DEPARTMENT OF MINES
SOUTH AUSTRALIA

O'DONOGHUE'S CASTLE COPPER PROSPECT, BALCANOONA STATION

Outside hundreds; outside counties

Pastoral Sheet 11S

- Mineral Claims 4606/4607; E. and V. McGrath -

by

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GEOLOGICAL SURVEY

CONTENTS

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ABSTRACT

Irregular oxidised ore bodies up to about 3 ft. thick, containing copper carbonates, quartz, sphaerocobaltite (cobalt carbonate) and wad (hydrated manganese oxide), occupy shear zones parallel with bedding, and crush zones across the bedding. There are also many veins of barren quartz or jasper associated with iron oxides. The host rocks are a shattered dolomitic sequence overlying the equivalent of the Copley Quartzite (Burra Group), and lying within the Paralana fault zone, 9½ miles east of north from Balcanoona H.S.

Winzes should be sunk or deepened and rises continued in No. 1 and No. 2 adits. Deep trenches should be blasted across the disturbed zone at the southern end of the crest of the ridge.

INTRODUCTION

O'Donoghue's Castle mine was opened up about 1900. Except for prospecting in 1907, 1917 and 1918, the prospect received little attention until the present operators took out two 40 acre claims in late 1964. Between December 10th and December 12th, 1964, surveyor B. Frost carried out a stadia survey and the writer investigated the geology around the old mine. A further examination was made by the writer accompanied by Mr. E. McGrath on February 3rd and February 4th, 1965.

LOCATION AND ACCESS

The old mine lies on the north-eastern flanks of the Flinders Range, 9½ miles north of Balcanoona head station which is 405 miles north of Adelaide, and 62 miles by way of a good graded road due east of Copley. About 8 miles north of Balcanoona along the dirt road to Arkaroola H.S., a track leads north-west along the southern side of a fence, passing through a gate in the State vermin-proof fence one mile from the turn-off. In a vehicle with 4-wheel drive it is possible to drive beyond the end of the track for $\frac{1}{2}$ mile over a hill and along the bed of a small creek to the windmill at O'Donoghue's Castle well, and thence through a gate south-east of the windmill to the south-eastern peg of MC 4606, about 300 yds. farther to the north-west.

The workings are on the crest and slopes of a steep north-easterly trending ridge rising about 200 feet above creek level.

GEOGRAPHY

The country consists of north-easterly striking lines of dissected hills forming the eastern foothills of the Flinders Range, flanked to the east by gravel-strewn flats interrupted by low escarpments (See Plates 1 and 2). The plain is part of the depression in which lies the salt pan of Lake Frome, about 25 miles to the south-east.

The climate is arid with an average annual rainfall below 10 ins. There may be long periods of drought interspersed with falls in the winter months which may be torrential. The creeks are generally dry and flow only during heavy rain, the water quickly flooding through the gravel plain towards Lake Frome.

HISTORY OF MINING AND DEVELOPMENT

The earliest record is contained in an extract from a report made in 1900 by an Inspector of Mines and quoted by Brown (1908, p. 108). Two adits had already been out and a number of opencuts and trenches had been excavated along the strike of the disturbed zone. According to the mine manager a little over 66 tons of ore with an average value of £5/14/- per ton had been sold to the E. and A. Copper Co., of which 30 tons contained rather more than 2% cobalt. Average ore was said to carry 2 oz. to 8 oz. of silver and 1 dwt. to 2 dwt. of gold per ton. Samples (mainly from the upper opencut) assayed from 15½% to 27¾% copper.

A departmental report in 1902 commented that work was almost at a standstill owing to the low price for copper and the high cost of transport. A report in 1907 noted briefly that the property had recently been taken up again. There was some activity in 1917 and 1918 (Mining Reviews 27, 28) after which time there is no record of any prospecting before the present claimholders pegged the property in 1964.

GENERAL GEOLOGY

The regional geology in this district has been mapped by R.P. Coats, after preliminary work by Crawford (1963), Mawson and others. The host rocks at the mine are the lower part of the Burra Group (Torrensian Series of the Proterozoic Adelaide System). The beds strike to the north-east with north-westerly dips and form the lower units on the southern limb of a major faulted syncline whose axis trends south of west from a point near Arkaroola H.S., about 5 miles to the north-east. The prospect lies between two north-easterly striking faults which are part of the Paralana fault zone, an important structure on the eastern side of the Flinders Range. Another parallel fault appears to run along the borders of the Range near the line of the vermin-proof fence, about ½ mile east of the mine. On the eastern side of the fault, higher Marinoan (Wilpena Group) beds have been brought into juxtaposition with Sturtian (Umberatana Group) rocks which are themselves faulted against the Burra Group sequence on which the prospect lies.

