NORTHERN TERRITORY GEOLOGICAL SURVEY

TECHNICAL REPORT

GS 90/016

Cu-Pb-Zn-Ag mineralisation within the Pine Creek 1:100 000 Sheet.

by

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INTRODUCTION

This report contains the details on all known Cu-Pb-Zn-Ag mineral occurrences within the Pine Creek 1:100 000 sheet*. The data collection phase consisted of a thorough search of both published and unpublished information sources, field inspections of the deposits and some petrological work (Appendix 1) on many of the significant deposits. This work constitutes a significant contribution in the preparation of a Metallogenic Map and Explanatory Notes of the Pine Creek 1:250 000 Sheet area.

PINE CREEK is centred about 175 km southeast of Darwin, and is traversed by both the Stuart Highway and the abandoned North Australian Railway. Well graded roads to Jindare, Moline, Frances Creek, Mount Wells and Mary River Station provide access to the remainer of the area along with numerous vehicle tracks found in old mining areas. PINE CREEK lies within the monsoonal zone and has an average annual rainfall of about 1 500 mm, most of which falls during the wet season from November to April.

Base metal mining and prospecting in the area has been carried out on a relatively small scale and on an intermittent basis since 1875. During the first half of the century vein deposits were an important source of a number of ore minerals. They were mined because they were relatively rich, near-surface deposits which lent themselves to hand-picking, so that high grade concentrations could be dispatched to distant markets.

Exploration within PINE CREEK is summarised on the Exploration Series Maps available from the N.T.G.S. Geoscience Resource Section. A number of companies have searched for base metal mineralisation at the "grass roots" level, however most of the exploration efforts have concentrated on delineating remaining resources at old mines and prospects. The most active explorers include: Bureau of Mineral Resources (1950-1970), United Uranium N.L. (1960-1970), Central Pacific Minerals N.L. (1970s), Geopeko Ltd. (1970-1980) and Nord Resources Pty. Ltd. (1980s).

Of the 40 base metal (Cu-Pb-Zn) occurrences within PINE CREEK, 36 are of *hydrothermal vein type*, 3 are *stratabound replacement type*, and one possible *stratiform type*. Production figures are low (Table 3.); the significant being Iron Blow with 13,920 t of copper ore. The reserves for many of the significant deposits are unreliable or unknown due to the lack of exploratory drilling.

GEOLOGY

PINE CREEK has been recently mapped by a joint BMR-NTGS team (Stuart-Smith, et al 1987) using 1:25, 000 scale colour air photos as part of a regional mapping program. More detailed mapping in the northwestern part of the sheet has been conducted by Nicholson (1978).

*The names of the 1:100 000 map sheets in this report are designated by the use of capital letters.

REGIONAL GEOLOGY

PINE CREEK lies in the southern part of the Pine Creek Geosyncline, the geology of which has been described by Needham et al (1980). The geosyncline contains Early Proterozoic metasedimentary rocks resting on a gneissic and granitic Archaean basement, exposed northwest and northeast of PINE CREEK (Figure 1).

The sedimentary rocks of the geosyncline are mainly shale, siltstone, sandstone, conglomerate, carbonate rocks and volcaniclastics. The sequence is intruded by pre-tectonic dolerite sills and syn- to post tectonic granitoid plutons. Largely undeformed platform covers of Middle Proterozoic, Late Proterozoic, Cambro-Ordovician and Mesozoic strata rest on these rocks with a marked unconformity.

LOCAL GEOLOGY

Stratigraphy

The stratigraphy of PINE CREEK is summerised in Table 1. An interpretive solid geology map with Cu-Pb-Zn-Ag occurrences within PINE CREEK is shown in Figure 2.

Metamorphism

All the Early Proterozoic rocks have been both, regionally metamorphosed to greenschist facies (with P-T conditions in the order of 350-400°C and 3-4 kb), and contact metamorphosed by syn- to post-tectonic granites.

Characteristic mineral assemblages of the major metamorphic lithologies are given in Table 2.

Structure

Two major phases of folding in the Early Proterozoic metasediments are recognised; the older (local F_1 = regional F_3), close to tight folds and the younger (local F_2 = regional F_4), widely spaced, open folds. Both predate the granite intrusions. Elongate basins and domes such as the Golden Dyke Dome developed from the interference of the two fold sets.

The F_1 folds are north to northwest trending megascopic to mesoscopic folds which generally plunge gently to the north. They are symmetrical and either upright or, inclined to the southwest, commonly with overturned limbs. The fold style is a composite of parallel and similar folds, in psammites and pelites repectively. A penetrative near vertical, slatey to phyllitic cleavage coinciding with the axial plane surfaces of the F_1 folds is well developed in the pelites.

The F_2 folds are not obvious in the field, due to their openess and spacing of several kilometers. They trend east and may be associated with poorly developed crenulation cleavages.

The regional F_1 and F_2 folds are locally modified by the *Pine Creek Shear Zone*, and by faults up to 20 km long which typically have small displacements ranging from a few metres to 1 km.

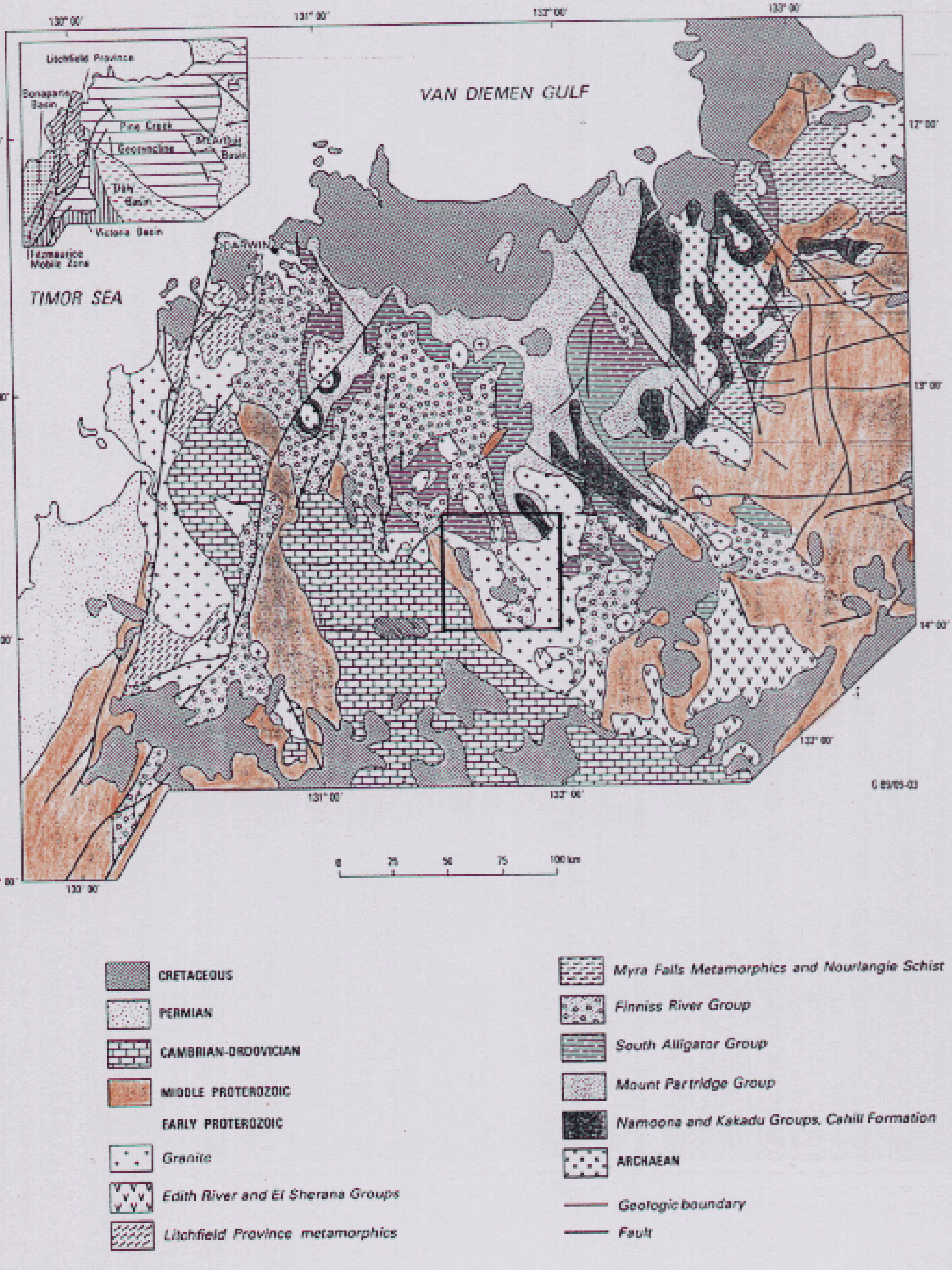


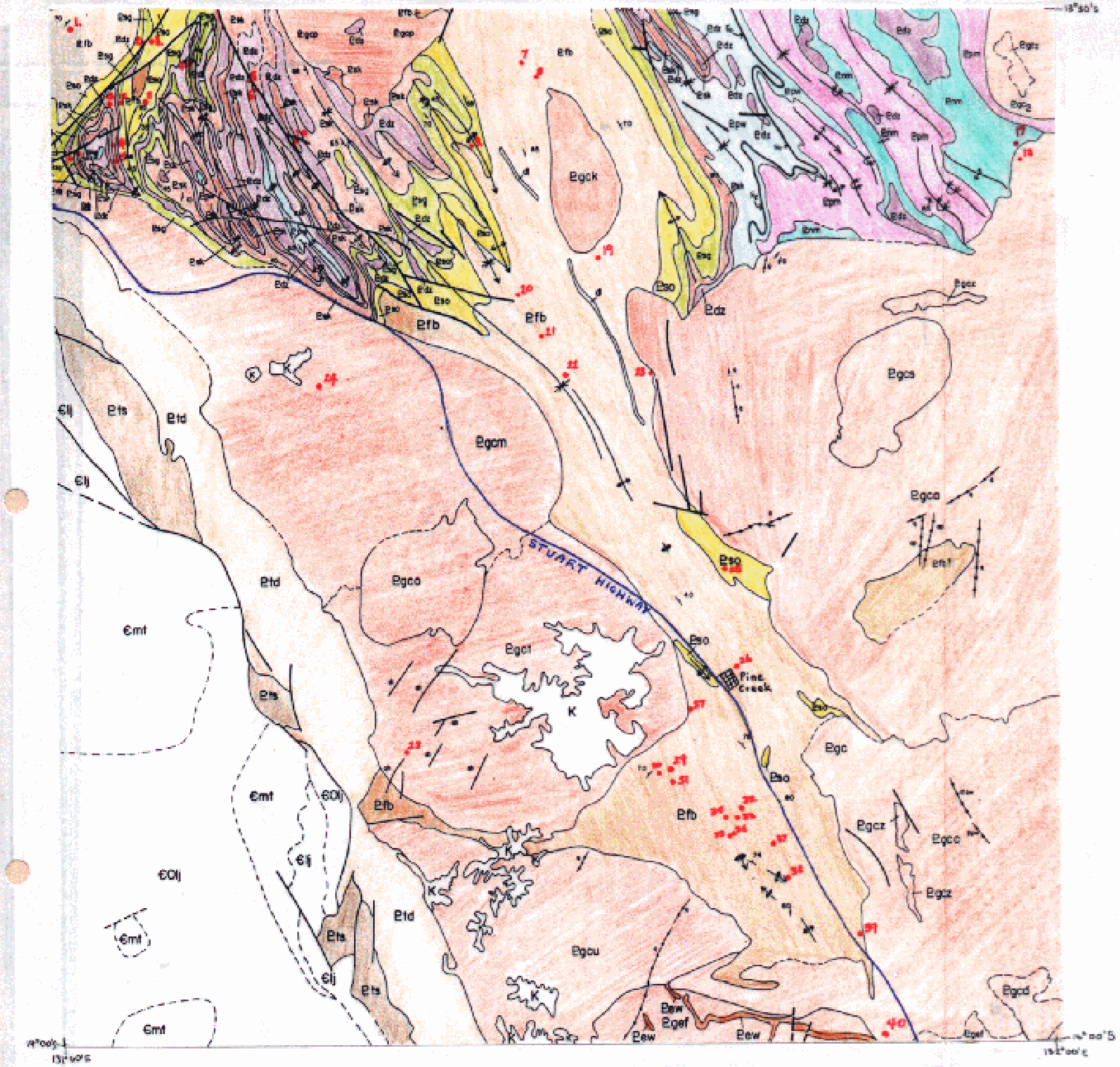
FIGURE 1 Regional geological setting of PINE CREEK.

TABLE 1. SUMMARY OF STRATIGRAPHY (from Stuart-Smith et al., 1987).

	Unit	*Main Rock Types*	*Relationships*	*Thickness (m)*	*Remarks**
QUATERNARY	Qa	Silt, sand, clay		<3	Alluvium
	Qf	Black and brown humic soil and clay		<2	Floodplain deposits at upper reaches of drainage courses
TERTIARY TO QUATERNARY	Cz	Sandy to gravelly lithosols	Veneer over Mesozoic and older units	<2	Regolith
	Czt	Sand and rubble of granite and sandstone	Flanks scarps of resistant Middle Proterozoic and Mesozoic rocks	<10	Talus deposits
	Czg	Unconsolidated gravels	Flanks steep ridges of Early Proterozoic hornfels	<3	Older colluvium
	Czs	Unconsolidated sand	Veneer on laterite and older formations	<10	Fan deposits
	Czl	Ironstone	Flat-lying cappings on older formations	<3	In-situ and reworked remnants of laterite profile
CRET-ACEOUS	K	Ferruginous quartz sandstone and conglomerate	Flat-lying veneer unconformable on older formations	25	Epicontinental deposits
CAMBRIAN TO ORDOVICIAN DALY RIVER GROUP	Jinduckin Formation (ЄOlj)	Limestone; calcareous sandstone, sandy limestone, quartz sandstone, siltstone and shale	Conformably overlies Єmt	950	Shallow marine, possibly intertidal
	Tindall Limestone (Єmt)	Massive thinly bedded limestone with chert bands and nodules in places	Disconformably overlies Єj_1	<150	Marine, fossiliferous. Öpik (1956)
CAMBRIAN	Jindare Formation (Єj_2)	Thinly bedded, fine to medium white quartz sandstone	Conformably overlies Єj_1	8	Continental to shallow marine
	(Єj_1)	Mottled fine to medium and pebbly quartz sandstone, purple micaceous siltstone and silty shale. Silicified carbonate breccia and sandy procellanite at base	Disconformably overlies or faulted against Ᵽts	200	
MIDDLE PROTEROZOIC TOLMER GROUP	Stray Creek Sandstone (Ᵽts)	Laminated to thinly bedded very fine brown quartzite, micaceous sandy siltstone, limonitic micaceous siltstone, minor ferruginous, silicified dolomite and dolomitic siltstone	Conformably overlies Ᵽtd	450	Shallow marine. Noakes (1956) and Walpole & others (1968)
	Depot Creek Sandstone (Ᵽtd)	Laminated to thickly bedded, pink to brown medium to coarse quartz sandstone micaceous siltstone, minor ferruginous, silicified dolomite and dolomitic siltstone	Unconformably overlies Early Proterozoic metasediments and granitoids	450	Continental to shallow marine, Walpole & others (1968)
EARLY PROTEROZOIC CULLEN BATHOLITH	Lewin Springs Syenite (Ᵽew)	Porphyritic microgranite, rhyolite, porphyritic quartz microsyenite and quartz micromonzonite	Numerous dykes intruding granitoids in the south	250	
	(Ᵽgc)	Granite, leucogranite, granodiorite (see Table 2 for a summary description of these rocks)	Numerous coalesced plutons intruding older Early Proterozoic metasediments and dolerite		Highly fractionated suites Stuart-Smith (1986)
CULLEN BATHOLITH	Bludells Monzonite (Ᵽgcz)	Grey-green medium equigranular biotite-hornblende-quartz monzonite, coarse porphyritic quartz monzonite, biotite-hornblende-quartz syenite, minor biotite-hornblende-quartz monzodiorite and olivine dolerite	Xenoliths and rafts within Ᵽgc		Fractionated alkaline suite Stuart-Smith (1986)
	(Ᵽgch)	Undivided hornfels	Xenoliths and rafts within Ᵽgc		Blocks of Early Proterozoic metasediments and dolerite
	Prices Springs Granite (Ᵽgp)	Pink-green or grey coarse equigranular to porphyritic granite	Intrudes older Early Proterozoic metasediments and dolerite		
	McKinlay Granite (Ᵽgk)	Pink-green coarse porphyritic granite	Intrudes older Early Proterozoic strata		
	Zamu Dolerite (Ᵽdz)	Chloritised medium quartz dolerite and amphibolite	Sills intruding (and folded and metamorphosed with) older Early Proterozoic strata	150	Continental tholeiite Ferguson & Needham, (1978)

TABLE 1. SUMMARY OF STRATIGRAPHY (Continued)

		Unit	*Main Rock Types*	*Relationships*	*Thickness (m)*	*Remarks**
EARLY PROTEROZOIC	FINNISS RIVER GROUP	Burrell Creek Formation (Ᵽfb)	Fine to coarse feldspathic greywacke, shale, slate, phyllite and siltstone; minor volcanilithic conglomerate; rare altered felsic to intermediate volcanics	Conformably overlies or faulted against Pso Intruded by Ᵽgc, Ᵽgp, Ᵽgk and Ᵽdz	1000	Flysch deposits derived from a dominantly volcanic source
EARLY PROTEROZOIC	SOUTH ALLIGATOR GROUP	Mount Bonnie Formation (Ᵽso)	Shale, mudstone, phyllite, siltstone, medium feldspathic greywacke, minor tuffaceous chert, glassy black crystal tuff, vitric tuff, lithic crystal tuff, carbonaceous shale, and rare banded iron formation	Conformably overlies Ᵽsg	700	Transition between low-energy, shallow-water, reduced environment and deeper water flysch facies
EARLY PROTEROZOIC	SOUTH ALLIGATOR GROUP	Gerowie Tuff (Ᵽsg)	Brown and grey siltstone, phyllite and argillite, glassy black tuffaceous chert, crystal tuff and vitric tuf	Conformably overlies Ᵽsk	300-400	Reworked subaqueous deposits of siliceous ash in a low-energy, reduced environment
EARLY PROTEROZOIC	SOUTH ALLIGATOR GROUP	Koolpin Formation (Ᵽsk)	Ferruginous and carbonaceous phyllite with chert bands lenses and nodules in places; minor massive limonitic ironstone, silicified dolomite, marl, pyritic and graphitic chiastolite carbonaceous hornfels, marble, para-amphibolite and muscovite-quartz schist	Unconformably overlies Ᵽpw$_1$ and Ᵽpw$_2$	200-300	Fresh to brackish shallow, acid and reducing environment Crick & others (1980)
EARLY PROTEROZOIC	MOUNT PARTRIDGE GROUP	Wildman Siltstone (Ᵽpw$_2$)	Siltstone, phyllite, silty phyllite, carbonaceous phyllite and minor laminated fine to coarse quartz sandstone, dolarenite, spotted micaceous hornfels and tremolite–quartz hornfels	Conformably overlies Ᵽpw$_1$ and unconformably overlain by Psk	350	Transgressive sequence of shallow-water facies transitional with fluvial facies of Ᵽpm
EARLY PROTEROZOIC	MOUNT PARTRIDGE GROUP	(Ᵽpw$_1$)	Phyllite (pyritic and carbonaceous at depth), siltstone, laminated red and white banded phyllite, massive hematite ironstone lenses (pyritic carbonaceous shale breccia at depth) and chiastolite muscovite carbonaceous hornfels	Conformably overlies Ᵽpm Conformably overlain by Ᵽpw$_2$ and unconformably overlain by Ᵽsk	400	
EARLY PROTEROZOIC	MOUNT PARTRIDGE GROUP	Mundogie Sandstone (Ᵽpm)	Coarse, pebbly feldspathic quartzite, arkose, and micaceous quartzite; minor chert and quartz pebble conglomerate. Red and white banded phyllite; carbonaceous phyllite; sandy siltstone; micaceous hornfels, and chiastolite carbonaceous hornfels	Unconformably? or disconformably overlies Ᵽnm	500	Fluvial fans Stuart-Smith & others (1980)
EARLY PROTEROZOIC	NAMOONA GROUP	Masson Formation (Ᵽnm)	Carbonaceous phyllite, slate, silty phyllite, siltstone, sandy siltstone, minor laminated medium to coarse grey quartzite and feldspathic quartzite, and massive ironstone. Rare muscovite tremolite marble	Unconformably? or disconformably overlain by Ᵽpm	1000	Low-energy marine environment Stuart-Smith & others (1980)



1. The Jar
2. Unnamed Cu
3. Iron Blow
4. Unnamed Cu
5. Pickfords
6. Saunders Creek
7. Speargrass
8. Lewis'
9. Unnamed Cu
10. Burrundie Cu
11. Mount Bonnie
12. N2
13. N5
14. Heatleys' Cu
15. Heatleys' Pb-Zn
16. Davis Creek
17. Unnamed Cu
18. Unnamed Cu
19. Union Extended
20. McKinlay
21. Flora Belle
22. Union Reefs
23. Unnamed Cu
24. Granite
25. Basin 6
26. Jensens'
27. Enterprise No2
28. Unnamed Cu
29. Copperfield
30. Unnamed Cu
31. Unnamed Cu
32. Lucknow
33. Quests
34. Unnamed Pb-Ag
35. Unnamed Cu
36. Unnamed Cu
37. Mount Wigley
38. Unnamed Cu
39. Unnamed Cu
40. Unnamed Cu

MESOZOIC
- K Petrel Formation

PALEOZOIC

DALY RIVER GROUP
- €Ol Jinduckin Formation
- €mt Tindall Limestone
- €lj Jindare Formation

MIDDLE PROTEROZOIC

TOLMER GROUP
- Ets Stray Creek Sandstone
- Etd Depot Creek Sandstone

EARLY PROTEROZOIC
- Eew Lewin Springs Syenite
- Egcm, Egco, Egcu, Egct, Egcp, Egck, Egcz, Egc, Egca, Egcc, Egcd, Egcf. Granitoid phases within the Cullen Batholith.
- Edz Zamu Dolerite

FINNISS RIVER GROUP
- Efb Burrell Creek Formation

SOUTH ALLIGATOR GROUP
- Eso Mount Bonnie Formation
- Esg Gerowie Tuff
- Esk Koolpin Formation

MOUNT PARTRIDGE GROUP
- Epw Wildman Siltstone
- Epm Mundogie Sandstone

NAMOONA GROUP
- Enm Masson Formation

FIGURE 2 Solid geology and Cu-Pb-Zn-Ag occurrences within PINE CREEK.

