these two rock types are difficult to differentiate when weathered.

Siltstone

This formation is exposed only on the western flank of the Mt. Frankland ridge and consists of a regular alternation of dark grey and pale grey - brown arenaceous siltstone bands up to 5 centimetres thick. The siltstone dips steeply towards the east and has a prominent westerly dipping cleavage.

Quartzite

The upstanding nature of Mt. Frankland is a reflection of the extreme hardness of the central core which consists of pink hematitic quartzite and sandstone dipping towards the east. This rock type, as for the underlying siltstone, is found exposed only on Mt. Frankland.

Diorite

A number of diorite dykes occur south and southeast of the Pierpont Morgan Prospect. They have intruded sandstone and carbonaceous shale and occur as irregular elongate bodies between 20 and 120 metres thick and up to 1.5 kilometres long with a vague preferred orientation between ENE and ESE.

The dykes have been heavily weathered and only a few boulders

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remain in a red-brown soil. The least weathered boulders consist of equigranular hornblende and feldspar with a minor amount of quartz.

Dykes of similar material beneath Specimen Hill may be the cause of the observed gravity and magnetic anomalies.

Conglomerate

A quartz, quartzite and quartz sandstone pebble conglomerate unconformably overlies chloritic siltstone between the Murrays Reward and Pierpont Morgan Prospects. The conglomerate is densely silicified in parts and is of limited extent, being about 20 metres thick and covering an area of some tens of hectares.

A similar but less indurated and silicified, conglomerate underlying basalt beneath the Balfour township is slightly stanniferous and was worked for tin about the turn of the century.

Basalt

Porphyritic olivine basalt of Tertiary age occurs at the Balfour township and near the Clump Prospect.

Structure:

The rocks in the area mapped have a regional strike between NNE and NNW and dip steeply towards the east. Graded bedding indicates that the beds ~~are~~ also young towards the east and are therefore right side up although a few exceptions occur in the vicinity of folds and faults.

Several major synclinal folds occur in the sandstone north and northeast of Mt. Balfour. The folds plunge moderately towards the north or south along NNW trending axes and have generally been modified by faulting. A few minor folds or flexures are associated with faults.

Faults are widespread in the area and although apparently not associated with the genesis of the cupriferous mineralisation, the intersection of cross faults and the mineralised zone may have served as a locus for the secondary concentration of sulphides.

The Balfour area appears to form part of an anticlinorium formed during the Mid - Devonian Tabberabberan Orogeny.

MINERALISATION

The quartz - dolomite - pyrite - chalcopyrite mineralisation at the Clump, Gully, Development, Blocks and Murrays Reward Prospects has been examined during previous field seasons and is the subject of earlier reports.

During the course of the regional mapping a discontinuous mineralised zone some six kilometres long was observed between the Pierpont Morgan and South Balfour Prospects and costean sampling was undertaken south of Specimen Hill and at the Central Prospect in the vicinity of Emmetts Creek.

These various prospects are discussed further as follows :

Central Prospect

Six costeans were constructed and sampled in the vicinity of Emmetts Creek at the northern end of the Central Prospect and a number of grab samples were collected, mainly from old trenches.

The costeans were constructed on a ridge along which minor amounts of quartz and gossanous material occur. Two of the costeans (7 and 8) were constructed on the eastern side of Emmetts Creek and four (9 to 12 inclusive) on the western side.

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(See attached photocopy of aerial photograph 105.) The assay results were as follows; the assay intervals being measured from the approximate centre of the costean.

Sample No. Bal	Location	Assay Value ppm Cu	Sample No. Bal	Location	Assay Value ppm Cu
	COSTEAN 7.			COSTEAN 8.	
1924	0 to 2.5m E	120	1938	0 to 2.5m E	200
1925	2.5 to 5.0	270	1939	2.5 to 5.0	450
1926	5.0 to 7.5	440	1940	5.0 to 7.5	120
1927	7.5 to 10.0	100	1941	7.5 to 10.0	70
1928	10.0 to 12.5	50	1942	10.0 to 12.5	<10
1929	12.5 to 15.0	<10	1943	12.5 to 15.0	<10
1930	15.0 to 17.5	<10	1944	0 to 2.5m W	180
1931	0 to 2.5m W	100	1945	2.5 to 5.0	300
1932	2.5 to 5.0	30	1946	5.0 to 7.5	170
1933	5.0 to 7.5	140	1947	7.5 to 10.0	170
1934	7.5 to 10.0	70	1948	10.0 to 12.5	120
1935	10.0 to 12.5	30	1949	12.5 to 15.0	180
1936	12.5 to 15.0	30			
1937	15.0 to 17.5	70			
	COSTEAN 9.			COSTEAN 10.	
1950	0 to 2.5m E	30	1963	0 to 2.5mE	<10
1951	2.5 to 5.0	130	1964	2.5 to 5.0	50
1952	5.0 to 7.5	100	1965	5.0 to 7.5	<10
1953	7.5 to 10.0	30	1966	7.5 to 10.0	30
1954	10.0 to 12.5	<10	1967	10.0 to 12.5	50
1955	12.5 to 15.0	<10	1968	12.5 to 15.0	50
1956	0 to 2.5m W	<10	1969	0 to 2.5m W	20
1957	2.5 to 5.0	<10	1970	2.5 to 5.0	50
1958	5.0 to 7.5	50	1971	5.0 to 7.5	120
1959	7.5 to 10.0	560	1972	7.5 to 10.0	50
1960	10.0 to 12.5	380	1973	10.0 to 12.5	50
1961	12.5 to 15.0	240	1974	12.5 to 15.0	40
1962	15.0 to 17.5	170	1975	15.0 to 17.5	70
	COSTEAN 11.			COSTEAN 12.	
1976	0 to 2.5m E	<10	1989	0 to 2.5m E	50
1977	2.5 to 5.0	<10	1990	2.5 to 5.0	50
1978	5.0 to 7.5	<10	1991	5.0 to 7.5	100
1979	7.5 to 10.0	<10	1992	7.5 to 10.0	30
1980	10.0 to 12.5	<10	1993	10.0 to 12.5	50
1981	12.5 to 15.0	<10	1994	12.5 to 15.0	40
1982	0 to 2.5m W	<10	1995	15.0 to 17.5	50
1983	2.5 to 5.0	20	1996	0 to 2.5m W	70
1984	5.0 to 7.5	<10	1997	2.5 to 5.0	50
1985	7.5 to 10.0	<10	1998	5.0 to 7.5	140
1986	10.0 to 12.5	<10	1999	7.5 to 10.0	100
1987	12.5 to 15.0	<10	2000	10.0 to 12.5	70
1988	15.0 to 17.5	<10	2001	12.5 to 15.0	80
			2002	15.0 to 17.5	40

The mineralised zone, as defined by the anomalous copper values, appears to coincide with the boundary between western chloritic siltstone and slate and eastern carbonaceous shale. No chalcopyrite is visible in the costeans.

This mineralised zone is at least 600 metres long although probably not continuous considering the uniformly low assay values from costean 11.

Grab samples of the ferruginous and gossanous material on the mineralised ridges yielded the following values:

(a) ~~east~~ west side Emmetts Creek - 1400 ppm Cu
(b) ~~west~~ east side Emmetts Creek - 200 ppm Cu

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Further investigations in this part of the Central Prospect should include three shallow diamond drillholes, one each between costeans 7 and 8, 9 and 10, and 11 and 12.

South of Specimen Hill

Four costeans were constructed and sampled in the area south (costeans 13 and 14) and southeast (costeans 15 and 16) of Specimen Hill. These costeans were constructed over ridges along which quartz and ferruginous sediments occur and on which several old workings exist including one shaft from which Ward (1911) reported picked samples containing pyrite, siderite, galena, sphalerite and chalcopyrite and assaying 7.53 per cent Zn, 2.69 per cent Pb, 0.23 per cent Cu, 2dwt 15gr Au and 2oz 13 dwt 14 gr Ag.

The costean assay values are as follow:

Sample No. Bal	Location	Assay Value ppm Cu
	COSTEAN 13.	
2003	0 to 5.0m E	70
2004	5.0 to 10.0	80
2005	10.0 to 15.0	100
2006	15.0 to 20.0	30
2007	0 to 5.0m W	50
2008	5.0 to 10.0	150
2009	10.0 to 15.0	50
2010	15.0 to 20.0	30
2011	20.0 to 25.0	80
	COSTEAN 15	
2019	0 to 5.0m E	70
2020	5.0 to 10.0	70
2021	10.0 to 15.0	400
2022	0 to 5.0m W	50
2023	5.0 to 10.0	50
2024	10.0 to 15.0	50

Sample No. Bal	Location	Assay Value ppm Cu
	COSTEAN 14.	
2012	0 to 5.0m E	150
2013	5.0 to 10.0	50
2014	10.0 to 15.0	40
2015	0 to 5.0m W	50
2016	5.0 to 10.0	20
2017	10.0 to 15.0	130
2018	15.0 to 20.0	380

COSTEAN 16.