A bed of hard pale arkose or quartzite forms craggy ridges and hillocks at the prospect. R.P. Coats (pers. comm.) considers that it is equivalent to the Copley Quartzite elsewhere in the Flinders Range. The sequence may therefore be divided as follows:-

3. Dolomitic sequence
2. Copley Quartzite equivalent
1. Mudstone, shale and siltstone with bands of dolomite.

1. The lowest beds at the mine are a succession of hard blue-grey, grey and greenish-grey laminated calcareous mudstone, siltstone and fine calcareous quartzite with bands of dolomite. A specimen taken about 50 ft. below the Copley Quartzite equivalent was described by the petrologist as a mudstone which has undergone low grade metamorphism and possibly contains cordierite ovoids. (Appendix I, Specimen TS 15391).

2. Copley Quartzite equivalent

The formation ranges in thickness from about 40 ft. to at least 120 ft. and consists of pale grey and buff coloured fine to medium grained arkose and quartzite which are generally shattered and jointed. An interesting feature is the presence of small-scale graded bedding revealed in thin section (Appendix I, TS 15392).

3. Dolomitic sequence

The arkose or quartzite is overlain by a thick dolomitic sequence extending beyond the western boundary of the claims. The beds include alternations of yellowish-brown weathered dolomite or dolomitic limestone; dolomitic siltstone and fine arkose, bands of blue-grey and greenish shale and laminated siltstone. There are scattered beds of fine pale quartzite.

In the northern part of MC 4606, the equivalent of the Copley Quartzite is succeeded by laminated shale, siltstone and fine quartzite with bands of dolomite becoming more abundant upwards, so passing into the main dolomitic sequences.

Specimens of dolomitic arkose and dolomite are described in Appendix I, TS 15393 and TS 15390.

ECONOMIC GEOLOGY

Mineralisation

The ore is usually a porous slaggy gossan of goethite (iron oxide) with infillings and encrustations of the copper carbonates malachite and azurite; and chrysocolla (copper silicate). (See Appendix I, Specimens TS 15394-15399;

TS 15438-15440). The lode material in No. 1 adit is dusted with black powder which is probably wad (hydrated manganese oxide) (TS 15438). Pink sphaerocobaltite forms colloform bands on a goethite boxwork in the winze in the opencut above No. 1 adit (TS 15440).

The copper and iron minerals have been formed by the oxidation of pyrite and chalcopyrite. An altered limestone taken from the dump outside the south-western workings contains pyrite replaced by goethite (TS 15395). In another specimen from the same dump, chalcopyrite has been altered to chalcocite and a little covellite (TS 15439).

Thus it is likely that chalcopyrite in the oxidised zone decomposed into iron oxide, and copper sulphate which reacted with carbonates in the country rock or with carbonate-bearing solutions to produce malachite and azurite. Chrysocolla was probably formed by the reaction of copper sulphate with silica-bearing fluids. The origin of the wad is uncertain. The manganese may have originally been in the form of disseminated manganese carbonate or oxide in the dolomitic rocks, later concentrated as colloidal solutions by mineralising fluids during the formation of the ore bodies, or there may have been manganiferous carbonates in the ore bodies subsequently oxidised and hydrated. No primary cobalt minerals have been reported. There are two possibilities: either the sphaerocobaltite was produced by the oxidation of a cobalt sulphide such as cobaltite (CoAsS) or linnaeite(Co_3S_4); or (more likely) that it was derived from finely divided cobalt oxide intimately associated with the manganese oxide.

In places, secondary chalcedonic quartz has encrusted azurite, as for example in the opencut above No. 1 adit (TS 15440).

Mineralisation was probably associated with the Paralana fault system, thought to have been part of the early Palaeozoic diastrophism, but the origin of the minerals in this region is not clear. Woodmansee and Johnson (1956) recorded bornite in vesicles in the pre-Burra Group Wooltana volcanics near Arkaroola, though it does not necessarily follow that the minerals were introduced by the lavas. Most mineral deposits in the district appear to lie on or near the Paralana faults and other dislocations (Crawford, 1963, Fig. 5) and the possibility remains that there may have been some re-mobilisation and concentration of minerals along the faults during lower Palaeozoic times. The nearest outcrops of lower Palaeozoic granitic intrusions are at least 10 miles to the north. Sprigg (1945) pointed out that uranium, copper minerals, manganese and quartz were apparently emplaced in Tertiary times along the Paralana fault farther north and also in the Mount Painter district. The pattern of ore genesis may thus have been complex; a major control appears to have been the presence of major faults, shear zones, and favourable stratigraphical horizons.

The zone of oxidation is at least 130 ft. below surface in No. 2 adit, and was probably formed by the lowering of the water-table since late Pliocene or early Pleistocene uplift and block-faulting of the Flinders Range.