TABLE 2. CHARACTERISTIC METAMORPHIC MINERAL ASSEMBLAGES (from Stuart-Smith et al., 1987).

Rock Type	*Regional Metamorphism*		*Contact Metamorphism*		
	Lower Greenschist	Upper Greenschist	Albite–epidote Hornfels Facies	Hornblende Hornfels Facies	K-feldspar–cordierite Hornfels Facies
Pelitic rocks	Sericite + quartz	Biotite + muscovite + quartz	Muscovite ± biotite ± chiastolite ± quartz	Muscovite + biotite ± cordierite ± albite ± quartz	Cordierite + andalusite + K-feldspar + biotite + quartz
Quartzose and feldspathic sandstone	Sericite/ muscovite + chlorite		Muscovite + quartz ± albite ± biotite	— ditto —	
Greywacke	Sericite + chlorite + epidote		Muscovite + biotite + quartz ± K-feldspar ± albite ± epidote ± actinolite	Muscovite + K-feldspar + quartz ± albite ± biotite	
Tuff	Chlorite + sericite + quartz	Biotite + muscovite + quartz	Muscovite + quartz ± biotite ± albite ± K-feldspar	— ditto —	
Carbonate rocks	Dolomite + quartz	Tremolite + garnet + biotite + quartz	Calcite + tremolite + epidote Calcite + tremolite + zoisite + sphene + quartz Tremolite + biotite + quartz	Grossular + calcite Diopside + quartz	
Dolerite	Chlorite + sericite + epidote + zeolites	Actinolite + biotite	Actinolite + biotite + epidote + clinozoisite	Hornblende + biotite + plagioclase + K-feldspar ± calcite ± sphene	

The Pine Creek Shear Zone is part of a major northwest trending wrench fault system extending from Darwin to Katherine, which occupies an embayment of metasediments between two lobes of the Cullen Batholith in PINE CREEK. Metasediments within the zone are schistose and chloritic, with bedding and cleavage both vertical and parallel. The geological position of the shear zone suggests that it may be the result of localised high strain caused by diapirism during granite intrusion.

The faults and shear zones are commonly infilled with white, coarse grained vein quartz and brecciated metasediments (Plate 1), and often host base metal mineralisation.

Plate 1 Quartz-filled fault near the Hayes Creek Inn, (GL 620 006 TIPPERARY)

MINERAL DEPOSITS

The Cu-Pb-Zn-Ag occurrences within PINE CREEK have been classified into three categories as previously mentioned on the basis of probable origin. The dominance of hydrothermal vein type occurrences over the others is reflected throughout the entire Pine Creek Geosyncline.

TABLE 3. Past Production

Mine	Ore	Grade
Lead-Silver		
McKinlay	763 t	~25% Pb, 1500g/t Ag
Flora Belle	390 t	~6% Pb, 300g/t Ag
Mt. Wigley	315 t	~5% Pb
Pickfords	~150 t	~6% Pb, 800g/t Ag
Lucknow	160 t	unspecified
Union Reef	~50 t	
Union Extended	~30 t	
Jensen's	~30 t	
Davis Creek	~10 t	
Unnamed	~10 t	
Copper		
Iron Blow	13,920 t	~4% Cu
Copperfield	3,450 t	~24% Cu
Enterprise No2	28.5t	~1% Cu
Granite Mine	5 t	50% Cu
Saunders Creek	~20 t	~20% Cu
Unnamed Occurrences	~100 t	~20% Cu
Gold-Silver		
Mt. Bonnie	110,000 t	7g/t Au, 230g/t Ag
Iron Blow	15,000 t	7g/t Au, 200g/t Ag

STRATABOUND REPLACEMENT TYPE

Within the Pine Creek 1:250 000 sheet there are only three examples of this type of deposit. The Iron Blow and Mount Bonnie deposits are classified into this group by the author on the basis of :

1. Stratigraphic control,
2. Magmatic textures of the ore,
3. Contact metamorphic and unusual hydrothermal alteration mineral assemblage of the wallrocks,
4. Dominance of carbonate gangue over silicates,
5. Magmatic sulphur isotope signatures, and
6. Limited strike length.

Iron Blow

Introduction

The Iron Blow mine (GL 761 044) is about 3.7 km south of the Grove Hill Siding, and has good access to the open cut all year round via a gravel road.

The Iron Blow outcrop was discovered in 1873, and first worked in 1886 by a company formed by an amalgamation of existing claim holders. Early inspections of the mine by government geologists include: Tenison-Woods (1886), Parkes (1892), Brown (1906), Jensen (1915), and Jensen et al. (1916).

Prospecting and mining operations by the Northern Territory Goldfields of Australia Ltd at the turn of the century are given in a report by McDonald (1901). The mine was worked by the above company from 1898 to 1906 producing some 13 920 t of oxide and sulphide ore. The mine was abandoned in 1906, and the shaft became infilled with water. Plans of the old underground workings are in a report by Hossfield (1937).

In 1912 George Buttle took up the leases and re-opened the mine with a government subsidy. A diamond drill hole put down by the government intersected a 23.3 m zone of low grade lode material (Hossfeld, 1937).

Smelting was ready to commence in 1914 when the outbreak of World War I upset the metal prices, and Mr Buttle found it necessary to surrender the mine and machinery plant to the government.

A geological and geophysical survey (EM, SP and Racom) of the mine area was conducted by A.G.G.S.N.A. (Hossfeld, 1937; Rayner & Nye, 1937). The EM and SP surveys gave satisfactory anomalies over the known portion of the lode and indicated an extension of the lode to the north.

In 1957 the mine area was re-mapped by a geologist from the Australian Mining & Smelting Co. Ltd. (Thomas, 1957) and later, stream sediment sampling on the banks of the Margaret River, to the east of the mine was carried out by the BMR (Corbett, 1960). Anomalous results obtained suggest a possible northern extension of the main lode.

Late in 1960 another geophysical survey (SP, EM, and ground magnetics) was conducted by the BMR (Skattebol, 1962). Two EM and one magnetic anomaly were delineated. Dunn (1961) re-mapped the mine area and recommmed a follow-up diamond drilling program to evaluate the prospect. In 1962 United Uranium N.L. put down 13 short wagon drill holes to test an anomaly north of the mine and the western shear zone. Results were not encouraging (Rix, 1964).

The N.T. Mines Branch, under an agreement with United Uranium N.L. put down six diamond drill holes totalling 711 m. Results were generally disappointing, indicating that the ore remaining was too small in tonnage and grade to make re-opening an viable proposition (Rix, 1964). A mineralogical examination of 15 samples from the ore zones intersected by DDH 1 and 2 was also conducted (Pontifex, 1964).

During 1968-69, Geopeko Ltd. carried out geological mapping, geochemical sampling (402 auger holes) and geophysics (SP and magnetics). Results were again disappointing, so Geopeko relinquished the area in December 1969 (Kitto, 1968 and Danielson, 1970).

Central Pacific Minerals N.L. re-mapped the Iron Blow area during 1970-71 as part of a regional exploration program (Shields & Pietsch, 1971). In 1974 a ground magnetometer survey was conducted by the Northern Territory Geological Survey (Woyzbun, 1976), which located a magnetic anomaly centered about 40 m south of the open cut. This anomaly is due to the existence of a pyrrhotite body at depth.

A Geopeko/BP Joint Venture then secured the option for the deposit in 1975. Further diamond drilling by Geopeko in 1976 and 1978 established a Zn-Ag resource in the sulphide zone of approximately 1.5Mt grading 6.7% Zn, 0.74% Pb, 0.43% Cu, 117g/t Ag and 1.1g/t Au (Goulevitch, 1978).

In 1984 the rights to mine the oxidised zone (upper 40 m) of the orebody were purchased by the Henry & Walker Group Ltd (now Zapopan N.L.). Subsequent reserves of 10 000 t gossan ore grading 9g/t Au and 250g/t Ag and 25 000 t sulphide ore grading 7g/t Au and 360g/t Ag were delineated. In 1985 15,000t of gossan ore grading 7g/t Au and 200g/t Ag was extracted and processed at the Mount Bonnie treatment plant.

Plate 2 Iron Blow open cut (1988).

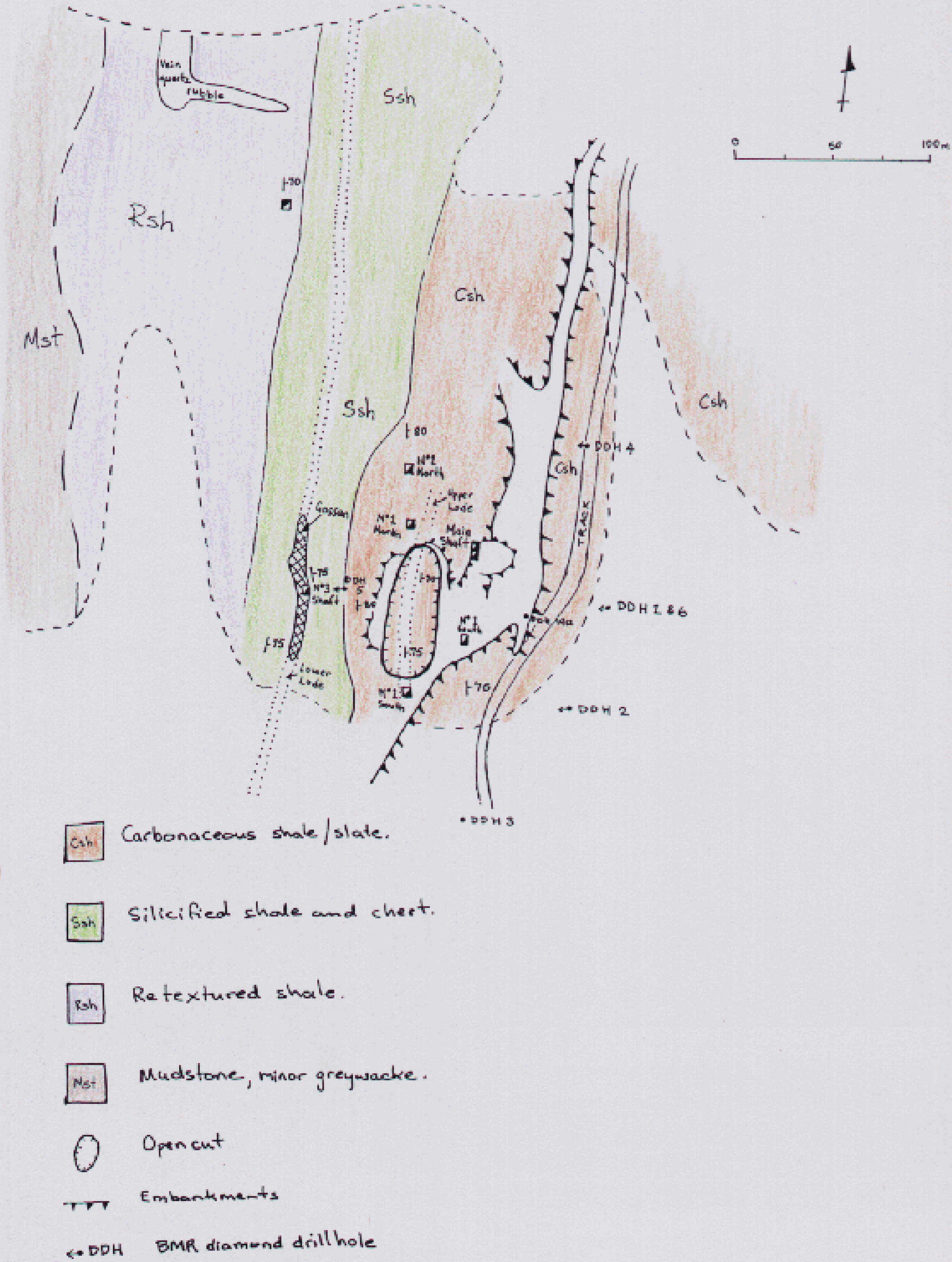


FIGURE 3 Geological plan of the Iron Blow mine.
(Modified after Danielson, 1970)

Geology

The Iron Blow mine lies on the western limb of the Margaret Syncline, which trends and plunges gently to the north. The host rocks are interbedded siltstone-shale (partially pyritic and carbonaceous)-greywacke-chert-hornstone with minor conglomerates and carbonates assigned to the lower Mount Bonnie Formation. Carbonaceous slates are the most common rock type exposed in the open cut (Plate 2). Silicified siltstone, hornstone and greywacke units are exposed to the west (Figure 3).

Most of the fine clastic lithlogies show either a slaty or phyllitic cleavage related to low grade regional metamorphism; or a spotty fabric produced by contact metamorphism. The latter reaches cordierite-hornfels grade in rare cases (in drill core) even though the nearest granite is some 5km to the northeast.

The sedimentary structures in drill core (namely graded bedding and slumping), the presence of "mud flow" pebble breccias, and the chemical and physical immaturity of the siltstones and arenites strongly suggest a turbidite origin for the sediments.

In thin section the carbonaceous slates consist of very fine lepidoblastic grey-green chlorite (40%) interleaved with fine quartz grains (30%), sericite (20%), with carbonaceous streaks and limonitic spots (NTGS 9548-Appendix 1). Other pelitic lithologies may consist of fine densely packed sericite flakes (70-80%), and fairly evenly distributed, irregular patches of grey-green chlorite and minor fine clastic feldspar splinters and quartz grains (Goulevitch, 1978).

The siliceous siltstones usually consist of extremely fine grained and compact phlogopite-sericite schists with accessory K-feldspar, chlorite, muscovite, epidote and sulphides (NTGS 9668-Appendix 1). The dark grey fine grained siliceous quartzites ("hornstones") normally consist of small splintery fragments of sodic-plagioclase and quartz set in a microcrystalline (hornfelsic) quartz matrix, with dispersed ultrafine carbonaceous pigmentation ($\pm$mica, <10%). Mineralogy and major element geochemistry suggest the hornstones are rhyodacitic volcanic derivatives (Goulevitch, 1980).

The greywacke units are up to a few metres thick and commonly interbedded with the finer grained sediments. In thin section the wackes are fine to medium grained, poorly sorted, loosely packed arenites composed of quartz (40%), cherty rock fragments (15%), feldspar (10%), biotite (2%) and opaques (3%) within a cherty-sericite matrix (NTGS 9671-Appendix 1).

Bedding in the mine area generally strikes north (350-010°) and dips steeply (60-80°) to the east. The significant steepening of the dips in this vicinity may be attributed to the close proximity (200m west of the open cut) of the Hayes Creek Fault. This fault is a major northeast trending quartz-filled reverse fault which has a strike length over 27km. Two minor northwest (340°) trending normal faults have been observed in the underground workings by Brown (1906).

Minor cross folding (F_2) is recognised in stereoplots of structural elements, which is characterised by a near-vertical east-west striking axial plane, S_2 (Goulevitch, 1978). Near transposition of both bedding and pre-deformation sulphide-silicate contacts parallel to the mineral foliation in the lodes is also apparent.

Mineralisation

The Iron Blow deposit comprises two steeply dippng (75° E) polymetallic sulphide-silicate lodes (Figure 4). The Upper Lode has a strike length of about 80m, a maximum thickness of 10m and extends down to 100m below the surface. This lode contains a northern lens which at the base of the open cut is 52m in length and 8m wide; separated by about 18m of barren slate from the southern lens which is 27m in length and 8m wide (Figure 5). Both lenses have been previously exploited down to 60m (200ft).

The Lower (or Western) Lode lies about 50m to the west of the Upper Lode, and has two sulphide lenses which contain most of the known mine reserves. This lode has a strike length of over 150m, a maximum thickness of 30m and extends over 200m below the surface (Eupene & Nicholson, 1990). A prominant gossan some 65m long and 1m wide of hematite, limonite, quartz and slate fragments is exposed on the surface.

Mount Bonnie

Introduction

The Mount Bonnie mine (GL 759 013) lies approximately 6.5 km south of Grove Hill Siding with good access by an all-weather gravel road up to the open cut.

The mine was initially worked in 1902 by Northern Territory Goldfields of Australia Ltd. who sank a 15m shaft which intersected a lead-rich gossan (Jensen et al., 1916), then abandoned. But in 1912 and 1916 the Mount Bonnie lode was developed as an underground mine with several vertical and inclined shafts, a 92m (300ft) long adit with minor drives and cross-cuts (Jensen et al., 1916).

In 1917-18 three diamond drill holes (locations unknown) were drilled to test the extension of ore at depth; only two holes intersected the mineralized zone (DDH1: 124g/t Ag and 3.1g/t Au between 100-111m, DDH 2: 404g/t Ag, 1.3g/t Au, 0.54% Cu, 10% Zn, 3.7% Pb between 113-125m) according to Bagas (1981). Australian Mining and Smelting Co Pty Ltd carried out detailed surface and underground geological mapping in 1957 (Thomas, 1957).