		Cu	Pb	Zn
2025	0 to 5.0m E	50	350	60
2026	5.0 to 10.0	50	230	50
2027	10.0 to 15.0	40	50	40
2028	15.0 to 20.0	70	900	40
2029	0 to 5.0m W	30	180	60
2030	5.0 to 10.0	80	180	90
2031	10.0 to 15.0	<10	400	100
2032	15.0 to 20.0	280	600	70

Pierpont Morgan Prospect

1oz = 20dwts = 31.1 grams
1dwt = 1.5552 = 24 grains

This prospect, which occurs as a prominent ridge, marks the northern end of a relatively straight zone of discontinuous mineralisation at least 6 kilometres long.

The prominent nature of the Pierpont Morgan Prospect ridge, which is about 300 metres long and up to 25 metres above the surrounding country, is due to the presence of quartz in a cupriferous mineralised zone. Ward reports that the mineralised zone is about 9 metres thick and consists of well defined quartzose material with heavily mineralised bands containing pyrite, chalcopyrite and covellite. The mineralised zone has been exposed by an adit driven from the eastern side of the ridge and a short (8 metres) drive towards the south yielded "oxidised and leached lode material with occasional bunches of sulphides".

This adit will be mapped and samples and it is recommended that two shallow holes be drilled at this prospect.

One costean at the southern end of the Pierpont Morgan ridge yielded the following assay values :

Sample No. Bal.	Location	Assay Value ppm Cu
2033	0 to 5.0m E	280
2034	5.0 to 10.0	<10
2035	10.0 to 15.0	<10
2036	15.0 to 20.0	<10
2037	0 to 5.0m W	<10
2038	5.0 to 10.0	<10
2039	10.0 to 15.0	<10
2040	15.0 to 20.0	<10

Waratah Prospect

This prospect is about 3 kilometres SSE of the Pierpont Morgan Prospect and has similar dimensions. It occurs on the same belt of mineralisation and likewise, has been opened up by an adit driven from the eastern side. Its name is taken from the nearby Waratah Creek.

Spoil from the adit includes cavernous and iron stained pyritic quartz which occurs within carbonaceous sediments. Chalcopyrite and secondary covellite and chalcocite occur within the quartz but rarely on the weathered surface. These sulphides are soft and friable and are readily washed from the quartz leaving clean cavities. This loss of the secondary sulphides is noteworthy when it is considered that much of the high grade ore (12 to 35 per cent Cu) taken from the Murrays Reward Prospect obviously consisted of secondary sulphides but that only minute amounts of such sulphides were observed in diamond drillcore from this area and it may be argued that much of the core loss from shallow drillholes represents intervals of soft secondary copper sulphide . The acceptance of such an argument would upgrade the potential of several prospects, particularly The Clump Prospect where core recovery was commonly very low over intervals of several metres.

Several grab samples of dump material from this prospect yielded the following assay values :

Sample BAL 1921 - ferruginous sediments and pyritic quartz - 2400 ppm Cu.
Sample BAL 1922 - pyritic and gossanous quartz - 480 ppm Cu.
Sample BAL 1923 - sulphide bearing quartz 6800 ppm Cu.

As noted earlier the Waratah and Pierpont Morgan Prospects lie on a relatively straight belt of mineralisation which occurs as a subdued discontinuous ridge and although from aerial photographs the mineralsed zone apears to transgress the enclosing sediments, the parallelism of the mineralised bands and enclosing sediments in the close vicinity of the mineralised zone points to a concordant nature if this being so, a sedimentary origin may be ascribed to the cupriferous mineralisation.

Each of these two prospects have the strike length of a potentially economic orebody, and diamond drilling will be necessary to determine grade , thickness and down dip continuity of the mineralisation.

It is recommonded that the Waratah prospect adit be mapped and sampled and that two shallow holes be drilled.

The South Balfour Prospect

This prospect is located on the extreme southeast margin of the mapped area and appears to lie on the same linear belt of mineralisation as the Pierpont Morgan and Waratah prospect.

The South Balfour mineralisation is identical to that of the other prospects and several [illegible] workings exist.

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A short adit on the western bank of Waratah Creek intersected about 12 metres of carbonaceous shale containing copper sulphate stains but high grade material is confined to a 90cm quartzose band by the adit portal. This mineralised band contains chalcopyrite, covellite and abundant pyrite. Most of the sulphides are concentrated in a single thin (≤20cm) band. A two compartment shaft evidently intersected heavily cavernous and pyritic quartz from which most of the copper sulphides had been leached.

In direct contrast to the Pierpont Morgan and Waratah Prospects, the South Balfour does not occur as a prominent strike ridge, which may indicate a low quartz content or a short strike length.

Further investigations appear warranted on this prospect and it is recommended that two costeans be constructed north along strike and that the adit and costeans be mapped and sampled.

RECOMMENDATIONS

It is recommended that field work be continued in EL 16/[illegible] during 1973 and that the various prospects be further investigated as follows:

Central Prospect

(a) Three shallow diamond drillholes in the vicinity of Emmetts Creek, one drillhole between each of costeans 7 and 8, costeans 9 and 10 and costeans 11 and 12.

(b) One diamond drillhole between DDH 18 and DDH 21 to test a suspected cross fault for sulphide enrichment.

Murrays Reward Prospect

One drillhole between DDH 16 and DDH 17, to test the down-dip continuity of the high grade cupriferous mineralisation intersected by DDH 16.

Pierpont Morgan Prospect

(a) Map and sample adit.

(b) Construct and sample costean.

(c) Two shallow drillholes to test grade, thickness and continuity of mineralisation.

Waratah Prospect

(a) Map and sample adit.

(b) Two shallow drillholes to test grade, thickness and continuity of mineralisation.

South Balfour Prospect

(a) Map and sample adit.

(b) Construct and sample two costeans.

(c) Diamond drilling if warranted by the results of (a) and (b).

The diamond drilling requirements for this preliminary programme would be as follows :

Central Prospect about 550 metres.
Murrays Reward Prospect about 225 metres.
Pierpont Morgan Prospect about 250 metres.
Waratah Prospect about 250 metres.

This total of about 1225 metres would no doubt be increased substantially should any promising mineralisation be intersected.

Construction of costeans and drillsites will be commenced early in January and arrangements will be made for the Longyear drilling crew and equipment to be moved to Balfour during the last week of January.

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24th December, 1972.

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A.C.I. MINERALS PTY. LTD.

MINERAL EXPLORATION IN EL.16/68, BALFOUR, TASMANIA

SUMMARY REPORT FOR FIELD SEASON, 1971-72

SUMMARY

Mineral exploration in EL.16/68 at Balfour, Tasmania was continued during 1971-72.

At the Clump Prospect, two deep drillholes indicated that the grade and thickness of the cupriferous quartz-dolomite formation tends to decrease with increasing depth. Surface geological mapping and costean geochemistry indicated that the quartz-dolomite occurs conformably within a sequence of carbonaceous siltstone, shale and sandstone and that the mineralized zone may extend south of the present exploration area.

It is recommended that no further exploration be carried out at the Clump Prospect.

Diamond drilling in the Murrays Reward-Central Mt. Balfour area has defined a zone of subeconomic and locally discontinuous cupriferous mineralization. This mineralized zone, which strikes west of north and dips steeply west, has a strike length in excess of 1100 metres and is apparently open at both ends. The copper occurs almost exclusively as chalcopyrite which is invariably associated with quartz and dolomite veins, segregations and thicker bands within chloritic and carbonaceous rocks. Remobilization and concentration of dolomite, chalcopyrite and pyrite appears to have taken place along at least one oblique fault.

The mineralized zone at Murrays Reward Prospect has been intersected by nine drillholes yielding an average grade of about 0.4 percent Cu and it is recommended that no further exploration be carried out on this prospect.

Although four holes have been drilled on the Central Mt. Balfour Prospect, no testing of the old mine workings has been carried out and it is recommended that a series of holes be drilled in the vicinity of the old workings.

Little is known of the potential of the area immediately south of Murrays Reward and it is recommended that costean geochemistry, geological mapping and further exploratory drilling be carried out in this area.

It is recommended that a geological examination be made of the old Pierpont Morgan and South Balfour prospects several kilometres south of Murrays Reward.

INTRODUCTION

Other results of previous investigations and other pertinent information are described in the report on the 1970-71 exploration activities (McIntyre 1971).

The 1971-72 field season commenced in September 1971 and the following programme was completed:

(a) Geological mapping of the Murrays Reward - Central Mt. Balfour area, Clump Prospect and the Specimen Hill area.

(b) Construction, mapping and sampling of costeans at the Clump Prospect and at the Central Mt. Balfour Prospect.

(c) Two deep drillholes (total depth 679.55 metres) at the Clump Prospect.

(d) Thirteen drillholes (total depth 1705.17 metres) in the Murrays Reward - Central Mt. Balfour area.

(e) Petrological examination of rock specimens. Personnel involved in the programme included a geologist, field assistant, cook, plant operator together with contract drilling personnel.