Lodes

At O'Donoghue's Castle prospect, the minerals occur as irregular concentrations within lodes up to about 3 ft. wide parallel with bedding, as for example in No. 1 and No. 2 adits. Coatings and impregnations of malachite are also present in fractures and fissures striking between south-westerly and north-westerly. There are many barren quartz veins parallel with bedding and in disturbed zones. Most of the veins and lodes occur in the dolomitic sequence overlying the Copley Quartzite. The southern part of the ridge on MC 4606 is shattered. The summit consists of ferruginous dolomite riddled with veins and stringers of barren milky or reddish quartz. The "igneous rock" recorded by Brown (1908, p. 108) is indurated ferruginous dolomite (See Appendix I, Specimen TS 15390). Spectrographic analyses of the rock indicated 3000 parts per million of copper and only 40 p.p.m. of cobalt (Appendix II, Report AN 1390/65).

While much of the lower part of the dolomitic sequence has been disturbed, riddled with quartz veins and impregnated with iron, it should be regarded as a shatter zone with local concentrations of copper and cobalt minerals, rather than as a continuous lode. The ore body opened up in No. 2 adit could be the downward extension of the outcrop at the top of the ridge, but that in No. 1 adit is probably a separate deposit. The apparent absence of copper minerals north of the opencut near the top of the ridge could be due to leaching.

Workings

No. 1 Adit

The adit is 78 ft. long crosscut along a bearing of 310° (magnetic). The portal is cut in laminated dark grey and blue-grey siltstone and fine quartzite, with a band of conglomerate consisting of rounded pebbles of grey quartzite in an ill-sorted gritty matrix. The conglomerate has been displaced about 1 ft. by a small fault striking east of north with a dip of 67° to the south-east.

At 62 ft. from the portal, the beds pass up into hard fine grey dolomite with bands of arkose, carrying small scattered blebs of malachite. The lode was intersected at 69 ft. and consists of up to about 18 ins. of iron oxide, disseminated azurite, malachite and chrysocolla parallel with bedding with a westerly dip of 55°. (See Appendix I, Specimens TS 15396/15397). The lode pinches out towards the end of the south drive which is 30 ft. long. Near the adit, it has been stoped out for about 20 ft. in a rise, over a length of about 20 ft. A sample over 1 ft. thickness assayed 12.77% copper and 1.7% cobalt, and spectrographic analyses revealed 2,500 parts per million of zinc and 1,000 p.p.m. nickel. (Appendix II, Report AN1389/65). Only a few blebs of malachite on fracture planes in dolomite were noted in a north drive 12 ft. long.

An irregular shoot up to 1 ft. thick of black slaggy ore parallel with bedding has been exposed in an underlay shaft about 12 ft. deep sunk in a shallow opencut above No. 1 adit. The lode material consists of iron oxide with blebs and small crystals of azurite, and a little sphaerocobaltite (See Appendix I, Specimen TS 15440). There is a coating of malachite on fracture planes. The country rocks consist of blue-grey silty shale and fine quartzite overlying at least 6 ft. of dolomite, striking to the north-east, with a north-westerly dip of 50°. The shaft has a similar underlie.

No. 2 Adit

This is a crosscut adit 232 ft. long on a bearing of 295° (magnetic), and the dolomitic sequence was intersected about 87 ft. from the portal. At the end of the adit, a winze 14 ft. deep with a westerly underlie of 63° has been sunk on the ore body. A sample over a width of 2 ft. 6 in. at the bottom assayed 3.90% copper, 0.178% cobalt and over 10,000 p.p.m. of manganese (Appendix II, Report AN 1625/65). The ore probably contains wad (Appendix I, Specimen TS 15438). The lode was followed upwards in a rise put up for 30 ft. at an angle of 60° from the junction of the adit and the south drive. The face at the top is in ferruginous and manganiferous gossan containing copper carbonates, which is up to 3 ft. thick, having been exposed over a width of about 8 ft.

A sample over a width of 2 ft. 9 in. taken from the back of the drive contained 0.023% copper, 0.006% cobalt and over 10,000 p.p.m. manganese. (Appendix II, Report AN 1625/65). Traces only of malachite were noted on the footwall along the remainder of the south drive which is 55 ft. long; and in the back of a north drive 6 ft. long.

South-western workings

The workings include a winze, irregular excavations and an opencut near the south-western crest of the ridge in highly shattered and disturbed indurated dolomite. A winze 12 feet deep and a short drive for about 8 ft. beyond it have been cut along the line of a shear zone striking north-easterly and dipping at 78° to the north-west. Fracture planes are spotted with blebs and films of malachite. Specimens from the dump contain gossanous material with chalcopyrite altered to chalcocite and covellite, as well as malachite (Appendix I, Specimen TS 15439). Assays revealed 24.00% and 19.91% copper; 0.063% and 0.045% cobalt and 2,500 p.p.m. manganese. (Appendix II, Reports AN1625/65 and AN1389/65).