In 1973 Horizon Minerals and Jingellic Minerals undertook a programme of detailed geological mapping and diamond drilling which outlined possible reserves of 480 000t grading 7.67% Zn, 0.4% Cu, 1.8% Pb, 186g/t Ag and 1.5g/t Au (Ivanac, 1974). The potential tonnage of the Mount Bonnie lode was estimated at 1.5 Mt (McNeill, 1973).

Increasing gold prices encouraged further drilling and underground resampling of the lode by the Geopeko/BP Joint Venture which included the excavation of 12 000t of gossan ore from the lode outcrop and transportation to Mount Wells Battery in 1979/80 (Rich et al., 1984).

The Mount Bonnie gossan zone (upper 70m) was subsequently mined from an open cut between 1983 and 1985, yielding some 110,00t grading 7g/t Au and 230g/t Ag (Eupene & Nicholson, 1990).

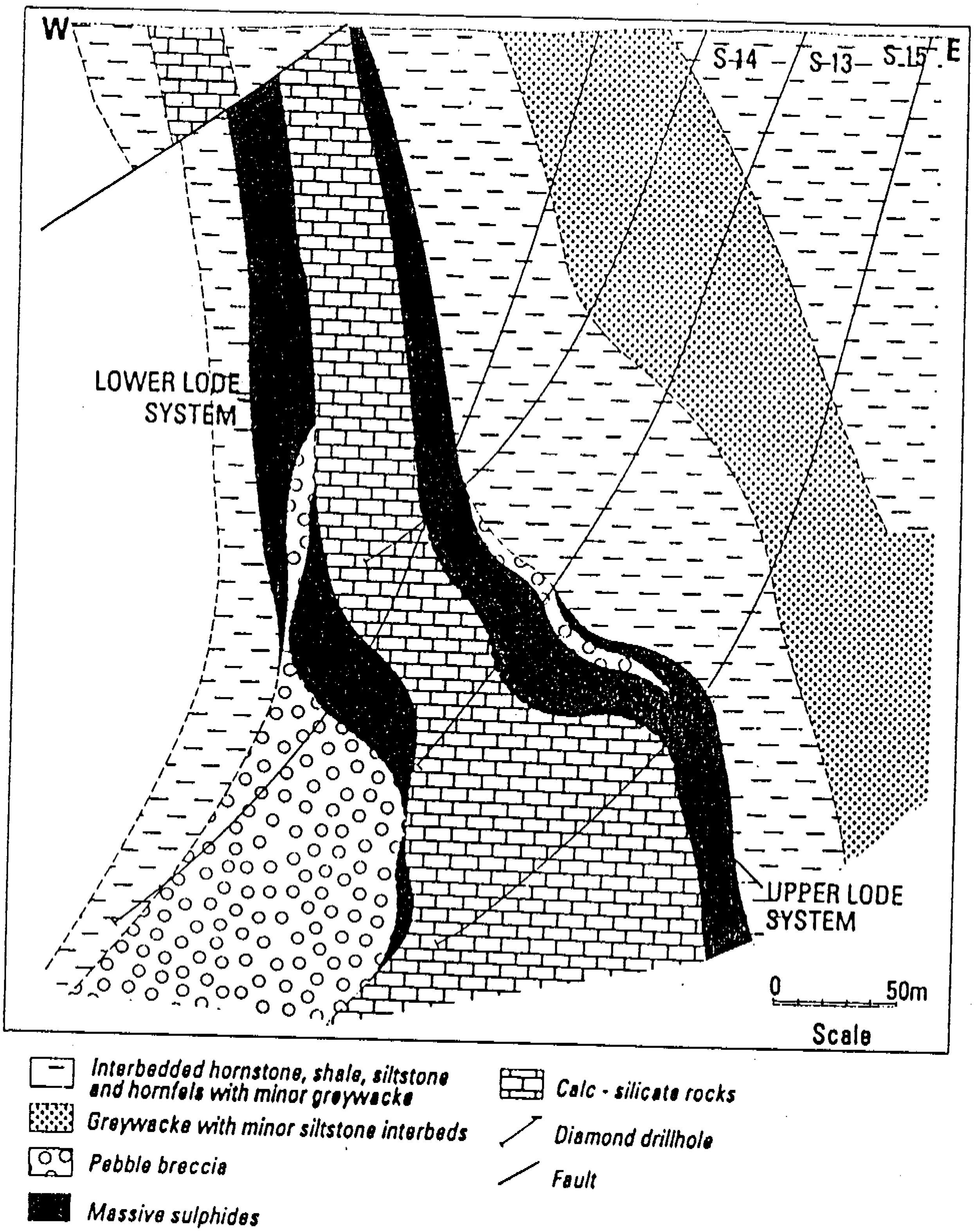


FIGURE 4 Geological section of the Iron Blow Lodes. (Modified after Goulevitch, 1978).

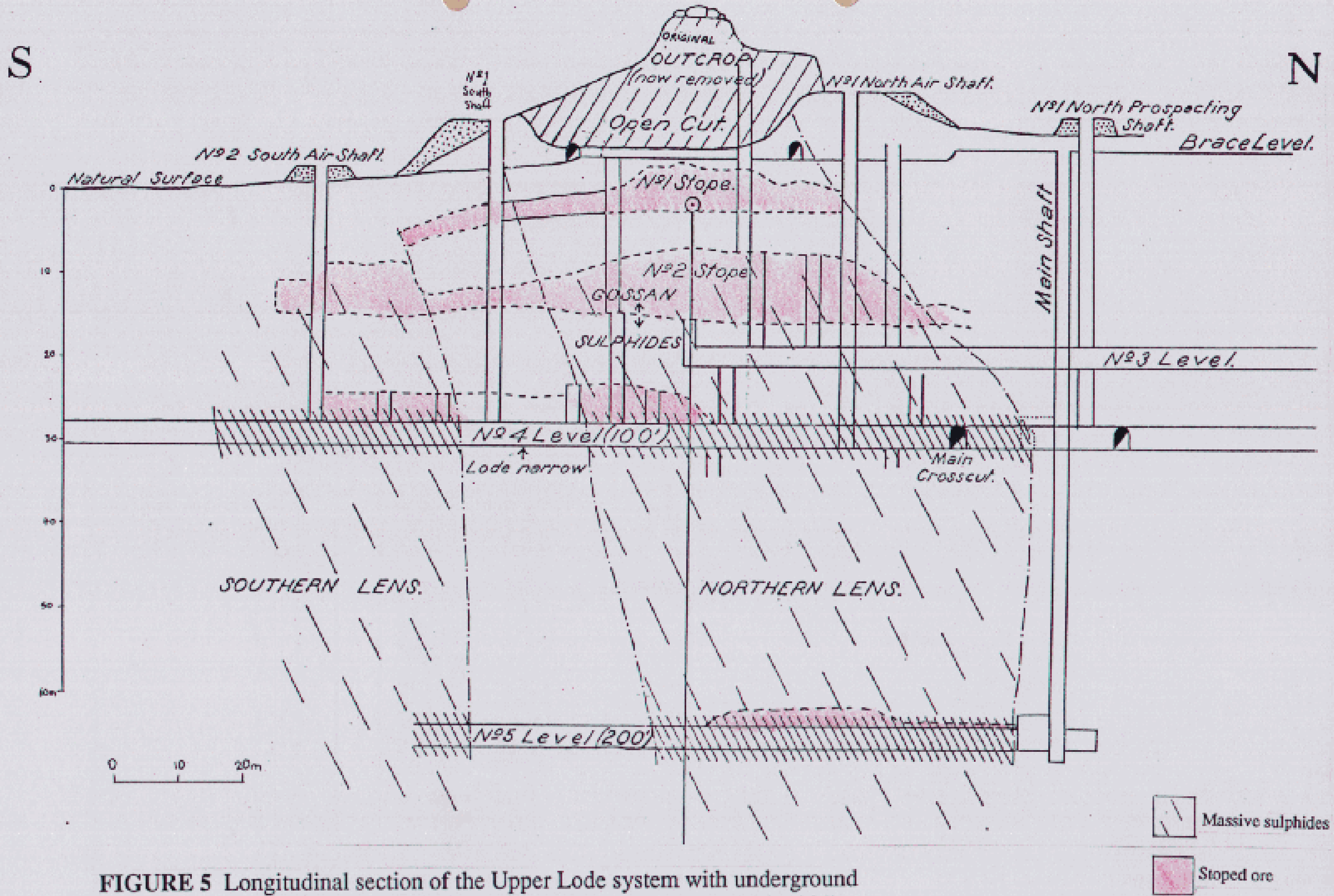


FIGURE 5 Longitudinal section of the Upper Lode system with underground workings at the Iron Blow mine (modified after Hossfeld, 1937).

Geology

The Mount Bonnie mine lies on the eastern limb of the Margaret Syncline, at the same stratigraphic level as the Iron Blow deposit. The host rocks are interbedded shale-siltstone-greywacke-hornstone-dolomite with minor pebble breccias of the lower Mount Bonnie Formation. These sdiments were metamorphosed to mid-greenschist facies and folded prior to granite intrusion. The granite has contact metamorphosed some of the pelitic lithologies to cordierite hornfels facies.

Surface mapping suggests that both the hangingwall and footwall lithologies are dominatly shales and silicified siltstones (Figure 6). Diamond drillhole intersections however, reveal a quite different footwall sequence which is not apparent on the surface (McNeill, 1973).

A dolomite unit appears to form the footwall of the main lode and lies stratigraphically above the amphibolite (Figure 7). The dolomite consists of recrystallised interlocking dolomite crystals (av, 100μm) with angular masses of fine grained chlorite, minor actinolite, phlogopite and sulphide (pyrite, sphalerite± pyrrohtite±galena). At depth, some 150m down dip the dolomite unit appears to grade into a pebble breccia which consists of siltstone and dolomite fragments within a matrix of recrystallised calc-silicate minerals, quartz, chlorite, or talc.

The amphibolite unit is most probably a small altered sill of Zamu Dolerite. In thin section it consists of fine to coarse chlorite and actinolite (up to 5cm) with variable amounts of pyrrhotite and sphalerite, with lesser pyrite and chalcopyrite. Veinlets of carbonate and sulphides are common.

The hangingwall of the main lens consists of silicified black to dark grey shales which commonly contain pyrite as disseminations and as 1-12mm thick concordant laminae (McNeill, 1973). Cordierite porphyroblasts (0.1-8mm) and chlorite development are also apparent.

Bedding in the mine area strikes northeast (020-030°) and dips moderately (40-60°) to the west. Several conformable thrust faults have been identified by diamond drilling (Figure 7), and are believed to have caused pinching and swelling of the main lode and partial repetition of the upper lodes (Rich et al., 1984). These faults are associated with numerous small bedding-plane faults together with drag folding of the hangingwall rocks; minor brecciation and quartz veining.

Several late-stage oblique faults which trend east-west (070-110°) offset portions of the lode (Figure 6). These faults are generally marked by small shear zones and are not usually quartz-filled.

Mineralisation

The Mount Bonnie deposit is a shallow dipping (40° W) polymetallic massive sulphide lode up to 15m thick (Figure 7). The original gossan exposed on the surface could be discontinuously traced over 240m along strike, and consisted of mainly limonite, hematite and limonitic clay with minor mimetite, duftite, cerussite, conichalcite, malachite, plumbojarosite and scorodite (Rich et al., 1984).

Plate 3 Mount Bonnie open cut (1988), looking north.

Ꞓso$_6$	Grey and purple shale/slate.	g	Gossan
Ꞓso$_5$	Pink siltstone, minor shale & greywacke.	Ꞓso$_1$	Silicified shale
Ꞓso$_4$	Grey shale, minor greywacke interbeds.	o—┤	Jingellic Mineral diamond drill hole.
Ꞓso$_3$	Grey siltstone	— —	Fault
Ꞓso$_2$	Grey shale/slate	⋯	Underground workings

FIGURE 6 Surface geological plan of the Mount Bonnie mine. (Modified after McNeill, 1973).

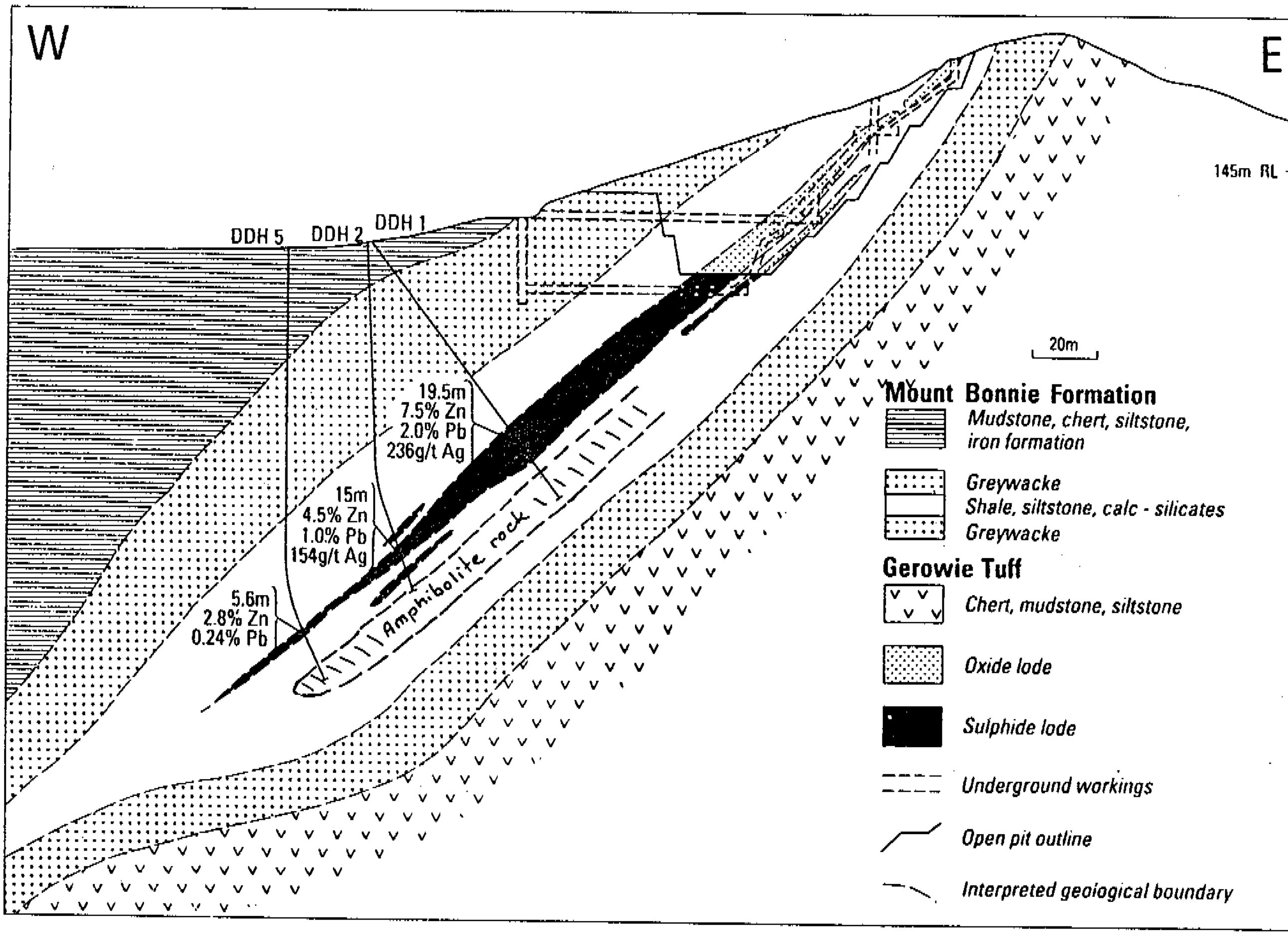


FIGURE 7 Geological cross section of the Mount Bonnie mine. (Modified after Rich et al., 1984).

The gossan was relatively enriched in gold and silver, the former element is present as very finely divided free gold and electrum, while silver occurred as particles of a few microns to nearly 1mm diameter of native silver, electrum, silver-copper alloy and silver-mercury alloy (Rich et al., 1984). The gossan also contained elevated contents of Pb, Bi, As, Sb, Hg and Sn; with a chalcocite-rich zone near the base of oxidation (Rich et al., 1984).

The exposure of the Mount Bonnie lode during open cut mining revealed that the gossan at the surface represents the oxidised portion of two stratabound sulphide lenses.

Mineralogy

The mineralogy of the sulphide lenses intersected by diamond drilling at Iron Blow and Mount Bonnie are very similar, consisting of a relatively complex sulphide-carbonate-silicate mineral assemblage (Plates 4 to 7) and sulphides, predominantly pyrrhotite, pyrite, and sphalerite; subordinate galena, chalcopyrite, arsenopyrite, marcasite, lollingite and trace amounts of tetrahedrite, jamesonite, bournonite, stannite, freibergite, native silver and gold.

The gangue mineralogy is dominated by carbonates (dolomite and calcite), chlorite and tremolite and varying amounts of quartz, talc, actinolite, muscovite, phlogopite along with minor fluorite, talc and garnet.

Hematite, limonite, mimetite, dufftite, scorodite and plumbojarosite are reported from the gossanous cappings (Rich and others, 1984). Gold, silver and lead are enriched in the oxidised ore which also contains elevated contents of bismuth, arsenic, antimony, mercury and tin (Rich and others, 1984).

The following mineralogical descriptions are largely based on reports by Pontifex (1964) and McNeill, (1973).

SULPHIDES

Pyrrhotite is a minor to abundant (up to 80%) sulphide in the massive sulphide lodes, often forming irregular polygonal mosaics containing voids which are often in-filled with later minerals. It forms intergrowths with sphalerite and chalcopyrite or is present as discrete grains in the gangue and sulphide matrix. In some cases, pyrrhotite contains inclusions of pyrite and arsenopyrite, fills embayments, and forms veins in these minerals.

Pyrrhotite is also present in varying amounts (1-20%) within the dolomite, pebble breccia and amphibolite (Mount Bonnie) wallrocks as disseminated grains and blebs, up to several millimetres across.

Pyrite is common in both the wallrocks and the lodes. Within the pelitic wallrocks, it is present as fine (0.01-0.05 mm across) subhedral grains forming laminations parallel to the bedding, suggesting a syngenetic origin. Pyrite within the sulphide-rich lodes forms massive or coarsely crystalline aggregates (up to 2 mm) within the carbonate gangue, or occurs as random euhedral crystals 0.1-1 mm across. Pyrite may constitute up to 70% of the sulphides in some sections of the lodes. It is often part or wholly replaced by marcasite, and commonly contains tiny (10-20μm) inclusions of euhedral arsenopyrite.

Marcasite generally makes up between 5-20% of the sulphides and invariably replaces pyrite and pyrrhotite around their margins and along cracks, as fine dendrites and lamellae. The lamellae are intimately intergrown with and grade into pyrite and pyrrhotite. Spaces between marcasite lamellae are partly filled by sphalerite, chalcopyrite and galena.

Sphalerite is sporadically distributed through the massive sulphide lodes, averaging about 10% by volume, is dark brown (iron-rich) in colour and cadmium-bearing, which suggests a magmatic origin. Texturally it forms irregular masses (up to 10 mm) and fine disseminated anhedral or skeletal intergrowth with the gangue.

Sphalerite usually contains exsolution blebs or rod-shaped bodies of chalcopyrite either randomly disseminated or along the cleavage traces of the sphalerite or concentrated at the margins, producing chalcopyrite rims (Plate 6). Sphalerite also contains inclusions of pyrite, arsenopyrite and pyrrhotite, and may also form along fractures in pyrite as well as and enclosing it.

Distinct bedding-parallel laminations of sphalerite within carbonaceous shale have been observed in a narrow core intersection from the Iron Blow mine (DDH S/9, 139.45 m) and have been interpreted as an evidence in support of a syngenetic origin for the sulphides (Goulevitch, 1980).

Arsenopyrite generally constitutes between 5-10% of the sulphides, forms euhedral crystals 0.05-0.2 mm in size, often partly or completely enclosed in Fe, Zn, Cu and Pb-bearing sulphides. Aggregates to 0.5 mm in size formed from fine euhedral arsenopyrite (0.01 mm across) have been recorded in ore from Mount Bonnie mine.