The field season was completed in May 1972.

DIAMOND DRILLING

The diamond drilling was carried out under contract by Longyear (Australia) Pty. Ltd. using a Longyear 38 drillrig fitted with an airmast percussion attachment. The drillrig worked 2 x 10 hour shifts per day, seven days per week and was operated by a runner and helper with a foreman-runner on standby. The airmast attachment enabled rapid progress to be made at the start of each drillhole and it is estimated that the use of the airmast, rather than diamond drilling from the collar, resulted in a direct saving to A.C.I. of about $9,945.

Diamond coring was most commonly completed with NQWL equipment and a triple tube core barrel although reduction to BQ was necessary in some drillholes.

Longyear personnel and equipment were found to be generally most satisfactory and it is recommended that future drilling contracts at Balfour be awarded to Longyear. One note of criticism regarding Longyear was that insufficient maintenance of the drillrig led to several mechanical failures towards the end of the field season.

THE MURRAYS REWARD - CENTRAL MT. BALFOUR AREA

The bulk of the 1971-72 exploration programme was concentrated in the Murrays Reward - Central Mt. Balfour area, which is taken to include the Murrays Reward Prospect and the Central Mt. Balfour Prospect, immediately west of the old Balfour township.

Underground Geological Mapping

The accessible areas of the three Murrays Reward adits and associated drives and crosscuts were examined and are described in a separate report (McIntyre, December 1971).

The mapping indicated that the major mineralized quartz-dolomite formation at Murrays Reward Prospect lies between an eastern footwall of chloritic slate and chloritic and carbonaceous slate and siltstone and a western hanging-wall of carbonaceous and graphitic slate. The structural environment of the mineralized zone is complicated by the fact that the footwall rocks dip steeply west and young east, i.e. they are overturned, and the hanging-wall rocks dip steeply east and are right-side-up and it is therefore apparent that the mineralized zone is not a simple strata-bound syngenetic body as has been formerly considered.

The genetic aspect of the mineralization is further complicated by the fact that at least two other minor quartz-dolomite zones were intersected by Adits No. 1 and No. 2.

It is considered that the present location of the mineralized zone is due to remobilization of an originally strata-bound deposit into a strike fault or similar structure or into the axial plane of a complex fold structure.

The Murrays Reward Adit No. 3 which coincides approximately with the boundary between Murrays Reward Prospect and the Central Mt. Balfour Prospect, intersected a thick zone of cupriferous quartz-dolomite which was later intersected by DDH 16. This mineralized zone strikes about N50° to 60° W, in marked contract to the N10° to 20°W strike of the quartz-dolomite in the vicinity of adits No. 1 and No. 2. This abrupt change in strike has been interpreted as being due to a northwest striking oblique fault along which the quartz and, more particularly, the dolomite and sulphides have been remobilized and concentrated.

An attempt to examine the extensive underground workings of the Central Mt. Balfour Prospect was abandoned due to the unsafe nature of the adit and drives.

Surface Geological Mapping

The geological succession in the Murrays Reward - Central Mt. Balfour area consists of the following formatious, from east to west.

Formation	1.	Chloritic slate
	2.	Chloritic and carbonaceous slaty siltstone
	3.	Cupriferous quartz-dolomite
	4.	Carbonaceous and graphitic slate and siltstone
	5.	Chloritic and carbonaceous slaty siltstone
	6.	Chloritic slate
	7.	Sandstone quartzite and carbonaceous sediments

The succession has been tentatively dated as younger Precambrian to lower Palaeozoic and youngs towards the east.

A small weathered residual of Tertiary basalt overlies the eastern chloritic slate.

The succession strikes slightly west of north and dips steeply east with the exception of the three easternmost formations which dip about the vertical or steeply west. The two formations (formations 1 and 2) to the east of the mineralized quartz-dolomite are overturned and young towards the east and it is suspected that these two formations can be correlated with formations 6 and 7 // 5 + 6? towards the base of the succession.

Sandstone, quartzite etc. (Formation 7)

This formation consists of grey and white quartz sandstone and quartzitic sandstone overlain by banded dark grey carbonaceous siltstone and pale grey arenaceous quartzose siltstone which together form a prominent ridge about 300 metres west of the Murrays Reward - Central Mt. Balfour ridge. The formation is about 100 metres thick.

Chloritic Slate (Formation 6 and 1)

This formation consists of medium to dark green, finely to coarsely foliated, chloritic slate, phyllite and siltstone at least 130 metres thick. Cleavage and bedding are generally sub-parallel although a westerly dipping cleavage has been observed.

Chloritic and Carbonaceous Slaty Siltstone (Formations 5 and 2)

This is a transitional formation between chloritic slate and carbonaceous and graphitic slate and consists essentially of banded quartzose arenaceous siltstone and dark grey carbonaceous siltstone and shale which have been slightly to moderately chloritised to the extent of imparting a pale to medium green colouration to the pale grey quartzose components. The boundaries of this formation are not clearly defined due to the diffuse nature of the chloritisation and the lack of outcrop.

Formation 2 and the carbonaceous member of formation 7 are lithologically similar and it is considered that the two formations may form limbs of a tightly folded structure comprising a western syncline and an eastern overturned isoclinal anticline.

Carbonaceous and Graphitic Slate and Sediments (Formation 4)

This formation occurs immediately west of the mineralized quartz-dolomite and consists of dark grey to black carbonaceous siltstone and shale and graphitic slate and slaty siltstone which commonly contain abundant quartz and quartz-dolomite veins, a few of which are chalcopyritic. Graphitic shear planes and vein material becomes more common as the mineralized quartz-dolomite is approached.

Cupriferous Quartz-Dolomite (Formation 3)

Copper mineralization in the Murrays Reward - Central Mt. Balfour area is invariably associated with quartz and dolomite which occur together in various proportions in the form of veins, segregations and thicker bands (< 10 metres thick). The copper exists almost exclusively in the form of chalcopyrite which occurs as small (≤ 1cm.) irregular blebs or as irregular and discontinuous stringers along incipient fractures. Trace amounts of galena, sphalerite and other copper sulphides, notably bornite and covellite, occur in parts. Pyrite is ubiquitous. A crude banding of the sulphides has been observed in some drillhole intersections.

Complete core recovery of the quartz-dolomite is rare, particularly from the shallow drillholes. Shearing, brecciation and leaching have combined to yield fragmentary and cavernous quartz from which sulphides and dolomite have been partially or completely removed.

The abundance of chalcopyritic quartz and quartz-dolomite veins adjacent to the main quartz-dolomite formation necessitates the definition of the mineralized zone by assay values rather than lithology and massive quartz-dolomite commonly forms only a minor part of the mineralized zone.

The mineralized quartz-dolomite occurs on the surface as a discontinuous fragmentary and apparently barren quartz formation.

Diamond drilling

During the 1971-72 field season thirteen holes were drilled to a total depth of 1705.17 metres in the Murrays Reward - Central Mt. Balfour area. The location, depth, cost and other details of the drillholes are tabulated in the appendix and further described in the drillhole reports. The individual drillholes are briefly described as follows.

DDH 13

A thick zone of anomalous copper mineralization was intersected between 43.58 and 83.52 metres. This interval containing an average of 3420 ppm Cu over an estimated true thickness of 22.5 metres. The bulk of the copper is concentrated in three subzones:-

(a) 43.58 to 46.02 metres (14800 ppm Cu)

(b) 53.95 to 56.69 metres (4560 ppm Cu)

(c) 71.94 to 83.52 metres (7200 ppm Cu)

DDH 14

A thick zone of anomalous copper mineralization was intersected between 84.43 and 105.61 metres. This interval containing an average of 0.95 per cent Cu over an estimated true thickness of 16.6 metres. The bulk of the copper is concentrated in four subzones:-

(a) 84.43 to 86.33 metres (1.78 per cent Cu)

(b) 87.39 to 93.27 metres (1.41 per cent Cu)

(c) 96.21 to 100.88 metres (1.12 per cent Cu)

(d) 102.35 to 105.61 metres (0.91 per cent Cu)

DDH 15

A weakly mineralized zone was intersected between 85.36 and 94.49 metres. This interval averaging 730 ppm Cu.

DDH 16

A thick zone of copper mineralization was intersected between 54.87 and 96.16 metres. This interval containing an average of 9300 ppm Cu over an estimated true thickness of 38.0 metres. The mineralized zone may be sub-divided into three subzones:-

(a) 54.87 to 63.39 metres (3250 ppm Cu)

(b) 63.39 to 84.13 metres (1.44 per cent Cu)

(c) 84.13 to 96.16 metres (5075 ppm Cu)

DDH 17

A suspected fault zone between 30.48 and 37.64 metres contains an average of 0.95 per cent Cu although the bulk of the copper occurs within the interval 36.12 to 37.64 metres. This interval assaying 3.46 per cent Cu.

Cont:

DDH 18

Traces of chalcopyrite (7625 ppm Cu) were present in a fault zone intersected between 29.57 and 31.70 metres.