A cavernous excavation some 10 ft. higher is about 12 ft. wide, 10 ft. high and 15 ft. long in shattered massive dolomite. A joint plane coated with malachite on the northern wall strikes to the north-east with a north-westerly dip of 35°.

At the crest of the ridge immediately above, a trench 35 ft. long has been cut to a depth of about 6 ft. along the strike of about 5 ft. of ferruginous indurated dolomite with blebs and patches of malachite and azurite, overlain by dolomite. The beds strike north-easterly with a dip of 40° to the north-west. At the northern end of the trench, malachite is present along a thin shear zone which appears to have been formed by bedding plane slip.

Trace Elements

Less than 3 p.p.m. of gold were found in all spectrographic analyses. Silver is anomalous but low, with between 20 and 50 p.p.m. in No. 1 adit and in specimens from the dump outside the south-western workings. Zinc ranges up to 2,500 p.p.m. and nickel up to 1,000 p.p.m. It is possible that zinc, nickel and also cobalt may be intimately associated with manganese which is over 10,000 p.p.m. in some parts of the ore bodies.

Titanium is anomalous in altered mudstone below the equivalent of the Copley Quartzite (5,000 p.p.m.) but is relatively low in lode material and the dolomitic sequence.

CONCLUSIONS

1. At O'Donoghue's Castle prospect, the host rocks are a dolomitic sequence of the Burra Group overlying the equivalent of the Copley Quartzite. The rocks are shattered and faulted in a zone lying between two major dislocations forming part of the Paralana fault system.

2. Copper and cobalt carbonates; and manganese oxide occur as sporadic disseminations and aggregates in gossanous ore bodies parallel with bedding, and also within fractured ground. The oxidised zone is at least 130 feet deep in No. 2 adit, though the presence of altered pyrite and chalcopyrite in the south-western workings shows that oxidation has been locally incomplete.

3. The origin of the minerals is uncertain but they appear to be related to the Paralana fault zone which was probably formed in early Palaeozoic times. There may have been renewed movement and mineralisation in the Tertiary.

4. The copper deposits appear to be irregular concentrations within a shatter zone, and No. 1 and No. 2 adits have probably intersected separate lodes up to at least 3 ft. thick whose extent in depth is not known. It is possible that the lode in No. 2 adit may be connected with the deposit on the surface in shattered ground at the southern crest of the ridge, about 100 ft. up dip beyond the top of the rise and the same distance farther south relative to the surface.

5. Reserves are difficult to estimate. At the present time, only a small quantity of ore is visible which, however, carried rich patches. The success of the project would appear to depend on proving the extent of the bodies in depth in No. 1 and No. 2 adits, and below outcrop at the crest of the ridge.

RECOMMENDATIONS

1. A logical step in development from No. 1 adit would be the sinking of a winze on the lode below the stoped rise in order to test its possible continuation in depth. The north drive should be extended for a few feet to confirm whether copper minerals have petered out in this direction. The rise should be continued through to the surface (about 20 ft.) to provide ore and also to improve ventilation.

2. Further ore should be available in the rise in No. 2 adit. It is not known if this lode connects with the mineralised ground exposed in the opencut at the southern end of the summit, but rising on the lode appears to be preferable to the extension of the southern drive another 80 ft. southwards as proposed in Brown (1908), unless the drive were put through 200 ft. further to the surface as an adit drive.

The winze on the lode should be deepened, and exploratory winzes might be sunk at intervals farther south along the drive to at least 50 ft., with connecting drives at the bottom to block out any ore.

3. Old trenches across the shattered dolomite along the crest of the ridge are relatively shallow. In order to decide if the apparent absence of copper carbonates is due to leaching at the surface, deeper cuts should be blasted across the ridge north of the opencut. Results would help guide similar trenching northwards along the ridge, and across the ferruginous quartz outcrops on MC 4607 in which traces only of copper carbonates were noted.

BIBLIOGRAPHY

BROWN, H.Y.L., 1908 - Record of the Mines of South Australia. (Fourth Edition). Govt. Printer, Adelaide. pp.108-109.

CRAWFORD, A.R., 1963 - The Wooltana Volcanic Belt, South Australia. Trans. Roy. Soc. S.Aust., 87, pp. 123-154.

SPRIGG, R.C., 1945 - Reconnaissance Geological Survey of the Mount Painter Area in Dickinson, S.B., et al., 1945 - Investigation of Uranium Deposits at Mount Painter, South Australia. Special Govt. Rep. (Unpub.)

WOODMANSEE, W., and JOHNSON, J., 1956 - Mineral Investigations in the Mount Painter Region: Progress Report. Unpub. Rep. Dept. of Mines of S.Aust., 41/134.