Galena takes up less than 3% of the sulphides and is often present as fine (0.01-0.02 mm across) discrete grains intergrown with sphalerite and marcasite or as extremely irregular masses and veins infilling inter-granular spaces, cracks, and embayments of earlier formed sulphides. Discrete grains of galena are accompanied by *tetrahedrite* and *jamesonite* in ore from the Mount Bonnie lodes.

Besides forming exsolution blebs in the sphalerite, *Chalcopyrite* occurs as subhedral grains up to several millimetres (average 0.5 mm across), forming intergrowths with other sulphides.

Lollingite is a minor primary mineral within the upper lode at the Iron Blow mine, forming fine grained, massive aggregates of interlocking laths and rhomb-shaped grains, which are often spacially associated with sphalerite and galena. *Tetrahedrite* is a minor sulphide within the Mount Bonnie lode, forming 50-100 μm grains, marginal to pyrite or intergrown with jamesonite.

Accessory sulphides identified by Pontifex (1964) in the Iron Blow lodes include *cubanite* ($CuFe_2S_3$), *bournonite* ($PbCuSbS_3$) and *stannite* (Cu_2FeSnS_4); with *jamesonite* ($Pb_4FeSb_6S_{14}$), *niccolite* (NiAs). Stannite is also identified by McNeill (1973) in the Mount Bonnie lodes.

Native silver inclusions have been observed within galena. *Native gold* (0.01 mm size grain) has been recorded in sulphide impregnated wallrock from the Mount Bonnie deposit. In the gossan, gold occurs as finely divided native metal and *electrum* (Rich and others, 1984).

CARBONATES

Dolomite and *calcite* are the principal carbonates within the ore zones, forming fine to coarse, interlocking anhedral grains with the sulphides and silicates (Plate 4). Relict irregular masses of dolomite show progressive replacement by Mg-chlorite (light green with Berlin brown interference colours) and tremolite. Most of the carbonates are recrystallised calcareous sediments located above and below the upper massive sulphide lenses and above the lower lodes, but not below the lower-most sulphide lens.

Coarse grained dolomite is also present as late-stage hydrothermal veins with *siderite*. These veins carry sulphides, including pyrrhotite, pyrite, sphalerite and chalcopyrite.

SILICATES

Chlorite is the most abundant silicate and three varieties are identified. The early chlorite (Type I) is present within the phyllites on the hanging wall sequence as fine lepidoblastic flakes which define the S_1 schistosity with sericite and probably resulted from prograde metamorphism.

The Type II chlorite is Mg-rich, and medium to coarse grained, forming pokiloblastic grains and aggregates often replacing carbonates, biotite, pyroxenes and early formed sulphides. It is also present as veins and as massive fine grained chlorite rock. This chlorite may be related to a hydrothermal or retrograde metamorphic event. The Fe-rich (Type III) green pleochroic chlorite with bluish grey anomalous interference colours is present as veinlets and is also considered to be of hydrothermal origin.

Tremolite is abundant in the sulphide impregnated breccias and wallrocks and is largely a product of contact metamorphism (~500°C)of the impure limestone. It usually forms medium to coarse grained laths and is closely associated with carbonates and other Mg-silicates.

Quartz is a common gangue mineral within the ore zone and a major constituent of lithologies within the footwall and hanging wall sequence. It forms fine to medium anhedra within mineralised wallrock, interstitial to sulphides and carbonates. Microcrystalline interlocking quartz is the main constituent of cherts in the hangingwall and footwall sequence. Silt-size monocrystalline quartz grains are a common component of fine grained siliceous metasediments (shales, siltstones and slates), while coarser

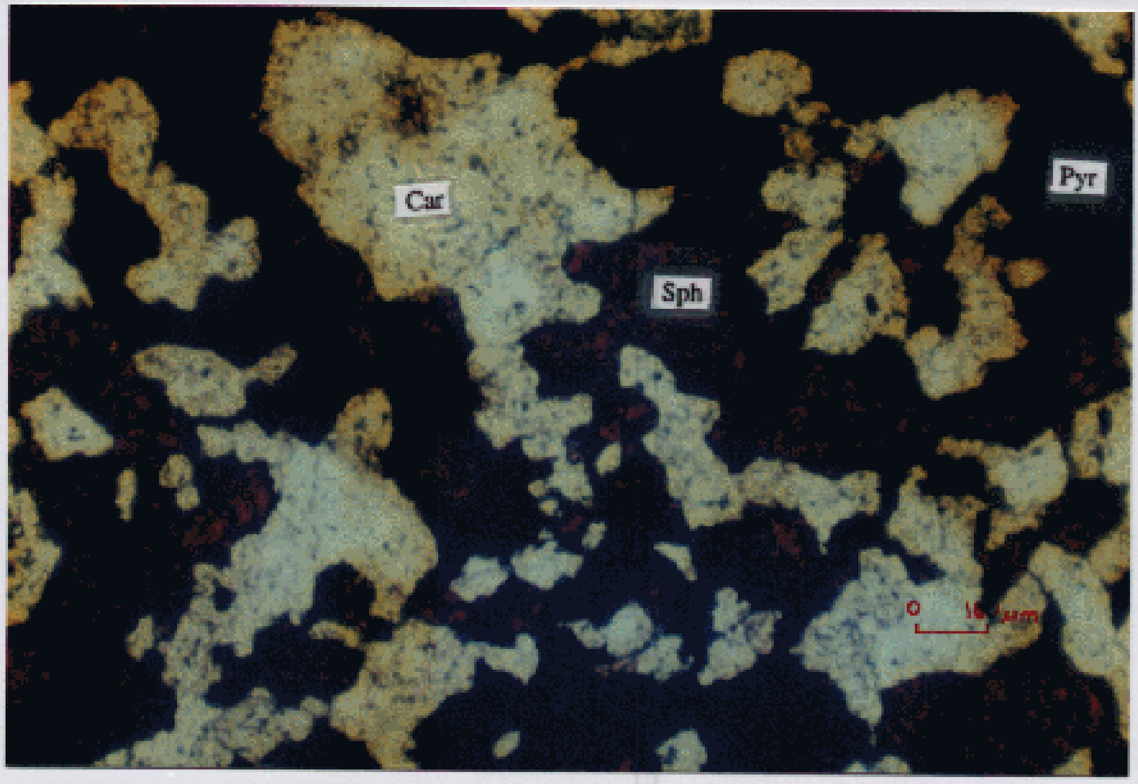


Plate 4 Granoblastic sphalerite (Sph) and pyrrhotite (Pyr) with carbonate gangue (Car); massive sulphide lode from the DDH S36 Mount Bonnie (NTGS 9834), transmitted light, //.

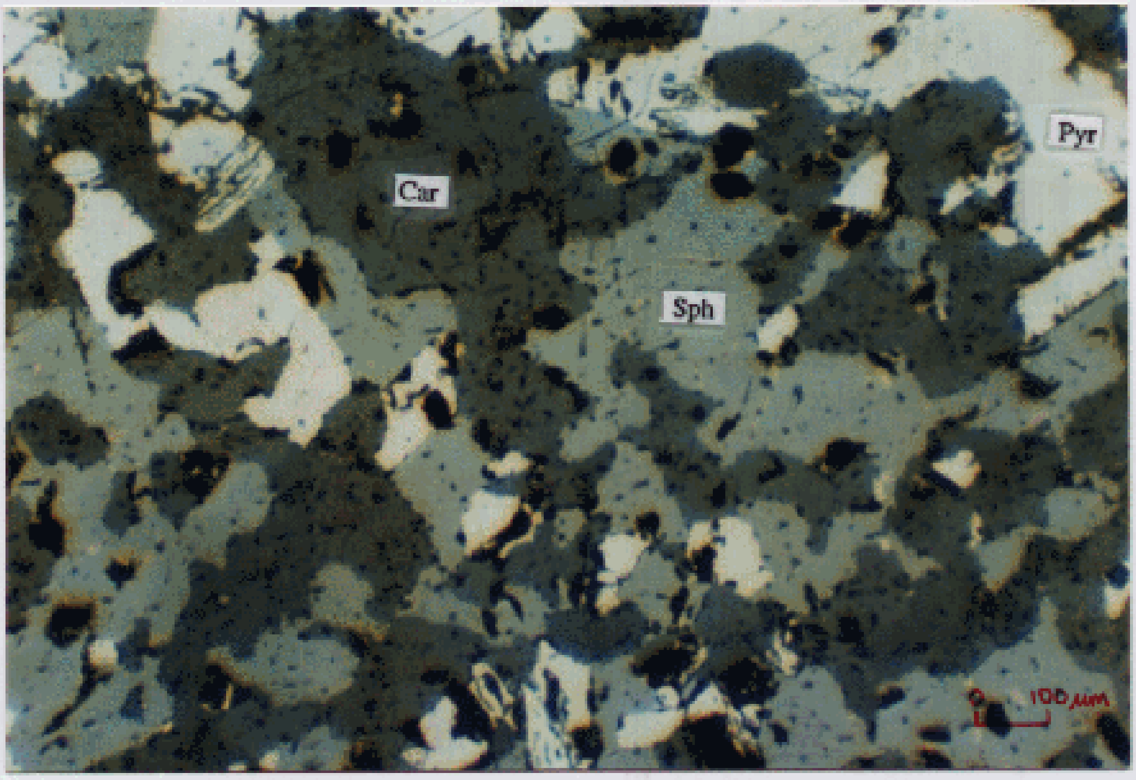


Plate 5 Reflected light //, view of Plate 4 image. (Minor yellow ore mineral is chalcopyrite).

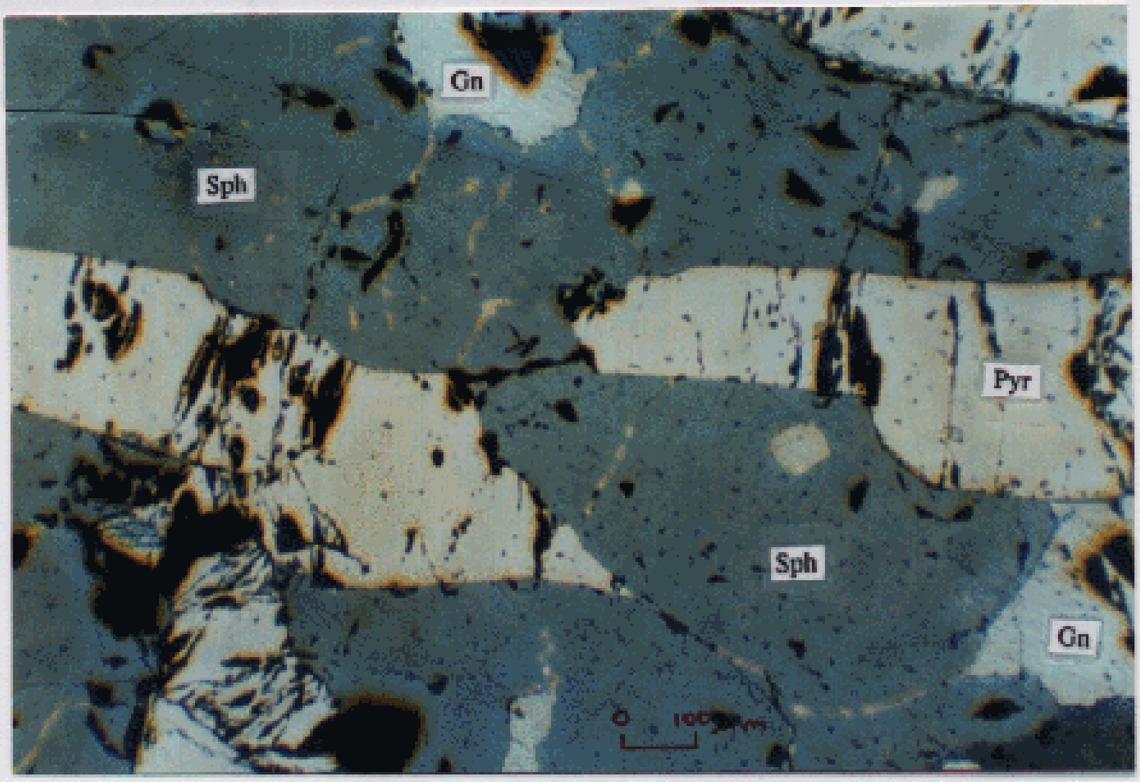


Plate 6 Granoblastic massive sulphides: sphalerite (Sph), pyrrhotite (Pyr) and galena (Gn), from DDH S36 Mount Bonnie (NTGS 9834); Reflected light //.

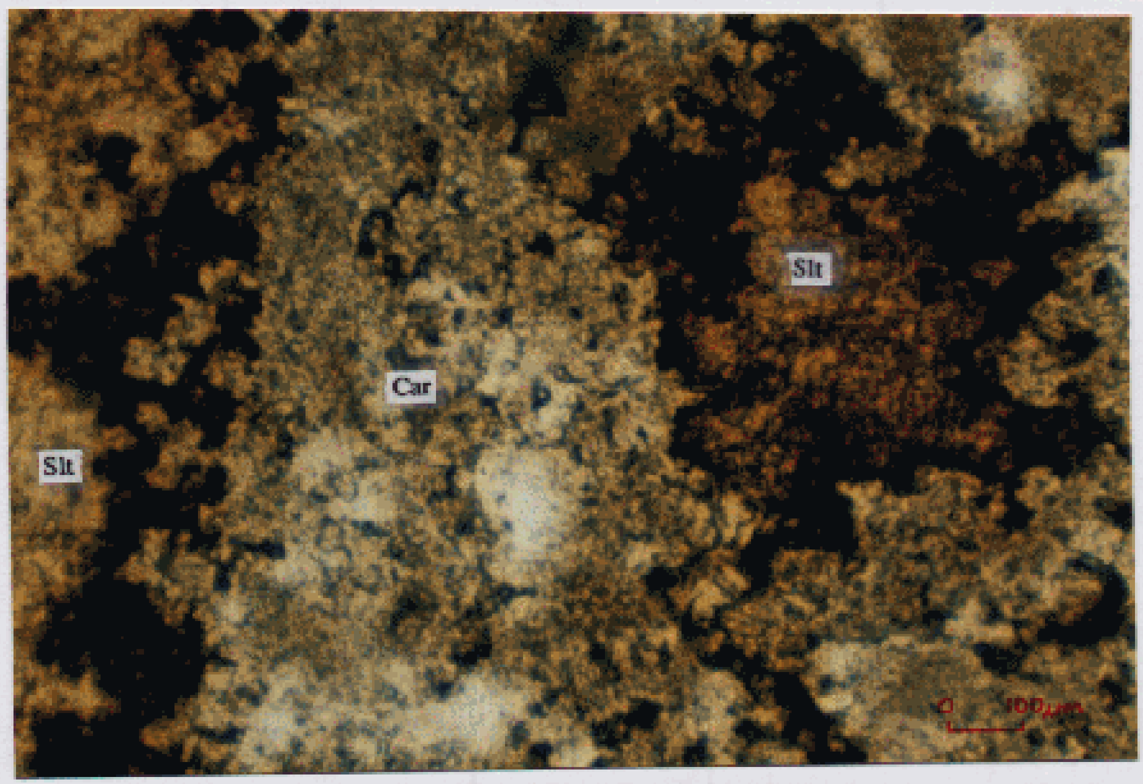


Plate 7 Carbonate (Car) replacement of siltstone (Slt) wallrock in sample from Iron Blow DDH1 (NTGS 9842); Transmitted light //.

quartz grains (0.3-0.7 mm across) form the detritus in the arenaceous units. Coarse grained granoblastic quartz comprises the discordant quartz veins and veinlets, infilling macroscopic to microscopic fractures and faults.

Talc is largely confined to the ore zone and adjacent wallrock in which it forms fine lepidoblastic grains interleaved with chlorite, tremolite or dolomite. Talc often replaces coarse tremolite crystals. Within the disseminated ore zone, talc occurs as relatively coarse, foliated flakes embedded in and intergrown with granular dolomite. Talc may also form sheared, talc-rich zones, such as in the footwall pebble breccias of the Iron Blow deposit.

Actinolite is often encountered within the amphibolite (altered dolerite) footwall of the Mount Bonnie mine sequence, forming clusters of dark-green radiating needles up to 1 cm long and crystalline masses within fine to coarse grained chlorite. Minor amounts of actinolite occur within the sulphide lodes of both deposits and within the altered footwall rocks of the Iron Blow mine.

Muscovite has formed within altered metapelites as a regional prograde metamorphic mineral, forming fine to medium grained flakes interleaved with chlorite, sericite, quartz and occasional feldspar.

Biotite has formed as a contact metamorphic mineral within siliceous and pelitic metasediments within the mine sequence and occurs as disseminated fine grained flakes which are often randomly orientated.

Sericite is present as a major constituent of the argillaceous metasediments within the mine sequence and as a minor component within altered wallrocks. The sericite within unaltered metasediments forms fine (0.05-0.1 mm size) lepidoblastic flakes with quartz, or chlorite or both, and with biotite. Fine sericite flakes also combine with fine quartz grains to form the matrix of arenaceous rocks. Within impure metacherts, sericite may form a network pattern which separates ovoid patches of microcrystalline quartz.

Phlogopite is found throughout the mineralised sequence, but is commonly concentrated within altered footwall metasediments, forming spots and massive bands. The mineral is probably the result of contact metamorphism of a calc-magnesium silicate rock, although the association of phlogopite with microcline and muscovite in some altered pelites suggests a potash metasomatic origin.

Accessory minerals include *fluorite, rutile, sphene, epidote, serpentine, magnetite, grossular, tourmaline, leucoxene* and *graphite*.

Alteration

The polymetallic massive sulphide lodes are accompanied by a number of hydrothermal alteration products resulting from; silicification, chloritisation carbonatisation, pyritisation and possibly potash metasomatism.

Silicification of the carbonate beds is the most evident form of alteration and has resulted in the development of low temperature "skarns". These rocks carry an assemblage of quartz-carbonate-talc-tremolite±actinolite within and adjacent to the massive sulphide ore zones. It is uncertain whether the dark grey pyritic chert beds ("jasperoids") were formed by sedimentary/diagenetic processes or by hydrothermal replacement of originally carbonate rocks. Given the minor to moderate abundances of chert beds within the Mount Bonnie Formation and Gerowie Tuff, the former explanation should be regarded as more likely at this stage.

Late-stage coarse grained granoblastic quartz veins are minor, and largely restricted to open-space filling of fractures in both wallrocks and ore.

Tremolite-actinolite and talc are the likely products of the progressive *decarbonation* of iron-bearing siliceous dolomites. However, if the development of diopside and garnet can be confirmed then the talc-tremolite-actinolite assemblage may represent a later hydrothermal stage associated with sulphide emplacement.

Chloritisation of the wallrocks is often both pervasive and intense, producing massive fine grained chlorite rock and chlorite veins adjacent to the massive sulphide zones. Other effects include partial and selective alteration of primary minerals such as replacement of carbonates, biotite and pyroxenes by chlorite.

Carbonatisation is largely low to high intensity vein controlled alteration in the form of late-stage, coarse grained dolomite, calcite and siderite veins which are often sulphide-bearing.

Pyritisation is present as low intensity, selective and vein controlled alteration phase within wallrocks adjacent to massive sulphide zones in the form of late-stage veinlets and coarse disseminated subhedra.

Potash metasomatism may be represented by the presence of random orientated flakes of phlogopite and muscovite which often form spots and bands in altered footwall rocks. Minor amounts of microcline are also often present.

Fluorite subhedra are present in very minor amounts within joints and late-stage calcite veins; usually stratigraphically below the lower sulphide lenses.