DDH 19

Copper mineralization was intersected between 60.66 and 73.50 metres. This interval containing an average of 4850 ppm Cu over an estimated true thickness of 6.5 metres. The bulk of the copper is concentrated in the interval 68.37 to 70.15 metres, which assayed 1.73 per cent Cu.

DDH 20

Abandoned at a depth of 33.53 metres.

DDH 21

A thick zone of copper mineralization was intersected between 38.10 and 55.20 metres. This interval containing an average of 0.57 per cent Cu over an estimated true thickness of 13.2 metres.

DDH 22

A thick zone of low grade but anomalous copper mineralization was intersected between 67.67 and 84.90 metres. This interval containing an average of 800 ppm Cu over an estimated true thickness of 12.9 metres. Low core recovery and substantial leaching of sulphides have combined to mask the true grade of this zone.

DDH 23

A thin zone of copper mineralization was intersected between 56.99 and 60.81 metres. This interval containing an average of 2.1 per cent Cu over an estimated true thickness of 3.1 metres.

DDH 24

A thick zone of low grade and sporadic mineralization was intersected between 187.00 and 232.35 metres. This interval containing an average of 1240 ppm Cu over an estimated true thickness of 39.0 metres. A subzone between 206.70 and 223.68 metres contains an average of 2800 ppm Cu over an estimated true thickness of 14.8 metres. Traces of galena and sphalerite were observed in the core of DDH 24 which was drilled beneath, and approximately parallel to, DDH 16.

DDH 25

A thick zone of copper mineralization was intersected between 202.90 and 242.04 metres. This interval containing an average of 2450 ppm Cu over an estimated true thickness of 29.2 metres. This zone may be subdivided into three subzones on the basis of copper distribution.

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(a) 202.90 to 212.46 metres (3590 ppm Cu)

(b) 212.46 to 228.33 metres (400 ppm Cu)

(c) 228.33 to 242.04 metres (4025 ppm Cu)

DDH 25 was drilled beneath and approximately parallel to DDH 13.

DDH 26

Two thin and weakly mineralized zones were intersected by DDH 26.

(a) 144.86 to 145.91 metres (1800 ppm Cu)

(b) 155.69 to 158.08 metres (2306 ppm Cu)

DDH 26 was drilled beneath, and approximately parallel to DDH 15.

Discussion of Drilling Results

The mineralized zone at Murrays Reward Prospect proper, i.e. between DDH 16 and DDH 19 inclusive, has been intersected by nine drillholes (DDH 10, 13, 14, 15, 16, 19, 24, 25 and 26) which cover a strike length of about 360 metres.

Several of the drillhole intersections yielded high grade copper values but in general the potentially economic grades occur over apparently sub-economic thicknesses and similarly, the overall assay defined mineralized intersections are of subeconomic grade. The mean grade of the nine intersections of the mineralized zone is about 0.4 per cent Cu.

The thickness and grade of both the assay defined mineralized zone and the lithologically defined mineralized quartz-dolomite formation varies considerably, both along strike and down-dip, and the interpolation of copper values between adjacent drillholes is of doubtful validity.

The close spacing of the drillholes, the low mean grades of the individual drillhole intersections and the locally discontinuous nature of the mineralized zone indicates that no cupriferous orebody exists at Murrays Reward Prospect and it is recommended that no further drilling be undertaken at this prospect.

Four holes (DDH 17, 18, 21 and 22) have been drilled at the Central Mt. Balfour Prospect. These drillholes covering a strike length of about 650 metres. Only one of these drillholes, DDH 21, can be regarded as having intersected potentially economic copper mineralization, although DDH 17 intersected a thin high grade zone which is interpreted as being an extension of the mineralized fault intersected to the south east by DDH 16.

Cont:

The old exploratory workings of the Central Mt. Balfour Prospect are situated between DDH 18 and DDH 21, a strike length of about 300 metres, and it is known that a small tonnage of high grade ore was mined from these workings. It is conceivable that a small orebody exists in the vicinity of these workings, and it is recommended that a limited amount of diamond drilling be undertaken in this area.

The only drillhole south of Murrays Reward (DDH 23) yielded encouraging assay values, a 3.1 metre interval containing an average of 2.1 per cent Cu. Little is yet known of the geology of this area and it is recommended that exploration be continued in this area; such exploration to include costean geochemistry, geological mapping and diamond drilling.

THE CLUMP PROSPECT

Diamond Drilling

A cupriferous quartz-dolomite zone defined by costean geochemistry and an I.P. survey was tested by six diamond drillholes during 1970-71. Significant amounts of core loss and leaching of sulphides hampered meaningful estimates of the grade of this mineralized zone and during 1972 two deep holes were drilled in an attempt to intersect the mineralized zone below the zone of leaching.

DDH 27

This drillhole was sited so as to pass beneath, and approximately parallel to, DDH 9 (the northernmost drill-hole of the 1970-71 field season) and was completed at a depth of 325.37 metres after intersecting a slightly cupriferous zone between 274.30 and 295.33 metres. This interval containing an average of 1080 ppm Cu over an estimated true thickness of 19.8 metres. The copper occurs as chalcopyrite associated with quartz and dolomite within sheared and fragmentary carbonaceous siltstone and is concentrated in two sub-zones:-

(a) 274.30 to 280.00 metres (2660 ppm Cu)

(b) 288.42 to 295.33 metres (1020 ppm Cu)

DDH 28

The drillhole was sited so as to pass beneath the old Clump Prospect exploratory workings and DDH 1 (The southernmost drillhole of the 1970-71 Field Season), and was completed at a depth of 354.18 metres after intersecting a zone of slightly anomalous copper mineralization between 304.62 and 309.09 metres. This interval containing an average of 540 ppm Cu. Minor traces of copper ($\leqslant$ 350 ppm Cu) occur in the vicinity of this mineralized zone.

The low grade intersections made by these two drillholes indicates that no grade increase occurs with increasing depth and it is recommended that no further exploration be carried out at the Clump Prospect.

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Geological Mapping

Surface geological mapping at the Clump Prospect (Jackaman, 1972) revealed that the mineralized quartz-dolomite occurs conformably within a sequence of sandstone and carbonaceous shale and siltstone.

Costean geochemistry indicated that the mineralized quartz-dolomite extends south of the southernmost drillhole at the Clump Prospect.

SPECIMEN HILL AREA

Geological mapping of the Specimen Hill area revealed a succession of quartz sandstone, sandstone-shale, siltstone-shale and chloritic carbonaceous shale within which occur hydrothermal cassiterite-wolframite veins and at least one hydrothermal quartz-chalcopyrite-galena-sphalerite vein system (Jackaman, June 1972). No economic significance is attached to this mineralization.

RECOMMENDATIONS

(1) A short programme of diamond drilling to be carried out at the Central Mt. Balfour Prospect between DDH 18 and DDH 21. If the results of this programme are encouraging then the drilling is to be extended north between DDH 21 and DDH 22.

(2) Costean geochemistry, geological mapping and diamond drilling to be carried out south of Tin Creek along the extrapolated strike of the Murrays Reward mineralized zone.

(3) A geological examination to be made of the Pierpont Morgan and South Balfour Prospects several kilometres south of Murrays Reward Prospect.

(4) No further exploration at the Clump Prospect.

(5) No further exploration at Murrays Reward Prospect.

(6) It is further recommended that should the exploration programme proposed for the 1972/73 field season yield discouraging results then A.C.I. relinquish title on EL.16/68 and cease exploration in this area.

REFERENCES

Jackaman, B. 1972 The geology of the Clump Prospect A.C.I. Report

1972 Untitled report on the geology of the Specimen Hill area.

McIntyre, M.H. 1971 Mineral exploration in EL.16/68 Balfour, Tasmania A.C.I. Report

1972 Underground mapping, Murrays Reward A.C.I. Report.

M.H. McIntyre

M.H. McIntyre
July 16, 1972

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COPPER OCCURRENCES IN E.L. 16/68, SOUTH OF MT. FRANKLAND, BALFOUR AREA

INTRODUCTION

A number of occurrences of cupriferous mineralization described by Ward (1911) lie within E.L. 16/68 south of Mt. Frankland but are not contained within the area covered by the available plans or aerial photographs and have yet to be examined by A.C.I.Minerals Pty Ltd.

The following descriptions are summarised from Wards report with reference to Plate V (Mount Hazelton Mineral Leases) on which are marked the mineral leases in force at that time.

The leases are concentrated in the following general area;

(a) Southeast of Mt. Frankland

(b) Doherty's Pimple to the Lindsay River

(c) Waratah Creek

(1) Leases southeast of Mt. Frankland

Lease 4302

Cavernous, limonitic and pyritic quartz occurs near Waratah Creek in the northern part of lease 4302. The quartz strikes about northwest.

Lease 4359

Silicified sandstone containing cavities after pyrite occurs in the western part of lease 4359 and strikes about northwest. Limonitic quartzite with cavities after pyrite outcrops in the southern part of this lease.