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AHB:AGK
25/3/65

LIST OF PLATES

APPENDIX I

PETROLOGICAL AND MINERAGRAPHIC REPORTS

Australian Mineral Development Laboratories

<u>Locality</u> O'Donoghue's Castle copper prospect. Balcanoona Station, Northern Flinders Range.

<u>Material</u> Rock and mineral specimens

P1/65 : HB 1/65 : TS 15390

This rock is an altered dolomite limestone. In hand specimen the rock is dark brown with minor light coloured areas. The fresh, lighter coloured parts of the rock consist mainly of dolomite (95%) with occasional mica flakes and quartz grains (5%). The small mica flakes averaging 0.06 mm in diameter are probably biotite while the elongate laths (0.5 mm in length) are chlorite (?antigorite). The quartz grains are of similar size to the biotite flakes. They are being replaced by dolomite and exhibit strain extinction.

Secondary limonite staining is prominent in hand specimen. This limonitic material forms 50% of the rock in the stained portions. The limonite forms a honeycomb texture and in general has only affected the carbonate, leaving the mica untouched.

The dolomite grains in the unstained portion of the rock average 0.016 mm in size. Along the border of the limonitic area some of the dolomite grains have been recrystallized and attain sizes up to 0.5 mm. These larger grains may include differently oriented, smaller carbonate grains.

P2/65 : HB 2/65 : TS 15391

This rock is a dark brown, spotted mudstone containing unsorted clastics up to 2.5 mm in size. The mudstone has undergone low grade metamorphism.

An average 80% of the rock is fine-grained matrix consisting of sericite with a preferred orientation, muscovite and a small percentage of quartz. The laminations in the rock have been emphasized by the low grade metamorphism.

The clastics are mainly quartz, feldspar, carbonate and aggregate grains. Quartz grains in the clastic fraction have a maximum size of 0.2 mm. The larger of these grains are quite rounded compared with the smaller angular grains. Rounded potash feldspar grains (mostly microcline) and plagioclase cleavage fragments are less than 0.5 mm in size.

Aggregates of porphyritic micro-granophyre and quartz-microcline as well as quartz mosaics and feldspar mosaics are present in the rock. These aggregates (maximum 2.5 mm diameter) have distorted the compacted fine-grained layers.

Poikiloblastic authigenic ?cordierite crystals have developed in the matrix. These crystals form oval shapes oriented parallel to the laminations in the rock. Inclusions of potash feldspar, quartz and mica are common.

Carbonate grains and opaques are present in accessory amounts.

P3/65 : HB 3/65 : TS 15392

This rock is an arkose. Although not evident in hand specimen, graded bedding is seen in thin section (3 cm thick).

The coarse grained areas contain:

	%
quartz	70 - 75
potash feldspar	25 - 30

Accessory mica, opaques and zircon.

P3/65 : HB 3/65 : TS 15392 (contd.)

However the finer grained portions contain up to 40% potash feldspar and 5% sericite with a corresponding decrease in quartz.

The graded bedding is the result of an overall sorting but no particular portions are well sorted. The coarse grained material forms an interlocking mosaic with virtually no sericite. However sericite and chlorite are present in the grain boundaries of the fine fraction.

Quartz and potash feldspar grains show a wide, but comparable, variation in grain size (maximum about 1 mm). These grains are angular to subangular and commonly have irregular overgrowths.

Accessory zircon and opaque grains are most abundant at the base of the finer material in the uppermost part of the graded bed. This finer section of the bed is a distinct unit although it fits the overall nature of the graded bed.

Limited recrystallization of quartz grains in a fracture was observed.

P4/65 : HB 4/65 : TS 15393

This rock is a dolomitized arkose containing 70 per cent carbonate. X-ray analysis showed a minor percentage of the carbonate to be calcite. The clastic remnants in the rock consist of quartz and potash feldspar in a 40/60 ratio with accessory amounts of tourmaline, zircon, muscovite and opaques (1%).

The potash feldspar in the original arkose exhibited secondary overgrowths. This was also the case with a few of the quartz grains. With the encroachment of the dolomitizing solutions these secondary overgrowths were the first to be replaced. The quartz appears to have undergone a more severe replacement than the associated feldspars. Grains of quartz are extremely embayed and often only minute remnants remain. Grains are seldom in contact.

These quartz and feldspar remnants have a complete size range up to 1 mm. The enclosing carbonate grains average 3 mm in diameter.

Weathering of the outcrop has caused leaching and iron staining to a depth of 1 cm. Dendritic iron stains occur along the crystal boundaries and cleavages. The carbonate grains in the stained areas are considerably smaller than in the body of the rock.

P5/65A : HB 5/65 : PS 8556

This sample is a vesiculate, goethite boxwork with malachite infilling the majority of spaces, (averaging 0.15 mm diameter). Sometimes the malachite aggregates are acicular, and at other times appear structureless. Successive alternate layers of malachite and goethite often infill the boxwork.