Paragenesis

Mineragraphic studies (Pontifex, 1964; McNeill, 1974) suggest that pyrite, pyrrhotite and arsenopyrite were formed first, followed by sphalerite, chalcopyrite, cubanite and stannite; which were then followed by marcasite, galena, tetrahedrite, bournonite, lollingite, jamesonite and native silver.

Origin

Several modes of origin have been given for the formation of the Iron Blow and Mount Bonnie massive sulphide orebodies including;

1. Shear zone hosted hydrothermal vein (Rix, 1964);
2. Devitrification of the underlying Gerowie Tuff (Goulevich, 1980); and
3. Sedimentary exhalative (Broken Hill-type) (Eupene & Nicholson, 1990).

The conformable hydrothermal vein occupying a shear zone hypothesis suggested by Rix (1964) seems fairly consistent with some of the mineralogy, textures and other

TABLE 4. Comparative characteristics of some stratabound sediment-hosted polymetallic Massive Sulphide Deposits.

DEPOSIT	SIZE (Mt)	Strike length	GRADES* Zn Pb Ag Cu	Assoc metals	AGE (Myrs)	Metamorphic	Tectonic Setting	Mineralogy	Volcanics/ Organic	Ore texture	COMMENTS	REFERENCE
Mt. Bonnie Iron Blow	0.5 1.5	240m 150m	9.5 2.0 230 0.8 6.7 0.7 120 0.4	Au,Mn As, Co Cd, Sb	1870-1880	L.grnsch & Cord. hrnfls	Flanks of syncl within geosyncl sequence	Po-Py-Sph Gn-Cpy-Apy Dol-talc-Qtz	Seq. of tuff beneath FW/ Carb. sh HW	Granoblastic massive; rare banding	Pebble breccias (synsed. faulting). Granites exposed 5km to nth & sth.	Nicholson & Eupene, 1990
Mt Isa (Pb-Zn)	90	1.6km	6.0 7.0 160 .06	Fe, Co	1650	L.grnsch	Flank of syncl adj to major fault	Py-Po Gn-Sph Qtz-Chl-Dol	(K-rich) tuff markers/ Carb-py-dol siltst	Banded	Poss. replnt deposit. Basin & slope facies of saline lake complex.	Forrestal, 1990 Perkins, 1990
Broken Hill (N.S.W.)	200	8km	10 11 175 0.2	Fe, Mn As, Au	1700	Regional granulite	Mobile trough	Sph-Gn-Po Qtz-Cal+ Ca-Mn-Fe silic.	Poss. volcs in ore seq. /tr graphite	Massive (recry'sed)	Ore assoc. with qtz-Gar-Mag-Ap; BIFs.	Mckenzie & Davies, 1990
Saxberget (Sweden)	4.5	500m	6.8 2.0 42 0.9	Fe, Mg Au	1900	U. amph (650°C)	Shallow marine	Sph-Py-Gn (Mag-Cpy) Calc-silic gneiss	Volcanoclastic host seq./ --------	Massive "skarn & ball ore"	Mainly bound to calc-silicate horizon. Granites lie <500m	Vivallo & Rickard, 1990
Clarkes Reef (SE N.S.W.)		100m	10% comb. Cu-Pb-Zn	Ba, Co As	Late Silurian	Regional L. grnsch	Fault bound syncl. within shall. marine	Py-Sph-Gn (Cpy-Po) Silst+Calc	Below FW/ Graphitic HW	Dissem to massive	Metal solution derived from source at depth. Massive discord. veins.	McQueen, 1989
Dugald River (NW Qld)	60	2.5km	10 1.0 30 --	Fe,Mn Ba,Cd Hg	M. Prot.	Regional U. grnsch	Faulted sabkha to fluv. seq.	Po-Py-Sph Gn-Apy-Tet Sh-Qtz-Cal	-------/ Carb/Graph. slate host	Banded (+ massive)	Recrystallisation & remobilisation of sulphides common.	Connor et al., 1990
Ban Ban (SE Qld)				Fe, Cd As, Mn Bi	200 Triassic	Contact Hmbl-Hfls	Siliceous sed. trough sequence	Sph-Py Mag-Po-Cpy Heden-Gar-Cal	Above skarn host/ --------	Granoblastic massive to disseminated	Microdiorite stock lies 200m to E. Typical skarn min. assemblage.	Ashley, 1980
Plomosas (Mexico)	1.5	200m	16 8.0 55 Tr	As, Sn Cd, Bi	Oligo.	------	Within fold belt	Sph-Gn-Py Cal-Qtz	------- -------	Massive (mantos)	Microsyenite stock 7km to SE.	Megaw et al., 1988
Pb-Zn Sedex (Typical)	15	>1km	5.6 2.8 60 0.2	Ba, As Mn, Bi Co, Mo	Mainly M. Prot.	Nil to granulite	Intracrat. basin adj to synsed fault. Shall mar.	Py-Po-Sph Gn-Bar-Cpy Carb-dol shale	Minor tuffs/ Black shale host	Banded (laminated) (±massive)	Ores assoc. with exhalat-ive cherts, BIFs or barite. Wide spread of $\delta^{34}S$ values.	Cox & Singer, 1987
Pb-Zn Skarn (Typical)	1.4	100m-1km	6.0 2.8 140 0.3	Au, Mn As, Cd Sn, W		Contact Hmbl-Hfls	Intruded migeosynclinal sequence	Sph-Gn-Po (Py, Mag, Cpy) Calc-silicate	-------- --------	Granoblastic massive to disseminated	Mn-Heden±Andra± Gross±Busta±Rhodonite host assemblage	Cox & Singer, 1987
Polymetallic Replacement (Typical)	1.8	1km	4.0 5.2 270 0.3	Au, Mn As, Sb Ba, Bi		Minor Contact	Faulted Shall. mar Mobile belts	Sph-Gn-Py Cpy-Tet Cal-Qtz-Dol	-------- -------	Massive to highly vugy	Tabular, pod-like ore-dies localised within bedding-plane faults or carbonate beds.	Cox & Singer, 1987

Abbreviations: Amph=amphibolite, Anda=andradite, Ap=apatite, Apy=arsenopyrite, Bar=barite, Busta=bustamite, Cal=calcite, Carb=carbonaceous, Chl=chlorite, Cord=codierite, Cpy=chalcopyrite, Dol=dolomite, FW=footwall, Gar=garnet, Gn=galena, grnsch=greenschist, Gross=grossular, Grph=graphite, Heden=hedenbergite, Hfls=hornfels, Hmbl=hornblende, HW=hangingwall, Mag=magnetite, mar=marine, min=mineral, Oligo=Oligocene, Po=pyrrhotite, Prot.=Proterozoic, Py=pyrite, Qtz=quartz, sh=shale, shall=shallow, Silic=silicate, Silst=siltstone, syncl=syncline, Tet=tetrahedrite. * Zn(%), Pb(%), Ag(g/t), Cu(%).

features of the deposits except for the presence of only minor amounts of brecciation and quartz veining as compared to the many other hydrothermal vein type deposits known in the area.

The dominance of carbonate gangue over quartz, the unusual calc-silicate alteration mineral assemblage, diverse sulphide assemblage, abundance of pyrrhotite and sulphide orientation parallel to S_0/S_1 are characteristics not present at any of the hydrothermal base metal vein type deposits inspected within the Pine Creek 1:250 000 Sheet.

Goulevitch (1980) suggests that the base metal deposits are stratiform massive sulphide-silicate-carbonate lodes of syngenetic origin. Lenses or beds of pebble-breccia (mud-flow origin) occur above, below and within the lodes and are only developed in the lode vicinity, suggesting an intermittent association. Distinct laminations of sphalerite in carbonaceous mudstones have been observed in core from Iron Blow and presented as strong evidence in favour of the hypothesis.

Goulevitch then suggests that the source of the base metal-bearing fluids were volcaniclastic rocks of the Gerowie Tuff. Dewatering of the tuffs during diagenesis (within a restricted sea-floor depression) could have produced saline metal-bearing solutions which precipitated metal sulphide when a reducing environment was encountered during the deposition of carbonaceous mudstones.

This hypothesis places a fair amount of emphasis on the stratiform nature of the sulphides whilst the dominant ore texture throughout the system is of a massive, granular interlocking nature (Plate 4 & 6). Exsolution textures of chalcopyrite in sphalerite indicate a depositional temperature in excess of 350°C. T.H. Donnelly (pers. comm., 1988) has analyed some 28 samples of pyrite, pyrrhotite, chalcopyrite and sphalerite for $\delta^{34}S$ from Mount Bonnie DDH1 and DDH3. The average of these samples was 2.0$\pm$1.3‰, which is characteristic for magmatic hydrothermal deposits.

The sedimentary exhalative (Broken Hill-type) model tenatively proposed by Eupene & Nicholson (1990) appears adequate for Iron Blow and Mt. Bonnie deposits which have many characteristics similar to the Broken Hill orebody (Table 4). However the Broken Hill deposit has several important differences (Table 4).

The most important differences are the extent of strike length (and subsequent size), ore associated with chemical sediment horizon (quartz-garnet-gahnite-magnetite), gold content and gangue mineralogy.

The Mt Isa Pb-Zn-Ag deposit is also similar in many aspects to the Mt Bonnie-Iron Blow mineralisation However recent re-examination (Neudert, 1984; Perkins, 1990) of the Pb-Zn ores at all scales indicate that they are replacive like the copper lodes (Perkins, 1984; Swager, 1985), rather than syngenetic or early diagenetic in origin.

The Mt Bonnie-Iron Blow mineralisation is very similar to a typical polymetallic replacement type deposit (Table 6) in terms of tonnage, grade, metal association, metamorphic environment, mineralogy, ore texture and geometry. These deposits commonly have a hydrous calc-silicate (actinolite, tremolite, epidote, talc, dolomite, chlorite, quartz) wallrock assemblage, and some undisturbed wallrocks extending into the massive sulphides.

If the Mt Bonnie-Iron Blow deposits were syndiagenetic in origin one would expect the ore to consist of recrystallised bands and aggregates of fine grained (av. 0.1mm) sulphides like at Dugald River, in northwest Queensland, which has the same mineralogy and similar host rocks. The Mt Bonnie-Iron Blow lode system has a typically granoblastic, massive, medium grained (av. 0.5mm) sulphide assemblage, similar to the mantos-type massive sulphide deposits.

STRATIFORM Pb-Zn TYPE DEPOSITS

Heatley's Pb-Zn

Introduction

Heatleys prospect (GK 741 984) is located about 3km south-west of the Mount Bonnie mine open cut. Access is by the old Stuart Highway via turning off the New Stuart Highway at GK 701 967 (Tipperary 1:100 000) then left after 3km onto gravel road then right after 400m onto vehicle track which meets the Magaret road, follow the Margaret road up to two old costeans on the side of the ridge, this is Heatleys Pb-Zn prospect.

Several shallow pits and trenches containing malachite and azurite were discovered by Central Pacific Minerals N.L. (CPM) during a regional prospecting survey in 1969 (Shields & Pietsch 1971). Chip sampling in the area revealed values of up to 2 000 ppm copper and anomalous lead and zinc values in the Koolpin Formation.

Follow-up exploration consisted of geological mapping at 1":1 350' (photo scale) and then 1":100'; an EM (Turam & Slingram) and SP survey by the BMR; a ground magnetic survey, costeaning and sampling; a detailed geochemical soil survey, percussion drilling 27 holes totalling 1082m and finally two diamond drill holes totalling 347m which intersected minor Pb and Zn mineralisation (Ivanac & Darby, 1970; Ivanac, 1970; Bullock, 1971; Baarda, 1972; 1973a; and 1973b).

Geology

Lithologies of the South Alligator Group and Zamu Dolerite are exposed in the Heatleys prospect area (Figure 8). The South Alligator Group is a distinctive sequence of iron-rich and tuffaceous sediments comprised of the Koolpin Formation, Gerowie Tuff and Mount Bonnie Formation in ascending order (Stuart-Smith et al 1987).

The Koolpin Formation in the Golden Dyke Dome area has been subdivided into three informal members, Lower Carbonaceous Metapelite Member (LCMM), Banded Ferruginous Member and Upper Carbonaceous Metapelite Member (UCMM) by Stuart-Smith, (1987), which correspond to the upper three of the four members described by Nicholson (1980).

The LCMM is poorly exposed in Heatleys area, and consists of carbonaceous metapelite (black shales and phyllite) with pyrite-rich bands, meta-quartz siltstones (NTGS 9670- Appendix 1) and minor chert bands.

The Banded Ferruginous Member is approximately 50m

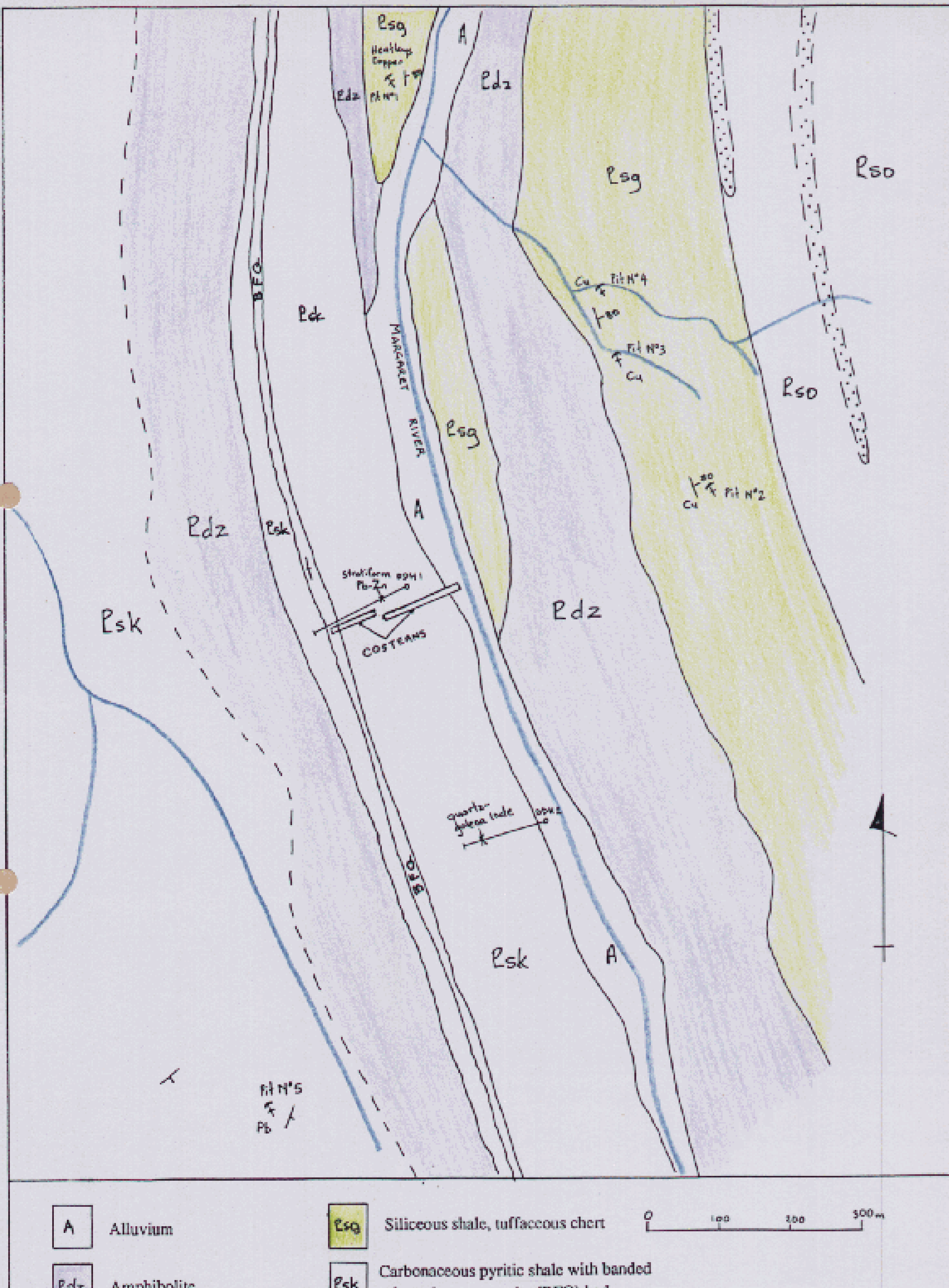


FIGURE 8 Geological plan of Heatleys prospect. (Modified after Shields & Pietsch, 1971).

thick and is characterised by the presence of banded, iron-rich sedimentary rocks which are interbedded with carbonaceous quartz-biotite metapelites.

The UCMM is about 75m thick and is the host of the Pb-Zn mineralisation at Heatleys. This member consists of carbonaceous and sulphidic metapelites (black shales and phyllite) with a pyrite-rich bed, numerous chert beds and minor tourmalinite lenses. The lower part of the member is characterized by anomalously high sulphide content (5-10%) dominated by pyrrhotite (Nicholson, 1978). The upper part of the member has a total volume sulphide content between 2-5%, with sphalerite as the dominant sulphide (Nicholson, 1978).

The Gerowie Tuff in this area consists of a sequence of interbedded tuffaceous pelites, phyllites and tuffaceous cherts or ashstones. The tuffaceous pelites are light grey laminated shales with angular and moderately sorted grains of quartz (60%), plagioclase (20%) and K feldspar (20%). The ashstones are usually well laminated rocks with 5-10% angular grains of quartz, plagioclase and microcline within a matrix (90-95%) of quartz, albite and biotite (Nicholson, 1978).

The lower 75 m ("Burrell Creek Facies") of the Mount Bonnie Formation lies within the Heatleys area (Figure 8). Two feldspathic greywacke-mudstone horizons, both 30-40 m thick, separated by about 50 m of interbedded phyllite and ashstone are exposed to the northeast of pits No 3 and 4.

Two major and two minor sills of Zamu Dolerite are exposed in the area. The rock is typically green-grey, medium grained and equigranular in hand specimen, and composed of dark green, ragged actinolite anhedra (60-70%), oligoclase to andesine feldspar (An_{20-40}), quartz, biotite with accessory sphene, magnetite and pyrrhotite. A remanant subophitic texture is often visible. The nearest granite is the McMinns Bluff Granite (pink-green porphyritic, hornblende biotite granite) exposed 2 km to the south.

Mineralisation

Two different styles of mineralisation are found in the Heatleys area.

1. Copper-bearing hydrothermal vein type, in the Gerowie Tuff, see page 33.
2. Stratiform Pb-Zn massive sulphides within the Koolpin Formation.

Stratiform Pb-Zn

This type of mineralisation was intersected by two diamond drill holes: HPDDH1 and HPDDH 2, put down to test a lead anomaly over sulphidic metapelites within the Koolpin Formation.

A conformable layer of massive fine grained sulphide 5 cm thick at 83 m was intersected by HPDDH1. This layer assayed >1% Pb, >1% Zn and 32g/t Ag (Baarda, 1972). HPDD靔 2 intersected an apparently conformable quartz-galena lode at a depth of 124m, within pyritic carbonaceous shales, which assayed 3.9% Pb and 11.5g/t Ag over 1.2 m. This layer is not necessarily correlated to the stratiform layer in DDH 1.

A 10 m pyrrhotite-rich bed was intersected in HPDDH 1, 10 m above the Banded Ferruginous Member. The pyrrhotite is in the form of thin lenses 0.5 mm thick or fine grains (0.01 mm) which often define laminae of 0.3 mm. Fine grained galena, sphalerite and chalcopyrite appear to have been formed with the pyrrhotite, while pyrite post-dates these sulphides, though it is still conformable and displays soft sediment deformation structures within the metapelites. Secondary euhedral pyrite is found infilling fractures in all rock types.

Nicholson (1980) suggests that the metals were syngenetically or diagenetically formed, originally derived from brines which were periodically exhaled during the deposition of the Koolpin Formation.