Lease 4346

This lease includes an outcrop of dense, slightly limonitic quartzite containing a few cavities after pyrite.

Leases 4281 and 4282

A well-defined mineralized zone is marked by the presence of quartz, limonite and hematite, and occurs as a series of overlapping (en echelon?) lenses a few metres long and less than one metre thick. A few trenches revealed that the quartz is heavily fractured and contains pyrite and traces of copper, and that the mineralized zone strikes northwest and dips toward the west.

In lease 4282 the mineralized quartz becomes thicker (1.8 metres) and more massive.

Lease 4358

A small outcrop of limonitic and pyritic quartz occurs on this lease.

(2) Leases between Doherty's Pimple and the Lindsay River

A major zone of mineralization in this area extends from Lease 3483 to Doherty's Pimple and can be traced on the surface for about 2 kilometres.

Lease 3483

A trench across a quartz outcrop ($\leqslant$1 metre thick) on the northern boundary of this lease exposed pyrite and traces of covellite. This mineralized zone dips toward the southwest whereas the enclosing iron-stained slate has a shallow dip towards the east.

A short distance to the southeast the mineralized zone is about 3 metres thick and consists of slightly pyritic quartz containing traces of chalcopyrite and covellite. The pyrite was found to contain 0.5 per cent Cu. The footwall slate contains irregular/impregnations of quartz and hematite over a thickness of 23 metres.

A discordant mineralized zone striking northeast traverses Lease 3483 and terminates abruptly against the main mineralized zone which has a northwest strike. At the time of Wards visit an adit was being driven towards the intersection of the two mineralized zones.

On the south bank of the Lindsay River near the southeastern boundary of Lease 3483, two small excavations exposed banded pyrite and stibnite in quartz.

Lease 3602

A trench about 10 metres from the western boundary of this lease revealed heavily pyritic quartz (3.6 metres thick) containing minor amounts of chalcopyrite and covellite.

Lease 3603

A deep trench across a quartz outcrop revealed about 4.2 metres of quartz (with chlorite, sericite and bands of sedimentary rock) containing pyrite, chalcopyrite and massive covellite. The mineralized zone dips toward the southwest in easterly dipping pyritic quartzite.

Lease 3607

An adit on this lease intersected about 24 metres of fractured (brecciated?) slate and about 2.7 metres of quartz containing pyrite, covellite and chalcopyrite.

A second mineralized zone on this lease strikes northwest , the outcrop consisting of iron-stained quartz with common cavities after pyrite.

Lease 3605

A quartzose mineralized zone about 3.6 metres thick outcrops in the centre of this lease and strikes about ENE. At the time of Wards visit an adit was being driven toward the mineralized zone.

Lease 4222

This lease contains two small developments of quartzose and slightly limonitic vein material.

Leases 4360 and 4361

A few shallow trenches exposed a quartzose mineralized zone striking slightly west of north and dipping toward the west. The mineralized zone contains pyrite, chalcopyrite and covellite. Several other limonitic quartz outcrops occur on these leases.

North of Lease 4360, iron-stained dolomitic quartz ($\leqslant$1.2 metres thick) containing chalcopyrite and covellite can be traced for more than 1.5 kilometres.

Lease 4605

Silicified sandstone and slate contain numerous cavities after pyrite.

Lease 4606

This lease contains a poorly defined quartz body in quartzite.

Lease 4607

A well-defined quartzose mineralized zone strikes slightly north of east and a few trenches revealed cavernous (after dolomite) quartz containing pyrite, chalcopyrite and covellite. The outcrop can be traced without interruption for about 120 metres.

North of lease 4607 and east of Lease 4672 a quartzose mineralized zone, striking slightly north of west and containing pyrite, chalcopyrite and covellite, can be traced for over 100 metres.

Lease 4672

Minor amounts of quartzose vein material occurs on this lease.

(3) Leases in the vicinity of Waratah Creek

Leases 3676, 3677 and 4237 (South Balfour Prospect)

Several quartz outcrops occur within these leases but relationshops, if any, between the outcrops are unknown.

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A quartz outcrop with subdued relief strikes about NNW across Lease 3677 and a shallow trench across the outcrop exposed iron-stained slate and pyritic quartz.

The main South Balfour Prospect workings occur on Lease 3676. A short adit driven WSW from the western bank of Waratah Creek intersected carbonaceous sediments containing cupriferous quartz. A quartz band about 0.9 metres thick contains chalcopyrite and covellite but high grade copper mineralization is restricted to a 35cm band near the adit portal. The enclosing sediments are iron-stained and contain cupriferous veinlets and common copper stains over a thickness of 12 metres. The mineralized zone and the host rock dip toward the west and east respectively.

A short distance south of the adit an 8 metres shaft yielded several tons of high grade copper ore from a mineralized zone 1.8 metres thick.

On the eastern side of Waratah Creek are two parallel gossanous quartz outcrops striking northwest. A short adit exposed a dolomitic mineralized zone containing quartz, pyrite, magnetite, covellite and chalcopyrite. A shaft on this mineralization was abandoned at a depth of 9.7 metres.

Lease 4236

An isolated outcrop of limonite occurs on this lease.

Lease 4245

This lease contains two outcrops of iron-stained quartz one of which is cupriferous.

Lease 4210

This lease contains an outcrop of limonite-stained quartz with cavities after pyrite.

Lease 3723

A number of pyritic quartz outcrops occur on this lease.

Lease 3798

A trench on this lease exposed heavily pyritic quartz about one metres thick.

Leases 3684 and 3685

These leases contain a subdued and poorly defined quartzose mineralized zone.

Lease 3682

This lease contains massive quartz with cavities after pyrite.

Lease 4228

Sandstone containing a few pyritic quartz veins occurs on this lease.

DISCUSSION

The old mineral leases between Doherty's Pimple and the Lindsay River contain potentially economic cupriferous mineralization and exploration of this area is justified on the basis of apparent grade (massive covellite on lease 3603 and pyrite containing 0.5 per cent Cu on lease 3483), thickness (from about 1 to 4.2 metres) and along-strike continuity (up to 2 kilometres).

The leases in the vicinity of Waratah Creek (other than the South Balfour Prospect) and those southeast of Mt. Frankland do not appear to warrant further investigation.

The cupriferous mineralization in the Doherty's Pimple-Lindsay River area (the Lindsay Prospect) appears to be identical with that occurring at most other prospects in the Balfour area, that is, cavernous quartz containing pyrite, chalcopyrite and covellite near the surface and dolomitic quartz containing pyrite and chalcopyrite at depth. One exception is the occurrence of banded pyrite and stibnite on lease 3483, stibnite not being recorded from any other part of the Balfour area.

The mineralized zones strike about northwest and dip about the vertical or steeply west in carbonaceous sediments which dip toward the east. These sediments commonly contain sulphide bearing quartz veins and segregations extending several metres on either side of the mineralized zone proper.

The Lindsay River, or southern, end of the Lindsay Prospect is between one and two hours walk from the end of the present vehicular track and in order to carry out detailed investigations in this area the construction of an access track would be necessary.

An unrecorded copper prospect is believed to lie on or close to the Lindsay River or tributaries. Mr. E.Bayley (prospector of Balfour) wishes to sell the location of a copper prospect which, he maintains, consists of chalcopyrite occurring on the surface in an unweathered condition. This occurrence implies that local erosion has kept pace with oxidation and leaching of the sulphides such as would occur in a stream channel.

The Lindsay Prospect lies outside the area covered by plans or aerial photographs held by A.C.I. although a Lands and Surveys set of photographs (1 : 50000 scale) would be suitable for reconnaissance work.

RECOMMENDATIONS

It is recommended that preliminary exploration be carried out at the Lindsay Prospect.

UNDERGROUND MAPPING - MURRAY REWARD

INTRODUCTION

The accessible areas of the two main adits and associated drives and cross-cuts exposing the main areas of operation during the early exploration and exploitation of the Murrays Reward mine, together with a third exploratory adit, have been mapped on a scale of 1:500.

GENERAL INFORMATION

The Murrays Reward mine was the only producer of any significant tonnage of copper ore on the entire Balfour mining field. Between 1909 and 1917 about 6177 tons of ore were mined, and of this total over 96 per cent was produced during the five year period 1909-1913 (Thomas and Henderson, (1943.)) The grade of ore parcels was reported to range between 12 and 35 per cent Cu (Moore 1912).

Three adits, one main shaft and a considerable amount of associated drives, crosscuts, raises and winzes were constructed during the exploration and exploitation of the ore body. The main shaft was about 97.5 metres deep but is now collapsed and flooded and is inaccessible. Similarly for all raises, winzes, and for much of the adits. Of the five original levels only the two near surface ones are even slightly accessible. All stopes are inaccessible.

This ore-body has been the subject of at least one published (Ward, 1911) and two unpublished (Moore, 1912 and Thomas & Henderson, 1943) reports.