Carbonate grains up to 1 mm infill larger spaces and frequently enclose malachite crystals.

Accessory quartz is also present.

P5/65B : HB 5/65 : PS 8557

This specimen is an altered limestone, somewhat more compact but mineralogically similar to TS15394. There has been considerable replacement of pyrite. This has resulted in pyrite pseudomorphs with iron oxide rims enclosing calcite and/or malachite crystals. Goethite forms a considerable portion of the rock and in the polished specimen is seen replac-

P5/65B : HB 5/65 : PS 8557 (contd.)

ing pyrite. [illegible] iron oxide boxworks are formed malachite and carbonate frequently infill these structures. Some of the carbonate has recrystallized to form larger grains up to 1 mm diameter although in some of the more heavily iron stained areas the grains are very small (0.04 mm diameter).

Recrystallized calcite fills many of the fractures through the rock although dendritic goethite is also frequently controlled by fractures.

Very little malachite is present in this specimen as compared with TS15394.

Quartz and plagioclase feldspar occur as accessory minerals.

P6/65A : HB 6/65 : TS 15396

This is a goethite - azurite specimen with primary and secondary quartz.

The goethite has a massive or boxwork structure. The massive portions exhibit a progressive concretionary development on an original boxwork texture. Detrital angular to sub-rounded quartz grains up to 0.6 mm across, as well as a very occasional potash feldspar grain make up nearly 10% of the rock. These grains are undergoing replacement by azurite or goethite.

Secondary encrustations of azurite infill many of the goethite boxwork structures and also form external coatings on the iron oxide. Minute well developed crystals of azurite are a feature on uninhibited surfaces. Secondary quartz growths commonly, partly or completely fill cavities in the goethite and in the azurite or adjacent to other quartz grains.

Accessory muscovite is also present. No cobalt minerals were observed in this specimen.

P6/65B : HB 6/65 : TS 15397

This sample is an altered, unsorted rock of arkosic composition. However, clastics form less than 25% of the rock of which the quartz/feldspar ratio is 55/45.

There is no obvious bedding although an irregular fine-grained layer is discernible as a separate entity. This layer has been offset a distance of 1 mm and the fracture infilled with chrysocolla and iron staining. Patches of coarse grained sub-angular quartz and feldspar aggregates up to 0.9 mm diameter are set in a fine grained groundmass of similar material. These layers apparently alternate with layers of fine (8 micron) material although the section was not large enough to observe this.

Between these layers of clastics are bands of secondary alteration in the form of goethite, chrysocolla and azurite. Chrysocolla and goethite may form the groundmass for the coarser clastics after replacement of the fines.

Within these goethite and azurite rich bands there are flakes of margarite(?) and muscovite commonly containing alternate bands of chlorite.

Chrysocolla exhibiting colloform banding often envelopes various grains and fills cavities throughout the sample. Azurite crystals also infill cavities in the rock. About 15% of the rock is made up of these two copper minerals.

P7/65A : HB 7/65 : TS 15398

This specimen is for the most part goethite. About 15% of the rock consists of quartz remnants, azurite, malachite, mica and chrysocolla.

The detrital quartz has been almost completely replaced by goethite. Cavities in this iron oxide material have been filled or partly encrusted by malachite, chrysocolla and/or azurite. Other cloudy, altered material is present

P7/65A : HB 7/65 : TS 15398 (contd.)

at times around the azurite in these cavities. The mica is chlorite and muscovite, as well as a little margarite(?) replaced by goethite.

P7/65B : HB 7/65 : TS 15399

This is a poorly sorted rock of arkosic composition. The quartz-feldspar ratio is about 50/50 but together they make up less than 60% of the rock. Chrysocolla, azurite and minor malachite form 20% while the remainder of the rock consists of mica and goethite.

The quartz and feldspar (potash) grains are angular to sub-rounded and vary in size from 0.7 mm to less than 8 µ. The larger grains (most are greater than 0.2 mm) are set in a fine grained matrix. Goethite laminations transect the clastic areas although most is in a non-clastic band associated with the larger areas of chrysocolla and azurite. These non-clastic areas are also the venue of most of the mica flakes. Both margarite(?) and chlorite are present.

Fractures throughout the specimen have been infilled by azurite and/or chrysocolla. The chrysocolla frequently exhibits colloform banding while azurite forms large crystal aggregates.

P56/65 : HB 30/65 : TS 15438

These specimens are for the most part iron oxide (goethite). A sample of the black powdery material from this set of specimens was x-rayed and found to be amorphous. A chemical test showed it to be an oxide of manganese (probably wad).

In thin section the porous iron oxide encloses, and has partly replaced, quartz grains up to 0.5 mm in diameter. However these grains form less than 5 per cent of the rock. Accessory mica flakes are also present.