HYDROTHERMAL VEIN TYPE DEPOSITS

LEAD-SILVER

McKinlay (MLN 406)

Introduction

The McKinlay silver-lead mine (GK 961 908) is located about 23 km northwest of the Pine Creek township. Access is via the Pine Creek - Mt Wells Road, then turning left at the intersection 2km northwest of Boomleera Siding. Travel southwest for 1.5km and turn left onto old track (which may be hard to find) which crosses Snaddens Creek, then travel along the track for 1km.

The production records of the McKinlay mine go back as far as 1888 when 22 tonnes of ore grading 70% Pb and 156 oz/t Ag was raised from a shaft sunk 400 m south of the original shaft (Shaft No 1). In 1890 the McKinlay & Mount Wells Mining Co. sunk two shafts on a regular and well defined 1m wide lode within 6 m (20ft) of each other down to a depth of 40m, with 75m drives at the bottom .

Some 270 t of ore grading 55% Pb and 140 oz/t Ag was sent away (Report on N.T. Mines and Mineral Resources, 1890, in Balfour 1978). The most valuable ore of 11% Pb, 11.6% Ag and 61g/t Au was won from Heffernon's workings (Dodson, 1969). Workings consist of 10 shafts and two small open cuts (Plate 8).

Following a recommendation by Parkes (1892), the sinking of a vertical shaft 60m south of Heffernon's was started, however all work on the lease was discontinued in 1891 because of the decline in the price of silver and the mining difficulties caused by the presence of water in the underground workings (Dodson, 1969). In 1892 a further 28 t of seconds left by Heffernon was shipped south, returning grades of 50oz/t Ag and 23% Pb. Total production between 1888 and 1892 was 762 t of lead-silver ore according to Crohn (1968). The ore grade was most likely in excess of 25% Pb and 1500g/t Ag

In 1966 United Uranium conducted a soil (Cu, Pb, Zn) survey. A syndicate of local prospectors pegged the original lease in July 1969, and sank a prospecting shaft to 30m, between Heffernon's and the Main Shaft, but the inflow of water stopped further development (Dodson, 1969).

Plate 8 Small open cut (Heffernon's workings) at the McKinlay Pb-Ag mine.

In 1969 the prospect was visited by the NTGS (Dodson, 1969) who carried out geological mapping, and drilled two diamond holes totalling 215m. The most significant intersection contained 2.4% Pb, 3% Zn, 70g/t Ag and 7.3g/t Au over 45cm at 80m depth in DDH1.

Late in 1969, Minerals Centre N.L. obtained the McKinlay leases and carried out an IP survey, stream sediment survey, detailed geological mapping and costeaning, all with discouraging results (Roberts, 1970).

Geology

The McKinlay mine area lies 3.5km southwest of the McKinlay Granite, within metagreywacke and slate/phyllite of the Burrell Creek Formation (Figure 9). The metagreywackes comprise about 60% of lithologysee at the surface, and are typically mid-grey, foliated, medium to fine, well cemented quartz-lithic arenites. These are thick ridge forming bedded units up to 5m wide, which can be traced up to 150m along strike in the southern part of the eastern mineralized zone (Roberts 1970).

Bedding strikes northwest (310°) and dips very steeply (70°) to the west occupying the western limb of a tight anticline located about 850m to the east. The main shear zone strikes northwest (330°) and dips 75° east at Heffernon's Workings. Several other north-trending faults, with sinistral movements are present in the area as well as conjugate sets which are commonly infilled with sulphide bearing vein quartz. Northwest trending intrafolial folds have been observed within pelitic beds.

Mineralisation

Several Ag-Pb lodes are present in the McKinlay mine area. At Heffernon's workings two shafts have been sunk 43m of each other on a ferruginous quartz lode. Within Heffernon's Shaft the northwest trending lode dips steeply (55°) to the east, is 0.75 m wide, and can be trace for about 100 m along strike. Fine to medium grained quartz-volcanic arenite with minor stockwork development form the wallrock. An aplitic greissen vein about 4cm thick is present within the footwall of the open cut.

The original shaft (No1 Shaft) has been sunk on a prominant Fe-Mn oxide-bearing quartz gossan which trends north-south, within host arenites which strike 330°. At the base (water level) of the shaft, the lode is about 0.35m wide and consists of vugy vein quartz, galena and cerussite. Assays of 42% Pb, 1400g/t Ag and 28g/t Au are recorded (Chief Wardens Report, 1892). The shaft was abandoned at the water table level (13m).

Two other shafts have been sunk on the lode next to the No1 Shaft, one vertical, the other inclined to the south. Rich sulphide ore assaying up to 5,000oz/t Ag was obtained (Chief Wardens Report, 1889). These shafts were also abandoned due to the water encountered at a depth of 17m.

The No2 shaft (GK 950910) is located about 1km west of the No1 Shaft on a vertical northwest 340° trending quartz-cerussite lode. This shaft was sunk down to water level (17m) and had a 5.2m drive to the south at this level. A bulk assay of ore taken at a depth of 13.7m returned 32% Pb, 1742g/t Ag and 21g/t Au (Chief Wardens Report, 1892). At the 17m level the lode width is about 0.4 m, about

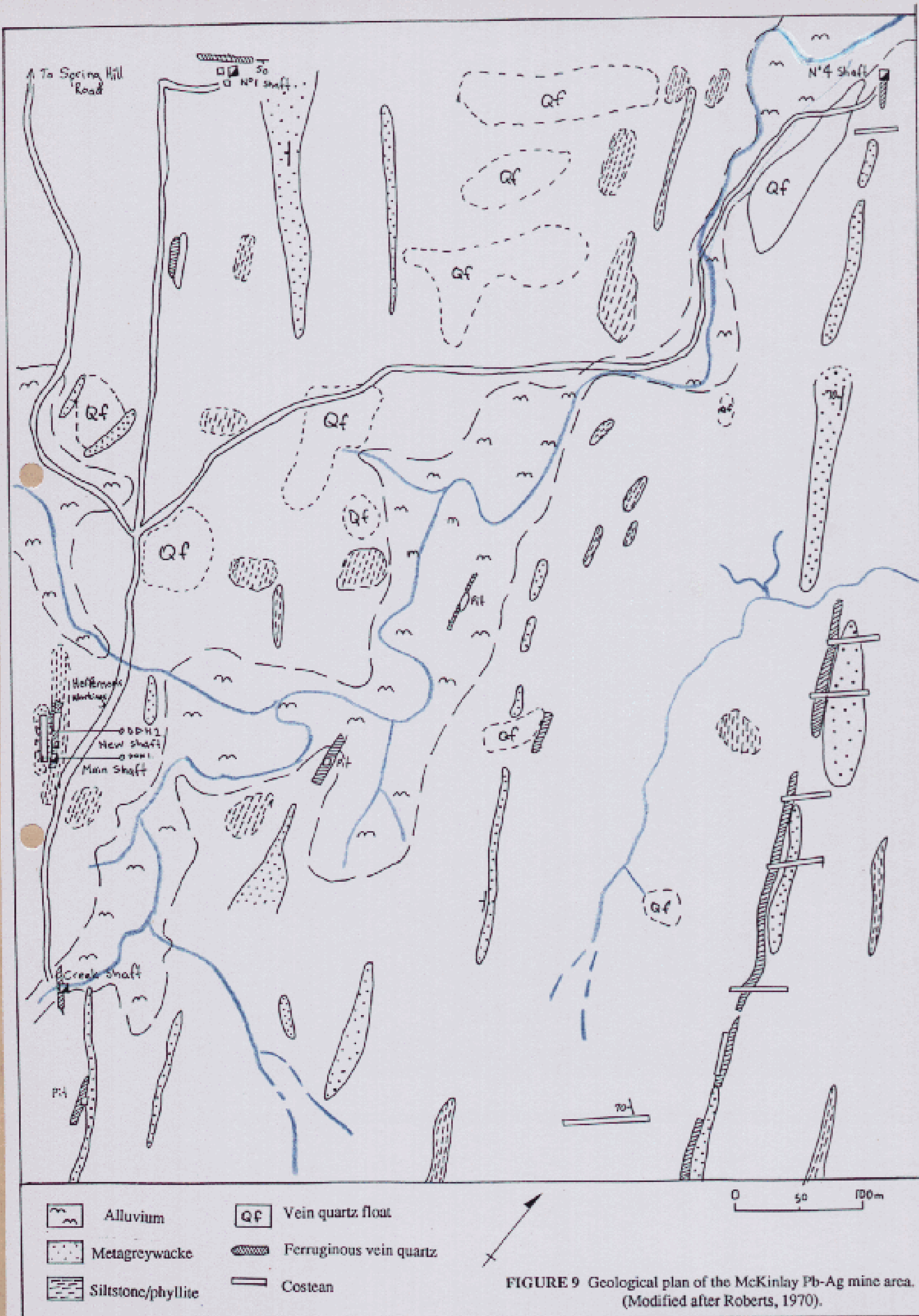


FIGURE 9 Geological plan of the McKinlay Pb-Ag mine area. (Modified after Roberts, 1970).

half the surface width (0.7m) and appears to significantly pinch and swell along strike.

The wallrocks are metagreywacke and phyllite of the Burrell Creek Formation which strike 325° and dip subvertically (80°) to the southwest. The quartz-lode system can be traced over a distance of 800m on the surface and has recently been tested by RC drilling for gold potential (Creagh, 1990). Significant results include:

3m grading 1.1g/t Au (44-47m, RC1)

2m grading 3.75g/t Au (56-58m (RC2)

These two holes targeted the quartz reef below the shaft, which returned an anomalous chip sample (9.8% Pb, 232g/t Ag and 7.5g/t Au) at the surface. Disseminated coarse grained galena, arsenopyrite and pyrite were encountered between 42 and 47m in RC1 but not assayed (Creagh, 1990).

Shaft No3 (location unknown) is situated on a hill, and was sunk to a depth of 25.3m on a 1m wide, quartz-cerussite lode which returned assays of 870g/t Ag (Chief Wardens Report, 1892). Shaft No4 is located about 500m northeast of shaft No1 on the point of a spur next to Snaddens Creek (Figure 9). This shaft was sunk on a 1.2m wide, vertical, northwest (315°) trending lode to a depth of 13.7m (45ft). A level which was driven (8.2m) to the south at the bottom of the shaft revealed a continuous high grade (70% Pb and 930g/t Ag) galena-pyrite bearing lode (Chief Wardens Report, 1892).

Examination of a polished block (NTGS 9538-Appendix 1) from the primary zone revealed a cataclastic ore, with a gangue textures consisting of chloritised slate and fine greywacke fragments within an augen-like matrix of coarse grained quartz. Fine to medium pyrite subhedra to euhedra were commonly fractured and corroded, whilst galena grains were stretched and commonly contained inclusions of sphalerite and arsenopyrite. Fine arsenopyrite euhedra and fragments are disseminated throughout the gangue and sulphide assemblage.

While this lode appears to have some potential a surface chip sample (MCC3) by Mining Centre N.L. returned only 2240 ppm Pb, 16 ppm Ag, 1280 ppm Zn (Roberts, 1970).

Heffernon's workings (GK 961908) are located where the abandoned mine symbol appears on the Pine Creek 1:100 000 geological map. The shaft (now collapsed) was originally sunk to 40m (130ft), intersecting a 1-1.2m wide lode which produced 270t of ore grading 55% Pb and 140oz/t Ag (Chief Wardens Report, 1890).

Most of the ore was stoped from the northern and southern drives which extended 45m each, at the 36.5m (120ft) level. A regular and well defined lode still remains unstoped below 40m. Two ore samples examined by I.R. Pontifex (*In* Dodson, 1969) consisted of 60% fine to medium grained galena which contain disseminations and patches of fine (60μm) pyrite euhedra; fine (100μm) sphalerite anhedra with tiny chalcopyrite exsolutions; and highly irregular patches of pyrargyrite. The patches of pyrargyite are believed to host most of the silver, which may also form veinlets within siltstone lithologies (Dodson, 1969). The principal gange minerals are quartz, siderite and chlorite.

The Main Shaft was sunk about 30m to the south of Heffernon's workings and was expected to intersect the main lode at 24.4m (80ft), but turned out to be barren. A new shaft (Shaft No5) was sunk to 30m (100ft) between Heffernon's and Main Shaft in 1969 by a syndicate of local prospectors, and subsequently abandoned due to the inflow of water. Several other prospecting pits and shafts have opened small lead-bearing vein quartz lodes (Figure 9).

The Eastern zone of mineralisation contains discontinuous outcrops of silicified stockwork, accompanied by kaolinite and epidote alteration (Roberts, 1970). Costeaning along the outcrops established that the lodes with a gossanous cap were within chloritised siltstone. The assay results from costean samples were generally low; best assay returned 195ppm Ag (Roberts, 1970).

While early diamond drilling and recent RC drilling results have downgraded the potential of economic tonnages beneath Heffernon's workings, RC drilling (MP12) some 800m to the south has intersected 11m grading 2.8% Pb and 327g/t Ag (Creagh, 1990). The McKinlay silver-lead system seems to extend into the Flora Belle and Union Reef Pb-Ag lodes and beyond, some 6km to the south. The lodes appear to be small and irregular (pinch and swell) in nature, and located along greywacke-siltstone contacts, and infillng cleavage-parallel faults and fractures within the Pine Creek Shear Zone.

Following the economic success obtained at the Woodcutters Pb-Zn-Ag mine after a persistent drilling program, further drilling is essential before this area can be justifiably downgraded, given the probable existence of extremely rich silver-lead ore remaining at depth, very similar to the ore which was mined from the McKinlay lodes.

Flora Belle (MLN 423)

Introduction

The Flora Belle silver-lead mine (GK 974 884) is situated about 20 km NNW of Pine Creek township and can be reached by a track that turns off to the west of the Mt Wells-Pine Creek road some 500 m north of the McKinlay River Crossing. The mine is currently owned by Mr John Doyle.

The old working consists of 10 shafts, which have been sunk on the main lode (Figure 10), and indicate extensive underground workings. The mine was worked in the late 1880s, producing 20 t of lead (14.8%) and 35 kg of silver (260g/t) from 135 t of ore (Needham, 1981) with up to 800 oz/t in places (Report on N.T. Mines and Mineral Resources, 1888; in Balfour, 1978).

The first shaft sunk on the lode was known as Bechervaise's Shaft (Plate 9), which reached a depth of 28.6 m (94ft), and was connected by a drive of 61 m (200ft) to the Air Shaft. By 1891 135 t of silver-lead ore was sent to Port Adelaide from these workings alone (Parkes, 1892).

Several shafts were sunk down over 30 m (100ft) with drives on a rich lode which was uniform in size and character (Report on N.T. Mines and Mineral Resources, 1889; in Balfour, 1978). The Main Shaft (Figure 10) went down to 64m (210ft) with drives to the north (12m) and south (18m), however only small amounts of high-grade ore could be retrieved.

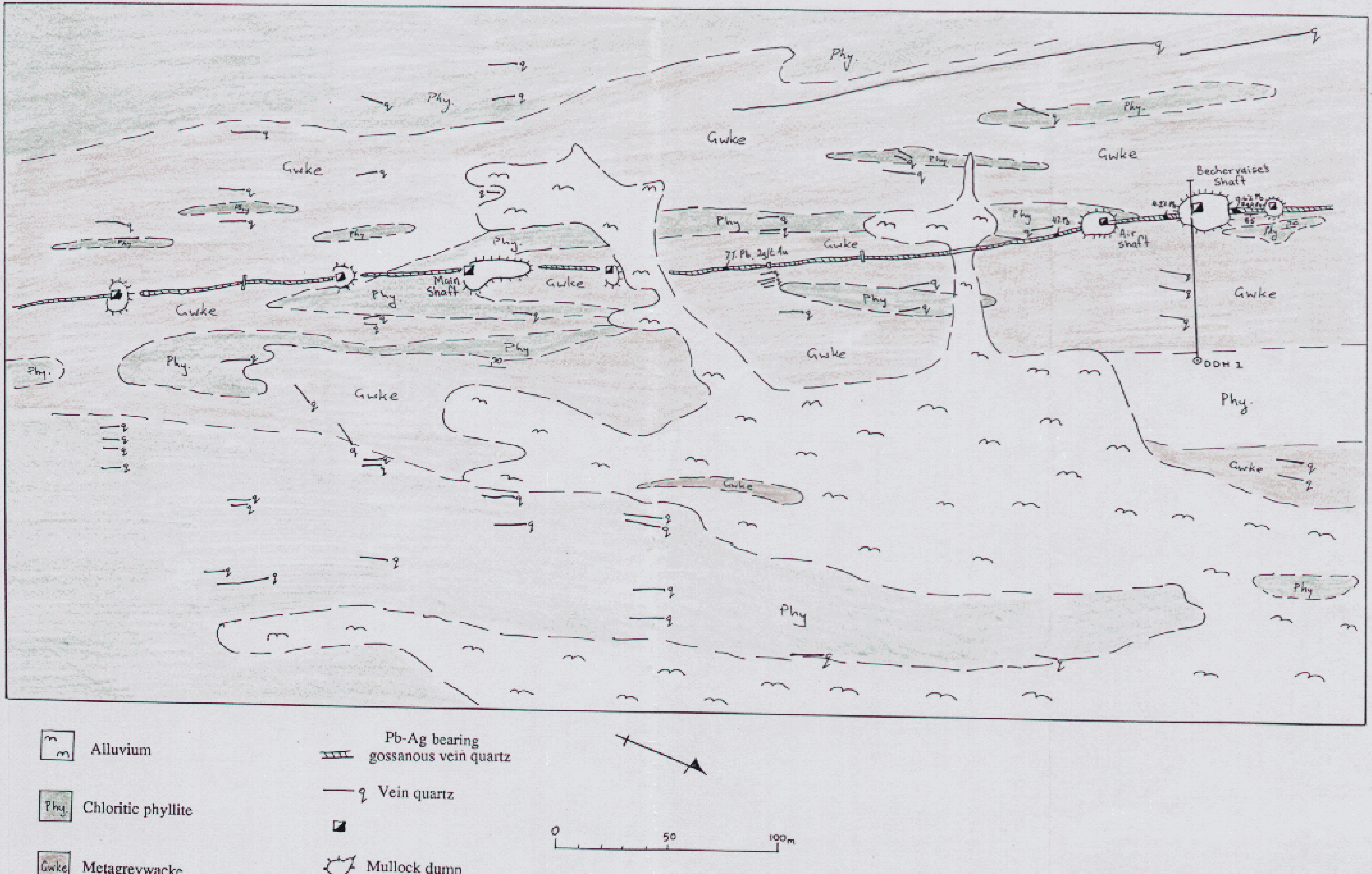


FIGURE 10

Flora Belle Pb-Ag mine;
surface geology and workings.
(Modified after Forbes & Sturm, 1967).

Due to flooding and lack of adequate dewatering equipment, Bechervaise's Shaft was abandoned and numerous shallow shafts and pits were sunk to the north and south of it (Parkes, 1891). Some 500 m north of Bechervaise's Shaft another shaft has been sunk to 24.5 m (80ft) on the ferrugenous quartz lode (Parkes, 1892).

In 1966 United Uranium N.L. conducted geological mapping, an EM survey and put down a 113.7m diamond drill hole (Forbes & Sturm, 1967). In 1970 Silver Mile Mining Pty Ltd carried out a programme of percussion drilling (totalling 40 holes). Results were generally not encouraging, highest assay recorded was 818g/t Ag, 6.8% Pb between 18.0-18.3m in P.H.22 (Wood, 1971).

Central Pacific Minerals has conducted geochemical and radiometric suveys as well as geological mapping (Ivanac, 1970). The last recorded production was in 1978 when 255 tonnes of ore material from the remaining dump yielded 5t Pb, 8kg Ag and 55g Au (Nyunt, 1985). A feasibility study was carried out in 1984 by Mines Division (Northern Territory Department of Mines and Energy), which proposed a profitable small-scale mining project involving two stages (Nyunt, 1985).