THE ADITS AND ASSOCIATED WORKINGS

NO.1. ADIT

(a) Introduction

The portal of No.1. adit is situated at the base of the eastern flanks of the steep Murrays Reward - Central Mt. Balfour ridge and lies at an elevation of about 204.2 metres. The portal has co-ordinates of 435198N, 319946E (Australian Map grid) and the adit was driven towards the west for 64.5 metres on a bearing of about 255° (true).

An insignificant amount of driving (4 metres or a bearing of 145° (T) and 2 metres on a bearing of 325° (T)) was undertaken about 35.5 metres from the portal. These drives attempted to follow a narrow (≤ 30 cm) quartz vein containing pyrite and secondary copper minerals, but was soon abandoned.

The adit intersected a major quartz-pyrite-chalcopyrite-covellite lode about 44.2 metres from the portal. Stoping of this lode was carried out from drives on bearings of 159° and 339° (T) and a raise was connected to the surface from the point of intersection.

Further driving (1.8 metres and 8.2 metres on bearings of 152° and 332° (T) respectively) was undertaken along a thin (≤ 25cm), cavernous quartz vein about 51.8 metres from the portal.

Although the main drives off this adit have collapsed and are now inaccessible, the remainder of the adit is still in fair condition. The mine workings off the No.1. adit formed the No.1. level.

(b) Geology

The initial 20 metres of this adit has exposed chloritic slate, shale and phyllite which strikes between N and N 10° W and which dips steeply west. Locally preserved graded beds indicate younging towards the east, the sequence thus being overturned.

Two types of lineation were observed in these chloritic rocks;

(a) Crinkle lineation plunging towards the south,

(b) Mineral lineation in the form of preferred orientation of oval to acicular chlorite(?) porphyroblasts which plunge roughly parallel to the dip of the bedding.

(b) Geology (cont)

A weakly developed cleavage dips towards the west less steeply than the original bedding suggesting the presence of an asymmetrical anticline towards the west. Bedding plane cleavage is also suggested by phyllitic surfaces parallel or sub-parallel to the original bedding planes.

A minor fault, striking about N 20° E and dipping about 50° west, occurs within a poorly defined transition zone separating chloritic rocks on the east from darker and more carbonaceous rocks on the west. The fault plane is marked by a thin ($\leq$ 2 cm) pyritic quartz vein.

The interval between about 20.0 metres and the main lode at 44.2 metres consists dominantly of carbonaceous, (although slightly chloritic in parts) shale, slate and phyllite containing a few thin pyritic quartz veins and rare thin ($\leq$ 5 cm) bands of carbonaceous quartzite. Dark grey to black graphitic bedding and cleavage planes also occur locally.

Locally preserved graded bedding occurs in the form of pale grey sediments (base) grading up into dark grey and apparently finer grained sediments at the top.

Quartz veins become more common as the main lode is approached and thin ($\leq$ 5cm) pyritic quartz veins were intersected at 24.5, 28.0 and 32.0 metres. At 33.5 metres cavernous and moderately pyritic quartz vein (15cm) was intersected.

At about 36 metres from the adit portal an attempt was made to drive along a quartz vein striking N24° W and dipping about 70° W. This vein is friable and cavernous (after sulphides and carbonate?) and contains abundant pyrite and sporadic covellite and green malachite stains. The drive was abandoned after a short distance, the vein apparently not increasing in either thickness or copper content.

Many thin ($\leq$ 5 mm) quartz veins, commonly pyritic, occur within the carbonaceous sequence and are commonly parallel or sub-parallel to the bedding planes.

A sheared zone of carbonaceous slate occurs immediately adjacent to the main lode between about 42.7 and 43.7 metres. This slate has a variable strike and dips vary about the vertical. A few minor faults are present and quartz veins are common; thin quartz veins ($\leq$ 5 mm) commonly parallel or sub-parallel to bedding and thicker ($\leq$ 3cm) veins commonly discordant. The quartz veins are irregular and discontinuous.

The main mineralized zone was intersected at about 43.7 metres and was reported by Ward (1911) to be about 3.6 metres thick. The drives and stopes on this lode have collapsed on either side of the adit and direct examination of the lode is restricted to observation through rotten timbers supporting the collapsed raise. The lode appears to consist of massive white quartz which is moderately to heavily iron stained in parts and which contains sporadic concentrations of covellite, malachite and pyrite. The lode appears to dip steeply west, an observation also noted by Ward who had easy access to the drives and stopes at the time of his examination of the ore-body. The actual dip of the lode cannot now be measured accurately.

The rocks on the western side of the lode consist of sheared and deformed dark grey and black carbonaceous and graphitic slate from which almost all traces of the original bedding have been obliterated.

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(b) Geology (cont)

This zone contains abundant deformed and discontinuous quartz veins many of which are pyritic and cavernous. A few veins contain, or are coated with, copper carbonate and/or sulphate, the most notable examples occurring at 59.0, 59.4 and 60.8 metres.

Boudin-like quartz pods or lenses occur at 58.0, 58.7, 59.4 and 61.9 metres and like most quartz veins in this zone are commonly parallel or sub-parallel to the cleavage.

A major synclinal fold, plunging 35° towards 160°T, occurs at 62.1 metres.

The third drive from the No.1. adit occurs at about 51.8 metres and was driven on a slightly cupriferous zone of quartz veins. The drive had a total length of about 11.5 metres most of which was driven from the south side of the adit on a bearing of 152°.

NO.2. ADIT

(a) Introduction

The portal of No.2. adit is also situated at the base of the eastern slope of the Murrays Reward - Central Mt. Balfour ridge at an elevation of about 199.6 metres. It lies some 120 metres south of No.1. adit, has co-ordinates of 434826 N, 320043 E (Australian Map Grid) and was driven towards the west for about 39.2 metres on a bearing of 249° (T).

Some difficulty was experienced in intersecting the expected main mineralized lode and several drives and crosscuts were constructed (see plan) in an attempt to locate the main lode.

(i) South drive. This commences about 28.2 metres from the adit portal and extends for 12.8 metres on a bearing of 191° T.

(ii) No.1. (southern) crosscut commences at the southern end of the souther drive and extends for 7.4 metres on a bearing of 95° T.

(iii) North drive. This drive commences about 27.0 metres from the adit portal and continues for about 50.5 metres on a slightly sinuous course towards 354° T.

(iv) No.2. (central) crosscut commences about 20.0 metres along the north drive from the junction of the north drive and the adit. The crosscut is 4.0 metres long on a bearing of 91° T.

(v) No.3. (northern) crosscut. This crosscut connects the northern drive with the main stoping drive to the west. It commences about 28.0 metres along the north drive and extends for about 22.5 metres on a bearing of 241° T.

(vi) From the western end of the No.3. crosscut further driving was undertaken;

(a) 3.1 metres on a bearing of 186° T

(b) an unknown distance, initially on a bearing of about 6°T and then detering to about 320°T. This drive is now in a state of collapse but old records suggest that it's total length was about 90 metres, along part of which, stoping was undertaken.

The mine workings off the No.2. adit formed the No.2. level.

NO.2. ADIT (cont)

(b) Geology

The initial 17.8 metres of the No.2. adit consists dominantly of chloritic slate and shale striking between N7E and N27W and dipping towards the west at angle between 62° and 90°. The slate is medium to dark grey-green and originally consisted of a carbonaceous shale.

The bedding planes commonly have a phyllitic sheen and it appears that a slaty cleavage occurs parallel to the original bedding.

As in NO.1 adit, two types of lineation were observed;

(a) a crinkle lineation, which may mark the location of incipient drag-folds, this lineation plunges towards the south at angles of 35° to 40°.

(b) A mineral lineation consisting of elongate chloritic (?) porphyroblasts was observed to be plunging 87° towards 254° (T) about 12.1 metres from the portal.

At about 5.2 metres is a minor fault which strikes N52W and dips 62° towards the west. The fault plane is marked by a thin ($\leq$ 2cm) quartz vein.

A thin ($\leq$ 5 cm) pyritic quartz vein with a prominent limonite coating occurs at about 6.2 metres. The vein strikes N9°W and dips about 85° towards the west.

A massive quartz vein ($\leq$ 40 cm) at 17.8 metres co-incides with the boundary between the chloritic slate to the east and carbonaceous and graphitic slate to the west. The vein is pyritic and iron stained, strikes N8°W and dips 80° towards the west.

Graphitic and carbonaceous slate containing several pyritic quartz veins occurs between about 18.2 and 21.5 metres. The slate strikes about N20°W and dips steeply west. The quartz veins in the graphitic zone are up to about 35 cm thick, and are commonly pyritic and one vein at about 18.7 metres contains very rare traces of chalcopyrite.

Between about 21.5 and 26.7 metres is a zone of massive quartz containing sheared and deformed bands and fragments of black graphitic and carbonaceous slate. The quartz occurs as veins, ranging in size from minor ($\leq$5 cm) to massive ($\leq$60 cm), which contain sporadic pyrite and traces of chalcopyrite and thin coatings of copper carbonate and sulphate. The whole zone is moderately limonitic.