P57/65 : HB 31/65 : TS 15439 : PS8571

One specimen is a porous, gossan material with malachite crystals forming 30 per cent of the rock. The gossan consists of irregular boxworks of iron oxide (goethite) and numerous carbonate (?calcium) grains (maximum size 0.25 mm) infilling many of the cavities. Accessory iron stained mica and unaltered laths of ?margarite are present. The ?margarite is growing at the expense of malachite and iron oxide.

A second, more compact specimen consists of iron oxide (goethite) and about 30 per cent malachite. This sample also contains primary chalcopyrite altering to chalcocite and a little covellite. The chalcocite is most common as rims on the chalcopyrite grains but occasionally the chalcopyrite has completely altered to chalcocite.

P58/65 : HB 32/65 : TS 15440

This is a very porous rock composed of iron oxide (goethite), azurite and sphaerocobaltite (pink) with accessory amounts of malachite, quartz, potash feldspar and mica. The mica includes flakes of muscovite, chlorite and ?margarite. Chlorite has completely replaced some minerals.

Quartz grains up to 0.6 mm in size are encrusted with iron oxide or scattered throughout the secondary copper and cobalt minerals. Azurite infills many of the cavities in the goethite boxwork and itself is encrusted by secondary chalcedonic quartz layers. Sphaerocobaltite forms colloform bands on the goethite boxwork.

Small radial growths of a pale green ?carbonate are associated with the cobalt and copper minerals.

P58/65 : HB32/65 : TS 15440 (contd.)

No erythrite was observed in this sample.

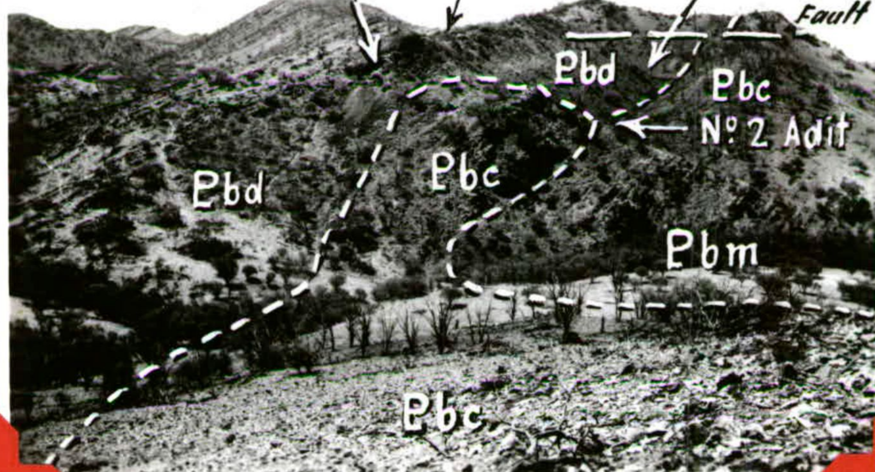
Investigation and Report by: I.F. SCOTT

Officer in Charge, Mineralogy Section: H.W. FANDER

L. WALLACE COFFER
Director

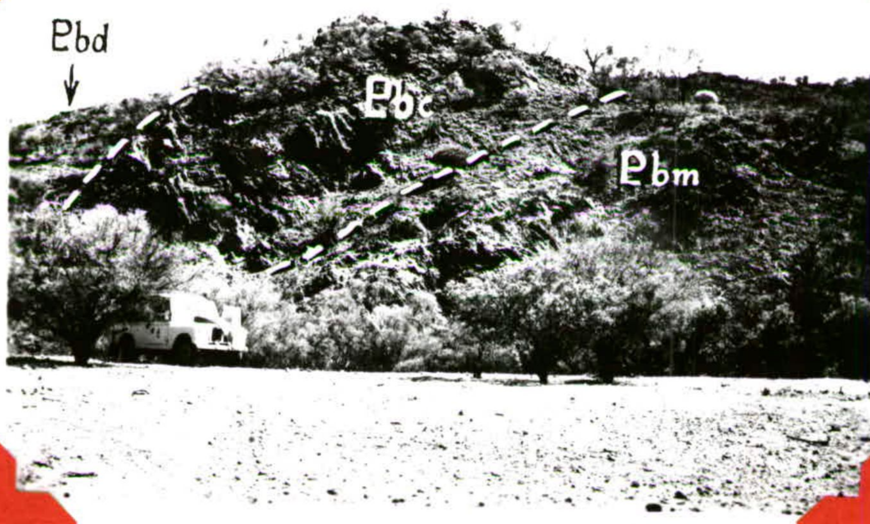
GRID. R 5 (Slide 6790). 15407

1. View eastwards from MC 4607.



R5 (Slide 6789) 15406

2. Workings viewed from south
(Ᵽbc = Copley Quartzite equivalent)



R 5 (Slide 6788) 15405

3. South end of ridge from boundary
of MC 4606 and MC 4607.

APPENDIX II

CHEMICAL AND SPECTROGRAPHIC ANALYSES

REPORT AN 1389/65 (Part)

Australian Mineral Development Laboratories

CHEMICAL ANALYSES

Sample Mark	Copper % (Cu)	Cobalt % (Co)
A1/65	19.91	0.045
A2/65	12.77	1.7
A3/65	8.21	0.22

A1/65 ; HB 8/65 Dump outside south-west cut.