Geology

The Flora Belle Ag-Pb mine lies in chloritised phyllites and metagreywackes of the Burrell Creek Formation, about 3 km northeast of the McMinns Bluff Granite. Phyllites are strongly foliated, trending northwest (330-340°) dipping very steeply (70-85°) west, occupying the limb of a tight anticline which lies about 700m to the east. Laminated phyllites comprise the footwall while fine to medium grained greywacke form the hangingwall at Bechervaise's Shaft. Flora Belle DDH 1 (Figure 11) intersected an interbedded quartz-sericite schist and chloritic phyllite sequence with numerous pyrite-bearing quartz veinlets.

Mineralisation

The Ag-Pb mineralisation at Flora Belle consists of an ore body some 600m long and 1m wide within a conformable northwest (330°) trending shear zone. The surface expression of the lode is represented by a series of discontinuous quartz (Fe-Mn) gossans, typically 0.5-2m wide and dipping about 85° east (Plate 10). The primary ore (Plate 11) consists of galena, pyrite, arsenopyrite with minor sphalerite, tetrahedrite, marcasite, chalcopyrite and pyrargyrite.

In polished section (NTGS 9815- Appendix 1) galena (60%) forms fine to medium grained euhedra typically aggregated, and containing inclusions of pyrite, arsenopyrite, tetrahedrite. Pyrite is usually fine grained (20-300μm), in the form of disseminated and locally clustered subhedra. Tetrahedrite forms scattered, fine bleb-like grains, whilst arsenopyrite forms minute euhedra, and sparse medium grained crystals.

The massive ore contains numerous blebs (0.1-10mm) of coarsely crystalline siderite, quartz and breccia blocks of wallrock. The mineralisation at Flora Belle is tabular and irregular in nature, associated with quartz veins occupying a shear zone which produced favourable channels for the ore solutions during the granite intrusion.

Plate 9 View of Bechervise's shaft from the southeast.

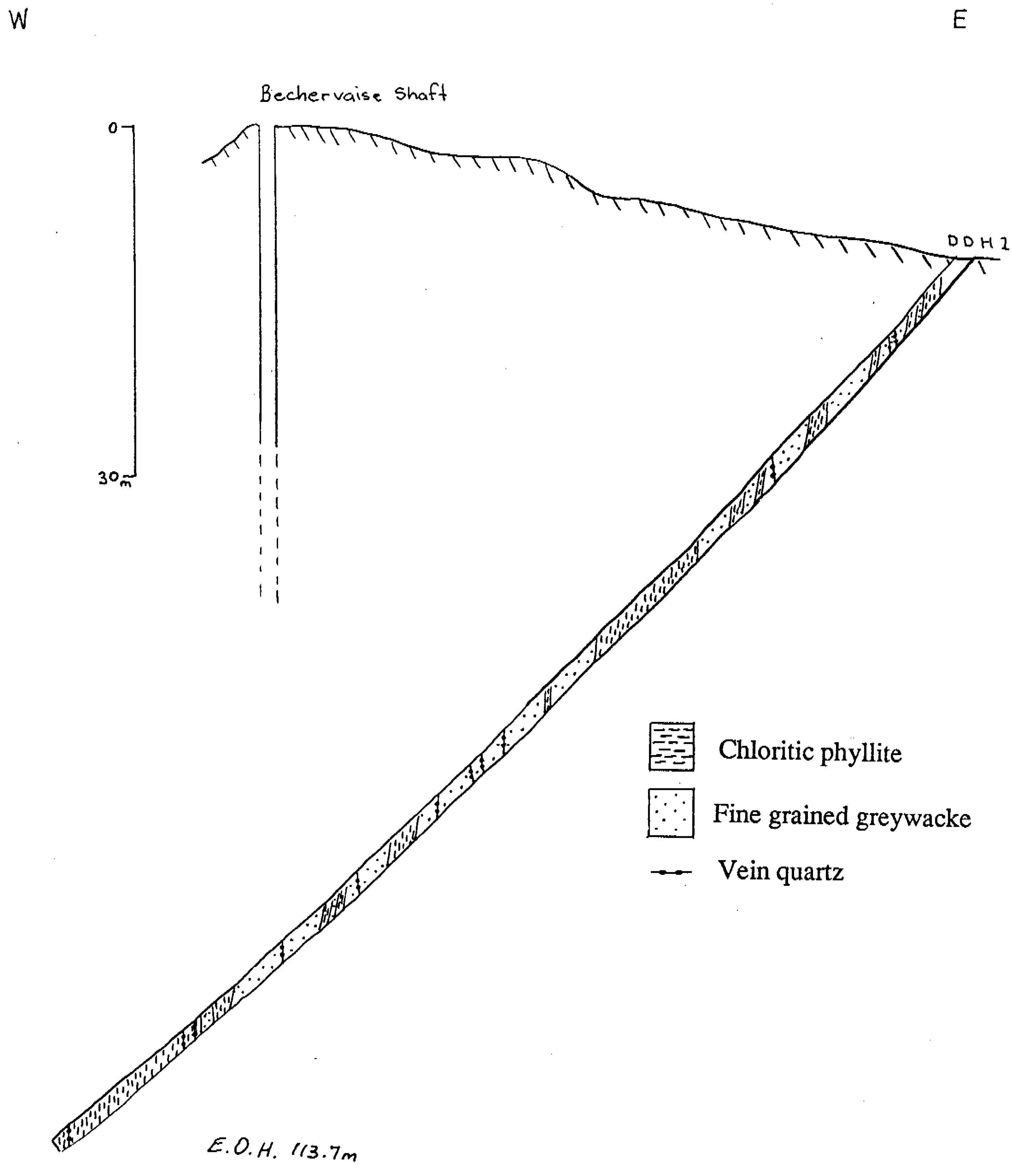


FIGURE 11 Section along Flora Belle DDH 1.
(After Forbes & Sturm, 1967).

Plate 10 Surface expression of the Flora Belle Pb-Ag lode. (tape 1m)

Plate 11 Massive galena ore from the Flora Belle mine.

The Flora Belle has good potential to become a short-life profitable mine. A feasibility study carried out by Mines Division (Nyunt, 1985) indicated that treatment of the dump material (15 000 tonnes 4% Pb and 400g/t Ag) would result in a pre-tax net profit of $1.3m following an initial capital outlay of $1500 000 over one year. A further 70 000 tonnes of Ag-Pb ore could be extracted from the orebody by open cut mining (Nyunt, 1985).

Inspection of the mine area in 1988 showed that no further drilling has been conducted following the very poor results obtained from the single hole drilled by United Uranium N.L. in 1967. Like the McKinlay Pb-Ag lodes the economic potential has been downgraded due to the lack of sufficient tonnage. More drilling would be necessary to prove ore reserves and nature of the orebody as the grades can be outstanding based on previous production figures.

Mount Wigley (ML 426A)

Introduction

The Mount Wigley lead mine (HK 087 617) is about 8.5 km south of the Pine Creek township, and can be reached by turning east off the Stuart Highway, and then driving cross-country for 800 m. Workings at the prospect (Plate 13) consist of a collapsed shaft (originally 25ft) within a 40x10x2m open cut (Figure 12). Recorded production in 1907 was 61 t of Ag-Pb ore (Crohn, 1968). During 1978 53 tonnes of ore was extracted and treated grading 5.6% Pb. In 1979 a further 200 tonne of ore was mined, grading 5% Pb (Bagas 1981).

Geology

The Mount Wigley mine lies within phyllites and metagreywackes of the Burrell Creek Formation, some 3.5 km west of the McCarthy's Granite (homogeneous pink and green coarse grained, porphyritic hornblende-biotite granite). Medium bedded phyllites and greywackes strike northwest (310-330°) and dip steeply (80°) southwest. A pervasive slaty cleavage (330°/80°/SW) is well developed.

Mineralisation

Mount Wigley contains a 0.8 m wide north-northwest trending (340°) galena-bearing quartz lode that dips very steeply (80°) to the east. The galena occurs as both veinlets (up to 100mm in width) and coarse grained disseminations (NTGS 9516) within the quartz gangue and fine stockworks in phyllite (NTGS 9513). The galena is often closely associated with chloritic wallrock fragments or infilling irregular fractures and other voids. The oxidised ore (NTGS 9515- Appendix 1) consists of massive cerussite with relict cores of galena.

The lode occupies a shear zone (indicated by angular clast of wallrock fragments floating in vein quartz), parallel to the local cleavage. Wallrock alteration is limited, with only minor selective and pervasive chloritisation visible.

This prospect represents another vein-type lead deposit within the north west trending Pine Creek Shear Zone, and has only minor potential (5% Pb over a 50m strike length). Diamond drilling is recommended to test the nature and grades of the ore shoot at depth.

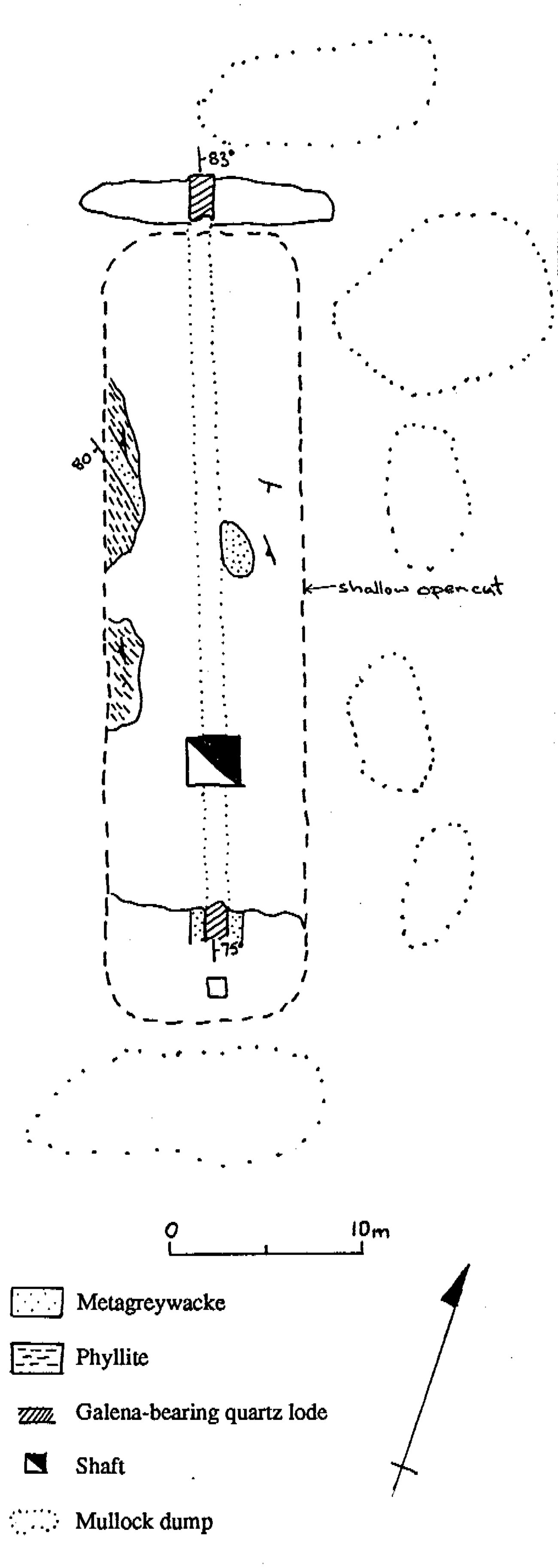


FIGURE 12 Mount Wigley lead mine;
Surface geology and workings.

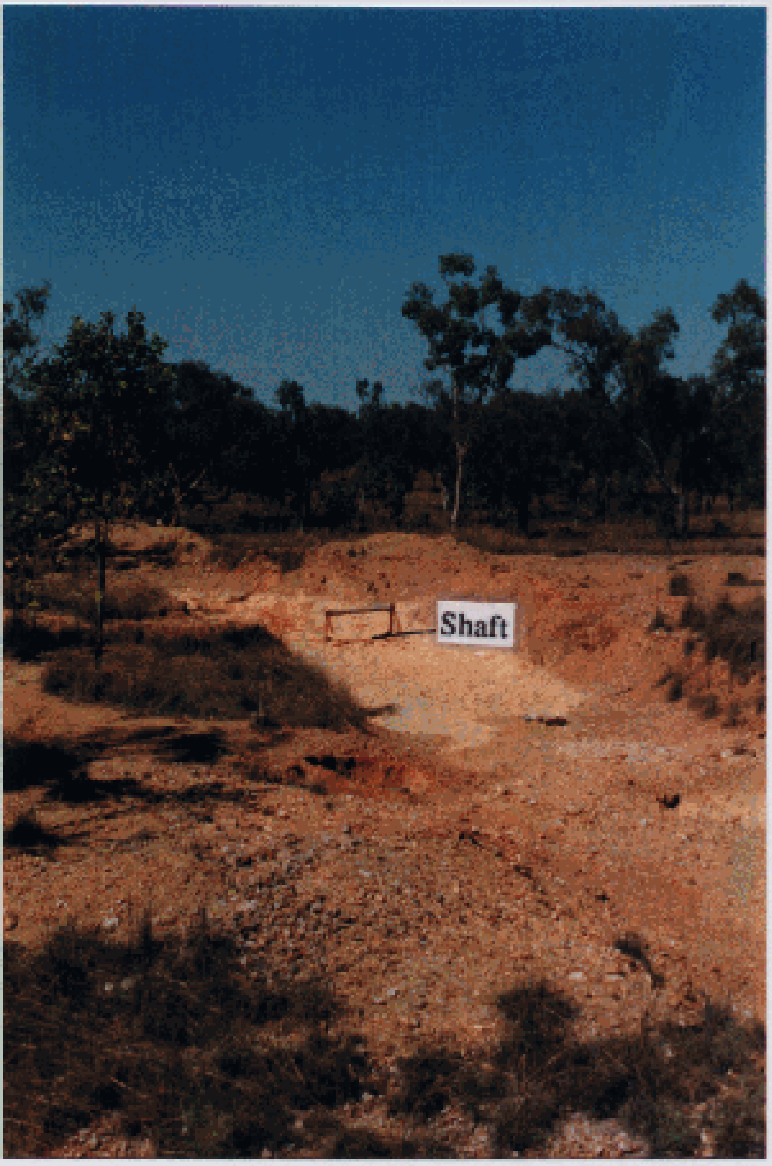


Plate 12 Mt Wigley lead mine workings, looking from the south.

Plate 13 Lucknow Pb-Ag lode exposed at the north end of the open cut. (tape 1m)

Lucknow (MLN 119)

Introduction

The Lucknow silver-lead mine (HK 070 632) is situated about 6.5 km south of the Pine Creek township and can be reached by a vehicle track to Mr Quest's that leaves the Stuart Highway 5.8 km south of Pine Creek.

The old mine is owned by Mr Allan Quest, who has recently (1986) assayed the lead lode and quartz veins in the vicinity for gold. Workings at the mine consist of two ten metre deep shafts and a 12x2x3m open cut (Figure 13). Total recorded production from the mine (1907) was 165t of Ag-Pb ore (Crohn, 1968).

Several costeans have been excavated across the lode, to the north and south of the old workings to delineate the nature and grade of the mineralisation (Figure 13).

Geology

The Lucknow mine lies within folded metagreywackes and phyllites of the Burrell Creek Formation, 4 km west of the Bonrook Granite (pink, equigranular biotite granite).

Thin section studies indicate that the phyllites are essentially composed of sericite (50%) and chlorite (40%) with a pervasive crenulation cleavage (NTGS 9525-Appendix 1). The metagreywackes are medium to fine grained, moderately sorted litharenites with 30% quartz (subangular to subrounded, partially recrystallised framework grains), 40% rock fragments (quartzitic, cherty-sericitic and sericitic-chloritic), 15% feldspar (mainly plagioclase with albite and pericline twinning), 5% metamorphic biotite, with 15% sericite and chlorite (recrystallised matrix). Bedding strikes 325-335° and dips very steeply (80°) southwest.

Mineralisation

The main workings at Lucknow are on a 1m wide north-northeast (015°) trending galena-bearing quartz vein which is vertical near the surface (Plate 13) but dips steeply (75°) to the west at depth.

The the quartz vein occupies a shear zone, which can be discontinuously traced along strike for over 300m. Cerussite is the dominant ore mineral found at the surface whilst the primary ore consists of fine to coarse grained galena, which occupies irregular fractures within a coarse grained granoblastic quartz gangue.

Galena contains varying amounts of silver and inclusions of sphalerite which in turn contain very fine exsolutions of chalcopyrite (NTGS 9512- Appendix 1).
The costeans across the lode to the north and south of the main workings indicate the quartz reef splays (Figure 13). This deposit is typical of many north trending Ag-Pb vein-type occurrences in the Pine Creek 1:250 000 sheet area.

Union Reef silver-lead (ML 219A)

Introduction

The Union Reef silver-lead prospect (GK 987 862) is about 18 km north-northwest of the Pine Creek township and can be reached by turning west off the Mt Wells road at the 60 mile sign near the old railway, then drive cross-country for about 1 km.

The workings (Plate 14) consists of two shafts (> 10 m) and two small pits (Figure 14). The prospect has been geologically mapped and the mineralised quartz veins and greywacke lenses channel sampled by the NTGS (Tapp, 1967); with one sample assaying 5.8% Pb and 0.67% Ag.

Plate 14 Shaft No1 Union Reef Pb-Ag prospect. (tape 1m)

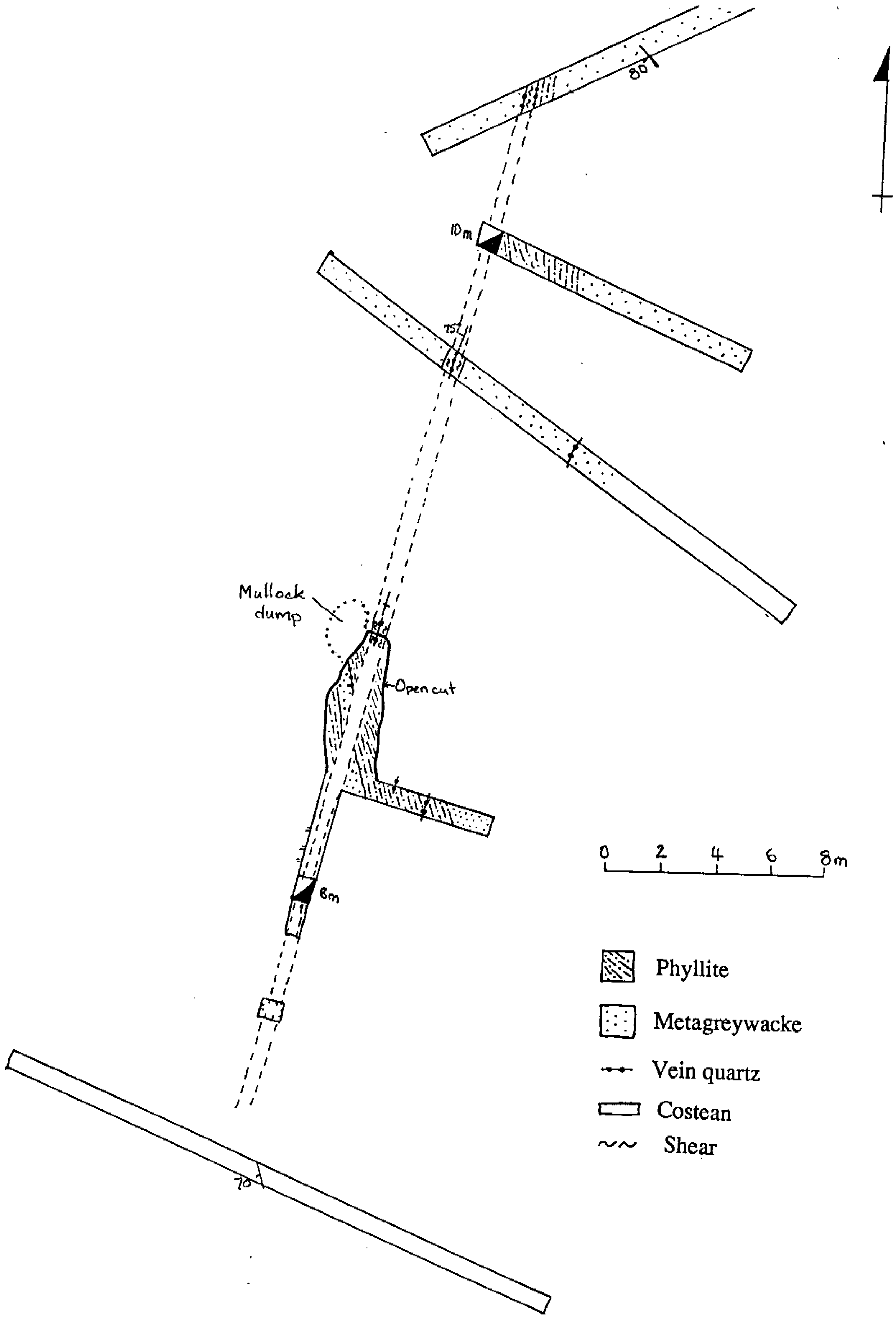


FIGURE 13 Lucknow Pb-Ag mine; geological sketch map.