The quartz zone appears to have a western fault boundary, the fault striking N4°W and dipping 57°E. Sheared graphitic slate occurs on the footwall of the fault.

The south drive intersects soft, brown (altered?) carbonaceous slates and black grey carbonaceous slates striking between N and N10°W and dipping about the vertical or steeply east.

About 5.0 metres along the south drive a minor isoclinal anticline plunges 55° towards 165° and appears to have an axial plane dip towards the west.

At the eastern end of the No.1. crosscut a minor fault striking N78°W and dipping 70°N, separates brown iron-stained slate containing numerous pyritic quartz veins from the soft brown altered (?) carbonaceous slate.

The western 6.0 metres of the main adit, west of the south drive, consists of dark grey and black carbonaceous and graphitic slate. At about 37.6 metres S_0 strikes N20°W, dips 87°E and youngs towards the east and S_1 strikes N38°W and dips 85°W.

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The north drive intersects sheared black graphitic slate containing numerous irregular and discontinuous quartz veins many of which are irregularly coated with copper carbonate and/or sulphate. The slate strikes about N15°W dips steeply west, and extends about 20 metres north along the drive.

Medium-grey carbonaceous slate with numerous crinkle lineations plunging 35° to 55° towards the south, and commonly finely laminated is intersected about 27 metres north of the adit/north drive junction. This slate is fissile and, unlike the black slate immediately adjacent to the south, is not sheared. It strikes between N4°W and N19°W and dips about the vertical. The plunge of the lineation appears to decrease gradually towards the north from 45° to 25° although locally the plunge varies considerably. North of the No.3. crosscut, this slate is intersected at a very acute angle by the continuation of the north drive. Quartz veins are rare in this carbonaceous slate.

As the north drive was unsuccessful in the attempt to intersect the mineralized lode, a third crosscut was driven towards the west and intersected the southern extremity of a copper bearing quartz lode.

At the eastern end of the crosscut a number of what appear to be quartz filled tension gashes occurring in black graphitic slate strike N37°W and dip 25° toward the west.

The rocks intersected by the No.3. crosscut are carbonaceous or graphitic shales and slates. The darker graphitic slates are commonly sheared and retain little trace of the original bedding and are usually associated with pyritic quartz veins. The paler carbonaceous slates commonly retain evidence of original sedimentary lamination and 11.3m west of the north drive/No.3 crosscut junction a banded pale grey and dark grey carbonaceous slate occurs in graded beds younging east.

The No.3 crosscut has intersected many minor and several major quartz veins, a few of which have slight coatings of copper sulphate and/or carbonate. The veins are commonly pyritic and leached and are more or less coated or stained with limonite. They commonly form quartzose zones consisting of several irregular and discontinuous veins containing bands, blacks and fragments of sheared and deformed graphitic slate, the whole zone being pyritic and iron stained. Thin ($\leq$ 5 cm) quartz veins are ubiquitous along the crosscut.

The major quartz veins or quartzose zone occur at;

11.9 to 14.9m; - quartzose zone consisting of a number of quartz veins, friable and leached in parts occurring within finely laminated carbonaceous slate and containing numerous blacks and fragments of carbonaceous and graphitic slate.

16.9 to 17.2m : - white, cavernous quartz vein with thin ($\leq$ 5 cm) parasitic veins on either side. The western boundary of this vein coincides with a fault striking north and dipping 45° towards the east with the east side apparently up. The fault plane is marked by minor concentrations of pyrite.

18.3m:- a cavernous, irregular and discontinuous quartz vein ($\leq$ 10 cm)

19.5m:- a pyritic and slightly cavernous quartz vein containing an irregular and discontinuous band ($\leq$ 5 cm) of massive pyrite. The vein strikes N38°W and dips 70°W.

At the junction of the No.3. crosscut and the No.2. level drive occurs a southerly plunging isoclinal anticline, the axial plane of which appears to coincide with the location of the southern extremity of a cupriferous quartz lode. Stoping of this lode was carried out during the early exploitation of the mine but the stopes are now inaccessible.

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The isocline occurs in pale grey and dark grey carbonaceous and graphitic slate which young towards the east and west on the eastern limbs of the fold respectively. Disrupted dragfolds which have a zone of shearing along their axial planes, can be observed in parts. The major fold defined by the dragfolds plunges about 50° towards about 160o (T) and the axial plane strikes N19°W and dips 72°W. The plunge of the fold corresponds with the plunge of the crinkle lineation observed at the eastern end of the No.3 crosscut and along the north drive.

On the roof of the southern end of the stoped area is an irregular quartz vein (approximately 30cm thick) which coincides approximately with the location of the axial plane of the isoclinal anticline and which appears to increase in thickness towards the north, i.e. in the direction of stoping. This vein contains an irregular and discontinuous band of massive sulphides, pyrite & chalcopyrite. It strikes about N7°W and dips steeply west.

The apparent coincidence of the lode and the axial of the folds leads to three interpretations regarding the genesis of the Murrays Reward deposit or, at least, that part of the deposit located at this particular position.

(i) a structurally controlled hydrothermal orebody deposited during or after the period of folding and whose present location was influenced by the existence of a shear zone parallel to the axial plane of the anticline. The orebody at this level appears to dip steeply west parallel to the axial plane of the fold and early mine plans indicate that the orebody as a whole also dips steeply west. The orebody at this level appears to plunge about 50° towards the south as does the isoclinal anticline. Similarly, Ward, after an inspection of the working mine considered that the oreshoots plunged towards the south. These observations suggest a significant correlation between fold structure and location of lode material.

(ii) a syngenetic sedimentary deposit which has undergone subsequent folding. The similar positions of the lode and fold are possibly due simply to coincidence.

(iii) a syngenetic deposit, subsequently, remobilized during a period of deformation and metamorphism and whose later concentration was influenced by a shear zone parallel to the axial plane of the fold.

NO.3. ADIT

(a) Introduction

The portal of No.3. adit is situated at the base of the western flanks of the Murrays Reward - Central Mt. Balfour ridge at an elevation of about 200.6m. It is approximately 200 metres northwest of No.1. adit, has co-ordinates of 435542N, 319385E (Australian Map Grid), and was driven towards the northeast on a bearing of N51°E (T). The adit is about 114.0 metres long, the final (northeastern) 15 metres being driven on a bearing of about N70oE (T). About 62 metres from the portal, driving was commenced from either side of the adit on bearings of 125° and 305° (T), the total length of driving being about 11.5 metres. At the end of the southern drive a winze was sunk to a depth of about 15.2 metres (Moore, 1912) but has been flooded and is now issuing a small flow of water. No other workings occur from this adit and no ore was produced.

Since the early exploration ceased in this area, the portal collapsed and the adit became flooded to a depth of about 1.8 metres. This has now been drained and the adit is still in fair condition.

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NO.3.ADIT (cont)

(b) Geology

The initial 36 metres of the No.3. adit intersected hard, dark grey to black carbonaceous and graphitic slate in which the original sedimentary bedding has been largely obliterated. Several S planes occur, one of which may coincide with the original bedding, which appears to strikes variably about N15^{o}W and dips steeply ($\leq$ 75^{o}) west. The cleavage strikes roughly north and dips towards the west, usually less steeply than the original bedding. Rare euhedral sedimentary (?) pyrite was observed. Quartz veins are very rare in this section of the adit. At about 35.4 metres a medium grey and dark grey to black banded carbonaceous slaty shale strikes N13^{o}W and dips 80^{o}W, the cleavage strikes N15^{o}E and dips 50^{o}W and graded bedding indicates younging towards the east, and it is suggested that an isoclinal anticline occurs in this section of the adit with an axis about 17.5 metres from the portal.

Between 35.8 and 46.6 metres that adit intersected medium to dark grey (with few pale grey bands) carbonaceous and graphitic slate in which the original bedding is locally well preserved and in which quartz veins are more common. Graded bedding (younging east) is also locally well preserved, and sporadic euhedral sedimentary (?) pyrite is more common.

At about 36.3 metres a minor fault strikes N19^{o}W and dips 55^{o}W. The fault plane is defined by a thin (5cm) band of pale grey sheared slate and a thin friable quartz vein.

Westerly dipping quartz veins occur as follows:

38.8m:- friable, pyritic, chloritic and sericitic quartzose vein ($\leq$ 10cm) striking N28^{o}W and dipping 55^{o} to 60^{o} W.

42.8m:- a pyritic and slightly cavernous white quartz vein containing a few thin bands of graphitic slate, and striking N33^{o}W and dipping 50^{o}W

46.3m:- an irregular pyritic quartz vein ($\leq$ 20cm), heavily limonitic in parts, striking N68^{o}W and dipping steeply west. This vein occurs in a 1.1m interval (45.5 to 46.6 metres) consisting of several thin ($\leq$ 3cm) quartz veins in black graphitic and carbonaceous slate.

In addition to these more prominent quartz veins there are numerous smaller ($\leq$ 1 cm) veins occurring in this section of the adit.