A2/65 ; HB 10/65 Across 1 ft. in stope in No. 1 adit.

A3/65 ; HB 11/65 Dump outside No. 1 adit.

Analyses by: A. JORGENSEN and J.A. POWELL

A/Officer in Charge, Analytical Section: A.B. TIMMS

L. WALLACE COFFER
Director.

REPORTS AN 1389/65 and AN 1390/65

Australian Mineral Development Laboratories

SPECTROGRAPHIC ANALYSES (parts per million)

		Sample Mark						
		A1/65	A2/65	A3/65	A4/65	A5/65	A6/65	A7/65
Copper	(Cu)	**10,000	**10,000	**10,000	3,000	200	150	100
Lead	(Pb)	15	150	120	7	50	10	7
Zinc	(Zn)	1,500	2,500	1,200	100	20	* 20	* 20
Cobalt	(Co)	80	4,000	1,200	40	12	50	4
Nickel	(Ni)	40	1,000	800	25	80	70	10
Tin	(Sn)	15	8	10	7	15	5	3
Silver	(Ag)	15	50	40	2	0.1	0.5	0.2
Gold	(Au)	* 3	* 3	* 3	* 3	* 3	* 3	* 3
Vanadium	(V)	3	5	10	2	150	25	3
Tungsten	(W)	* 20	* 20	* 20	*200	*20	*20	*20
Titanium	(Ti)	20	40	800	10	5,000	800	30

A1/65 ; HB 8/65. Dump outside south-west cut.

A2/65 ; HB 10/65. Across 1 ft. in stope in No. 1 adit.

A3/65 ; HB 11/65. Dump outside No. 1 adit.

A4/65 ; HB 9/65. Dolomite from crest of ridge. (See also Appendix I, TS 15390).

A5/65 ; HB 12/65 Mudstone. (See also Appendix I, Specimen TS 15391).

A6/65 ; HB 13/65 Arkose (Copley Quartzite equivalent). (See also TS 15392).

A7/65 ; HB 14/65 Dolomitic arkose (See also Appendix I, TS 15393).

Notes:

See also chemical analyses for copper and cobalt for A1/65, A2/65, A3/65.

** indicates "more than".
* indicates "less than".

Spectrographic Analyses by: G.R. HOLDEN

A/Officer in Charge, Analytical Section: A.B. TIMMS

L. WALLACE COFFER
Director

REPORT AN 1625/65 (part)

Australian Mineral Development Laboratories

CHEMICAL ANALYSES

Sample Mark	Copper %	Cobalt %
A 37/65	0.023	0.006
A 38/65	3.90	0.178
A 39/65	24.00	0.063

A 37/65; HB 27/65. Across 2 ft. 9 in. in drive, No. 2 adit.

A 38/65; HB 28/65. Across 2 ft. 6 in. at bottom of winze, No. 2 adit.

A 39/65; HB 29/65. Specimen from dump, south-west cut.

Analyses by: A. JORGENSEN

A/Officer in Charge, Analytical Section: A.B. TIMMS

L. WALLACE COFFER,
Director.

REPORT AN 1625/65 (Part)

Australian Mineral Development Laboratories

SPECTROGRAPHIC ANALYSES

parts per million

		Sample Mark		
		A 37/65	A 38/65	A 39/65
Lead	(Pb)	4	100	4
Zinc	(Zn)	50	800	400
Silver	(Ag)	0.3	1.5	20
Gold	(Au)	* 3	* 3	* 3
Iron	(Fe)	** 3%	** 3%	3%
Tin	(Sn)	3	7	8
Tungsten	(W)	* 20	* 20	* 20
Vanadium	(V)	2	1	1
Nickel	(Ni)	1	100	15
Titanium	(Ti)	200	150	10
Manganese	(Mn)	**10,000	**10,000	2,500

** indicates "more than".
* indicates "less than".

A 37/65 ; HB 27/65. Across 2 ft. 9 in. in drive, No. 2 adit.
A 38/65 ; HB 28/65. Across 2 ft. 6 in. at bottom of winze, No. 2 adit.
A 39/65 ; HB 29/65. Specimen from dump, south-west cut.

Spectrographic Analyses by: G.R. HOLDEN

A/Officer in Charge, Analytical Section: A.B. TIMMS

L. WALLACE COFFER
Director.