The quartzose lode containing the copper mineralization occurs between about 46.6 and 64.3 metres and has a true thickness of about 15.8 metres. The lode appears to strike about N 50^{o} - 60^{o}W and dip about 55^{o} - 70^{o}W. It consists of massive quartz, pyritic and cavernous in parts, which intersects the bedding ob suggesting an epigenetic orebody. The lode may be subdivided as follows;

46.6m:- western boundary of lode, N52^{o}W, dipping 60^{o} to 70^{o} W.

46.6 - 47.5m:- massive, white, although iron-stained and jointed, quartz containing a 3 cm band of massive pyrite and chalcopyrite. The quartz is cavernous in parts and contains a few thin bands of sheared, grey carbonaceous slate.

47.5 - 51.8m:- iron stained and deformed, carbonaceous slate containing numerous irregular & discontinuous quartz veins and lenses which are commonly pyritic and cavernous and which contain sporadic thin bands of massive sulphides (dominantly pyrite).

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NO.3. ADIT (cont)

(b) Geology (cont)

51.8 - 53.0m:- dark red-brown, heavily limonitic and highly cavernous quartzose vein containing abundant pyrite, sporadic secondary copper minerals (mainly malachite), rare chalcopyrite and a few irregular slate inclusions. The quartz occurs as an irregular framework which originally contained massive sulphides.

53.0 - 54.9m:- cavernous quartz containing minor fragments and irregular bands of carbonaceous slate.

The quartz contains sporadic disseminated pyrite and thin ($\leq$ 2 cm) pyrite bands. Red-brown limonite and iron-staining is common. The quartz and the pyrite bands dip 50° to 60° west.

54.9 - 57.9m:- white quartz, highly cavernous in parts but generally massive, contains veins, blebs and small lenses ($\leq$10cm) of sulphides (pyrite and rare chalcopyrite) and a few bands of deformed slate.

57.9m:- a 25 to 40 cm band of massive sulphides within massive quartz. The sulphides include pyrite (dominant), minor covellite and rare chalcopyrite. Malachite is also present. The sulphides occur on the western wall of the drive and strike N60°W and dip about 62° west.

57.9 - 61.3m:- massive quartz, heavily limonitic in parts, containing minor slate bands.

61.3 - 64.3m:- massive white but iron-stained quartz containing bands of sheared and deformed carbonaceous (and slightly chloritic (?)) slate. The quartz is fractured and slightly to moderately cavernous.

Between about 64.3 and 66.5 metres is a band of hard (quartzitic in parts) sheared and deformed dark grey carbonaceous slate containing common thin ($\leq$ 5 cm) quartz veins and veinlets and common pyrite occurring as disseminated euhedra or as small blebs or lenses. The slate is heavily limonitic in parts.

At 64.9 metres is a prominent quartz vein ($\leq$ 10cm) striking N45°W and dipping 55° W. The vein is moderately fractured and iron stained and contains minor pyrite.

At 66.5 metres a quartz vein ($\leq$ 15cm) strikes N32°W and dips 70°W. This quartz vein is of variable thickness and continuity, is moderately fractured, heavily limonitic in parts and contains sporadic slate inclusions.

This last quartz vein coincides approximately with the boundary between the hard, dark grey, deformed and quartzose slate to the west and a 13.2 metre interval of soft pale grey and slightly porphyroblastic carbonaceous slate occurring between 66.5 and 79.7 metres. This slate is significantly softer and more friable than that to the west and contains sporadic chlorite (?) porphyroblasts and minor films of chlorite on cleavage planes. The original bedding is vaguely preserved and pale and medium grey colour banding becomes more prominent towards the eastern boundary of this interval. The slate strikes about N8°W and dips steeply ($\leq$85°) west or about the vertical.

A few quartz veins occur within this sequence, the most notable being;

67.5m - a 10cm quartz vein of variable thickness and continuity is associated with a band ($\leq$50cm) of hard and compact pyritic and carbonaceous slate.

69.4m - an 8cm quartz vein striking N40°W and dipping 60°W. Contains a few thin ($\leq$ 3mm) bands of green (chloritic?) sediments parallel to vein walls.

73.8m - very friable pyritic and chloritic quartz vein ($\leq$ 5cm) containing thin ($\leq$1cm) bands of chloritic (?) slate parallel to vein walls. The boundaries of this vein appear to be slightly chloritic.

The rocks intersected between 79.7 and 84.4 metres are similar to those in

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NO. 3. ADIT (cont)

(b) Geology (cont)

the interval 66.5 to 79.7 metres but are usually harder (quartzitic in parts), darker and contain common thin (≤ 5cm) quartz veins. At about 83.2 metres a band of soft, white and pale grey carbonaceous slate youngs east.

Massive white quartz occurs between 84.4 and about 88.7 metres. This quartz contains only minor amounts of pyrite and very little iron-staining has occurred. The eastern 1.5 metres of this interval also contains quartzite and iron-stained carbonaceous slate.

Between about 88.7 metres and the eastern end of the adit at 114.0 metres is a sequence of pale and medium grey banded, carbonaceous shale and slate striking north and dipping about the vertical or steeply (> 80°) east. Graded bedding can be commonly observed and indicates younging towards the east.

A crinkle lineation plunging 25° to 35° towards the south, becomes prominent between 105.0 metres and the end of the adit. Quartz veins are uncommon in this sequence. Moderately hard grey carbonaceous quartzite and quartzitic slates and sandstone occur at 90.2 and 95.1 metres respectively.

The quartz lode containing the No.3. adit copper mineralization appears to intersect the bedding obliquely suggesting an epigenetic structurally contracted mineralized zone.

UNDERGROUND SAMPLING

A total of 26 channel samples were collected over intervals of 1.52 metres and assayed for copper, gold and silver early in 1970.

The results were:-

Adit 1

Eight samples were collected and assayed with the following results.

Sample No.	Location	Cu%	Au(1)	Ag(2)
5	Nth end No.1. drive	0.15	Tr	1.0
6	Immediately east of main lode	0.42	X	0.2
7	Roof of main drive (main lode)	7.90	X	0.3
8	0 to 1.5m east of No.3. drive	0.08	0.01	0.5
9	Sth end of No.3. drive	0.017	X	Tr
10	0 - 1.52m. west of No.3. drive	0.01	X	0.1
11	1.52 - 3.05m west of No.3. drive	0.009	X	0.1
12	3.05 - 4.57m west of No.3. drive	0.036	Tr	Tr

Note: Au and Ag measured in ounces per long ton
Au = X indicates less than 0.01 OZ/long ton
Ag = X indicates less than 0.1 OZ/long ton
Tr indicates trace detected but too small to be weighed.

With the exception of sample 7 which was collected from the lode proper, all samples were of definitely sub-economic grade, with an average of 0.1° per cent Cu. Silver was present in all samples and averaged 0.28 OZ/long ton. Very minor amounts of gold were detected in three samples only, with apparently no gold, occurring in the main lode.

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Sample No.	Location	Cu%	Au	Ag
13	24.4 - 25.9m along adit - quartz/slate	0.236	X	0.1
14	25.9 - 27.4m along adit - quartz/slate	0.43	X	Tr
15	27.4 - 28.9m along adit & Nth end of south drive	0.9	X	0.3
16	Nth end of south drive	0.2	X	0.2
17	2.5 - 4.8m along No.3. crosscut	0.065	X	0.4
18	Western end No.3. crosscut	0.035	X	0.2

No potentially economic copper values were recorded. No gold was detected. Silver was detected in all samples and averaged 0.2 OZ/long ton.

Adit 3

A continuous series of 13 channel samples were collected along the adit and north drive and covered a length of about 19.8 metres which included the quartz lode.

The results were:-

Sample No.	Location	Cu%	Au	Ag
19	48.8 to 50.3 metres from portal	0.15	X	0.2
20	50.3 to 51.8 metres from portal	NOT RECEIVED		
21	51.8 to 53.4 metres from portal	0.66	X	0.1
22	53.4 to 54.9 metres from portal	1.11	X	0.1
23	54.9 to 56.4 metres from portal	0.18	X	0.1
24	56.4 to 57.9 metres from portal	1.18	X	0.1
25	57.9 to 59.5 metres from portal	1.21	X	0.1
26	59.5 to 61.0 metres from portal	2.35	X	0.1
27	61.0 to 62.5 metres from portal	0.19	X	0.1
28	62.5 to 64.0 metres from portal	9.56	X	Tr
29	64.0 to 65.5 metres from portal	0.60	X	0.2
30	65.5 to 67.0 metres from portal	0.17	X	0.2
31	67.0 to 68.6 metres from portal	0.089	X	0.1

If it is valid to assume that these assay values are values after down-grading by leaching of the copper minerals then there would appear to exist a potentially economic cupriferons interval occurring between about 53.4 and 61.0 metres and averaging 1.2 per cent Cu.

Gold was not detected in the No.3. adit samples.

Silver was detected in all samples and averaged about 0.1 OZ/per long ton.

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