Geology

The rocks exposed at the prospect are predominantly slates and minor greywackes of the Burrell Creek Formation, which lie about 2.5 km east of the McMinns Bluff Granite (pink and green, prophyritic hornblende-biotite granite).

Strongly foliated (330°/90°) slates dominate the lithological exposures in the vicinity. Minor thin lenses of medium to coarse grained greywackes are interbedded with the slates. In thin section the slates are composed of 50% chlorite, 20% talc, 15% sericite, 10% siderite (fine veinlets), 3% quartz and 2% iron oxides (NTGS 9527- Appendix 1).

Several north-northwest trending quartz filled shears, up to 0.5m wide have been emplaced along cleavage planes and are closely associated with the greywacke lenses (Figure 14).

Mineralisation

Two shafts have been sunk on a 1m wide north-northwest (330°) trending quartz vein (Plate 9) within a vertical shear zone. No galena was observed, however a greywacke-quartz breccia chip sample from shaft No1 assayed 4.5% Pb and 70g/t Ag (Tapp, 1967) The small (4x2x2m) pit near the creek some 120m east of Shaft No2 contains a galena bearing quartz vein within a 1.7m wide shear zone 350°/70°W. Two samples (Figure 14) returned assays of 930g/t Ag, 13.2% Pb and 57g/t Ag and 18.3% Pb respectively.

The mineralisation is found in irregular, small, rich shoots within quartz veins and associated greywackes. Galena is fine to coarse grained, irregular both in shape and distribution, commonly infilling fractures within a coarse granoblastic quartz gangue.

The mineralisation within the greywackes is massive, containing varying amounts of sphalerite, galena, bismuthite and pyrite. A sample obtained from one of the mullock dumps near a shaft (NTGS 9678- Appendix 1), contained a composite layered, medium grained (0.1-2mm), granulose aggregate structure of sphalerite (20%), bismuthinite (12%), galena (12%) and pyrite (10%) within a granoblastic quartz (30%) and siderite (15%) gangue.

Minor tetrahedrite is present as fine (0.1mm) grains generally enclosed within galena, while chalcopyrite occurs as sparse, minute exsolution blebs in sphalerite. Mineral interrelationships suggest that pyrite formed first followed by bismuthite, sphalerite, and galena. Siderite veinlets are common within the slaty wallrocks.

This occurrence lies on the McKinlay-Flora Belle Pb-Ag line of mineralisation, within the Pine Creek Shear Zone. While the main ore shoot appears to be of relatively low grade, the other lode down near the creek may have some potential, its extent and depth should be determined, as the channel sample assays are encouraging.

Union Extended

Introduction

The Union Extended silver-lead prospect (HK 005 923) is 14km south-southeast of the Mount Wells Battery. Access is by a track to the Union Extended gold mine, which leaves the Pine Creek-Mt Wells road about 2.5-3km north of the McKinlay River Crossing.

Workings at the southern part of the prospect consist of a shaft (Plate 15), 11 m long open cut and an exploration pit. The northern part consists of a 15m deep shaft, an open 4m long stope and a few small pits (Figure 15). It appears that about 50t of Pb-Ag concentrate was removed from the stopes and pits.

Geology

Rocks exposed in the vicinity consist of interbedded metagreywackes, phyllites and slates of the Burrell Creek Formation. The metagreywackes are medium grained, strongly foliated (flaser fabric apparent in thin section) rocks composed of foliated chlorite (Mg-Al rich variety) and biotite which incorporate numerous attenuated lenses of polycrystalline quartz, cherty rock fragments and feldspathic grains elongated parallel to the schistocity (NTGS 9540- Appendix 1).

Exposures of pink and green, coarse grained, slightly porphyritic hornblende-biotite granite assigned the the McKinlay Granite are found about 1.5km to the northwest. Bedding stands vertical and strikes northeast (030°) coinciding with a very well developed S_1 cleavage. Conjugate joints trending 050° and 010° can be seen around the open stope.

Plate 15 Workings at the southern part of the Union Extended Pb-Ag prospect.

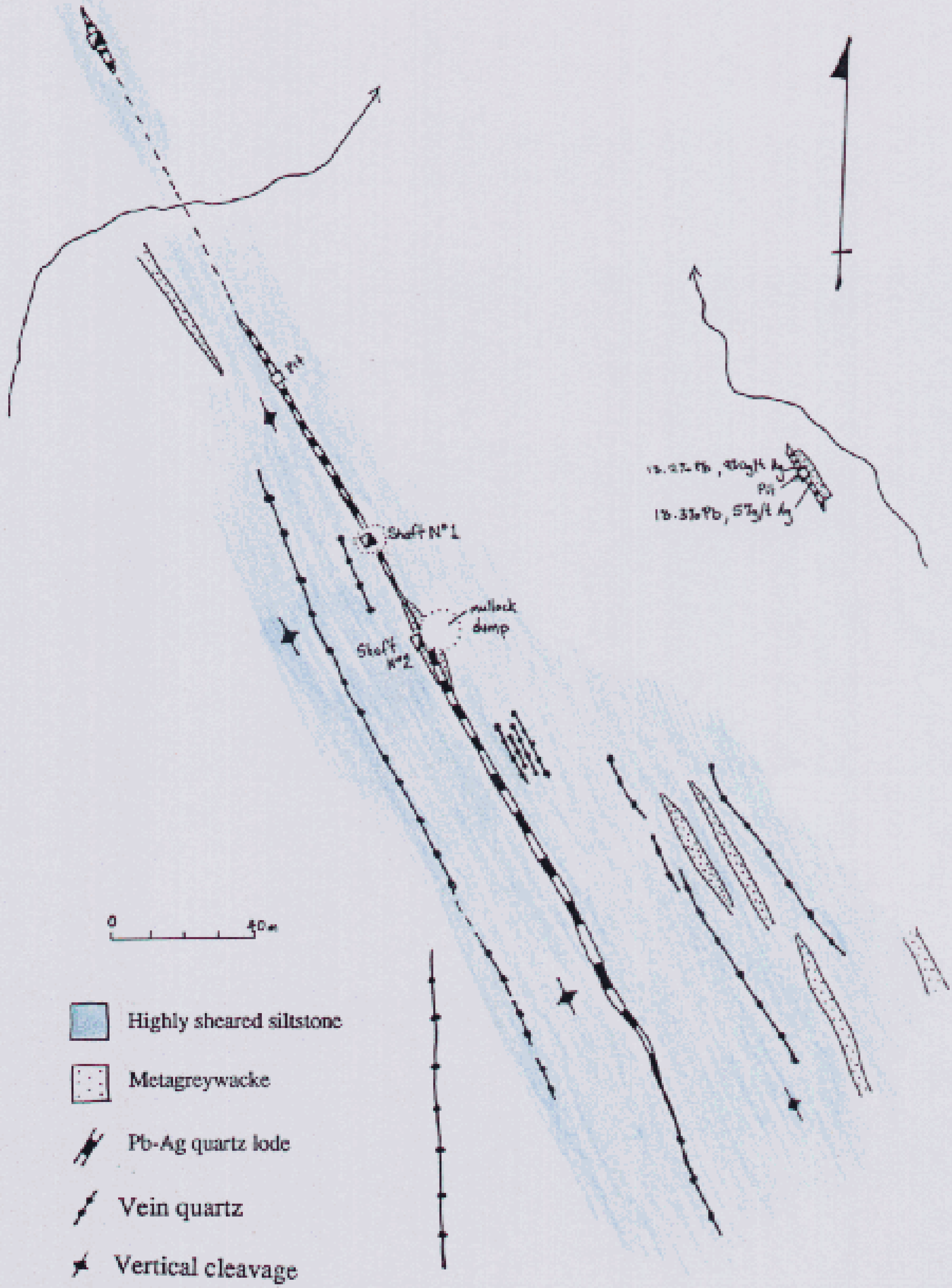


FIGURE 14 Union Reef Pb-Ag prospect (Modified after Tapp, 1967).

Mineralisation

The silver-lead mineralisation at the Union Extended prospect is confined to a 1.5m wide north (355-015°) trending vertical galena-bearing quartz lode. The lode can be discontinuously traced on the surface over 100m. The ore material extracted from the main stope consisted of coarse grained, massive galena with minor fragments of wallrock (phyllite). Quartz veins carrying coarse grained galena predominated in the southern workings.

The oxidised ore was rich in cerussite with minor galena, and assayed 21% Pb and 135g/t Ag (NTGS 9539). Minor amounts of malachite and chalcopyrite are also present within the galena-bearing quartz veins. The lode appears to occupy a shear zone of limited extent and potential.

Pickfords (Bonnie Jean)

Introduction

Pickfords silver lead prospect (GL 819 013) is about 6km east of the Mt Bonnie Mine, and can be reached by a south-bound track which leaves the Fountain Head-Mt Wells Road some 7km west of Grove Hill.

The prospect was inspected by Dr. Jensen (Jensen et al., 1916) who described the mineralisation and the geology. Later, in 1956 it was investigated by Enterprise Exploration Company Pty Ltd (Thomas, 1956), who mapped and sampled the prospect with discouraging results; the highest assay result was 5.9% Pb from a sample west of the main workings.

The old workings consist of two shafts 5 and 18m deep, with a 15m cross-cut to the lode with 20m of lateral development both north and south on lode; three shallow open cuts (Plate 16); along with several small pits and costeans which extend over a 50 m strike length (Figure 16).

The prospect was worked intermittently between 1900 and 1915 for the high silver content in the oxidized ore. Recorded production totals 1.3kg Ag, 0.1kg Au and 9 t of Pb (Needham, 1981).

Geology

Pickfords lead prospect lies within a narrow lens of Gerowie Tuff bounded by carbonaceous shales and slates of the Koolpin Formation to the west, and massive amphibolites of the Zamu Dolerite to the east (Figure 16). The brecciated argillites of the Gerowie Tuff appear to occupy the hinge area of an overturned syncline, although the nature of bedding within the unit could not be defined. The Koolpin shales however, dip steeply (65°) to the west (260°).

The tightly folded host rock sequence has been off-set by a northeast trending dextral wrench fault by about 200m according to Jensen and Winters (1916). This fault has been off-set by the same distance to the north by the Saunders Creek Fault which has a strike length of 10km.

There are a number of quartz reefs in the vicinity of the workings which consist of coarse white, bucky to drusy massive quartz with minor sulphides. These veins have silicified the argillites extensively at the surface. A small exposure of grey coarse grained, equigranular to

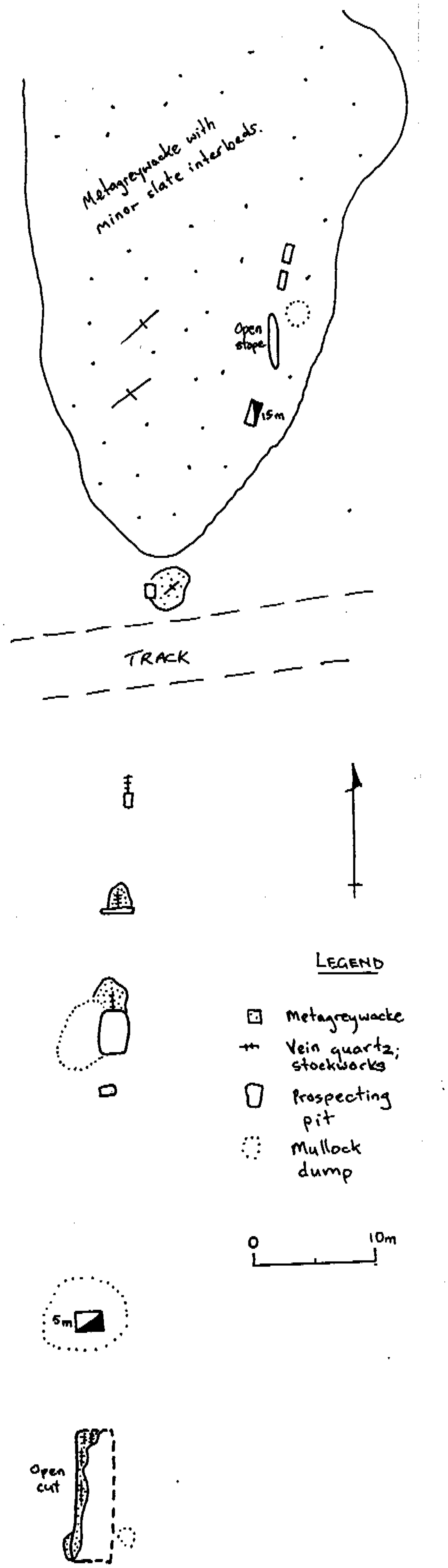


FIGURE 15 Geological sketch of the Union Extended Pb-Ag prospect.

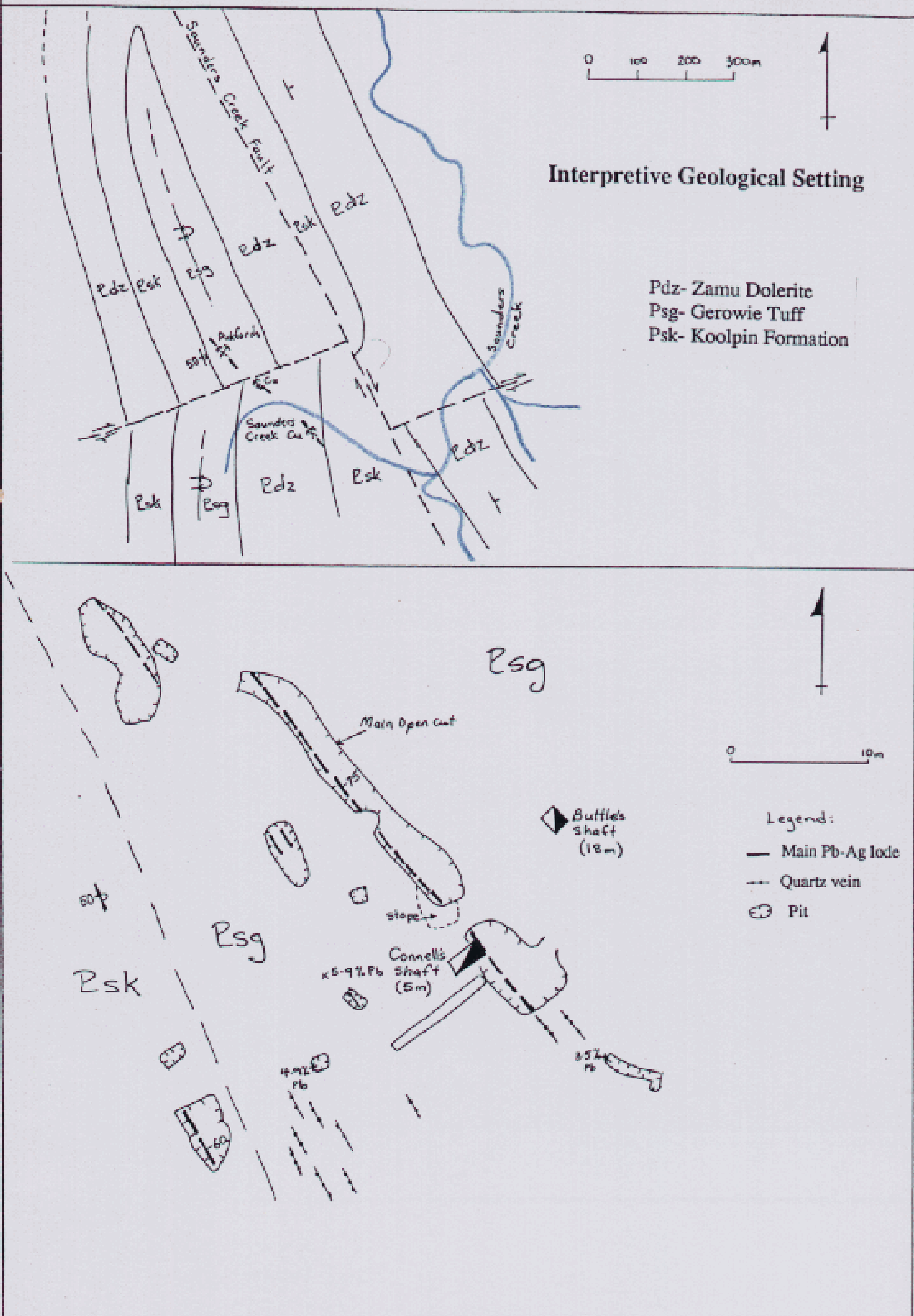


FIGURE 16 Pickfords Pb-Ag mine; geology and workings.
(Modified after Thomas, 1956)

Plate 16 Southeast end of the main open cut at Pickfords Pb-Ag prospect. (tape 1m)

porphyritic granite (Prices Springs Granite) lies about 3.5km the northeast of the prospect. The Prices Spring Granite also probably occupies the significant embayment of no outcrop 2km to the northeast.

Mineralisation

The main lead mineralisation at Pickfords is confined to a northwest (320°) trending shear zone within the silicified argillites. The lode is about 1m wide, dips steeply (75°) to the east and consists of cerussite and galena veinlets associated with coarse grained, white drusy vein quartz.

In polished section (NTGS 9543P- Appendix 1) the ore consists of medium to coarse skeletal galena (10%) anhedra infilling irregular voids and fractures, chalcopyrite forms isolated fine to medium subhedra, and sphalerite occurs as fine exsolution, mainly in galena. The gangue consists of white granoblastic quartz veins, siliceous rock fragments and possibly rhodochrosite.

The quartz vein outcropping just to the east of the silver-lead lode has been tested by two pits and found to contain disseminated medium grained chalcopyrite (6%) and galena (4%) within coarse grained drusy quartz. While a pit sunk on the quartz reef to the north has revealed lead-copper mineralisation containing galena, cerussite, pyrite, chalcopyrite, bornite and malachite.

Further south (90m) along the Pickford line of mineralisation an old shaft can be found on a copper-bearing vein within Zamu Dolerite. The shaft was sunk to a depth of 6m on a 0.3m wide vein which consisted almost entirely of malachite (Thomas, 1956). A chip sample from this lode assayed 15.4% Cu (Harris, 1990). The amphibolite has been moderately sheared and altered to form a chlorite schist. A similar but slightly larger occurrence (Saunders Creek Copper Prospect) lies 150m to the south (Figure 16).

The narrow (1m) and limited strike length (50m) of the silver-lead lode indicates a relatively small potential tonnage for this deposit. Recent chip sampling by Cyprus Gold Aust. Corp. recorded one sample which assayed 3.68% Pb, 45g/t Ag and 3.2g/t Au (Harris, 1990). The other Cu-Pb bearing quartz reefs have not been properly tested, their economic potential still remain low.

Jensen's

Jensen's silver-lead mine (HK 069 706) is located about 850m northeast of the old Pine Creek Railway station. Access is very good with all-weather gravel roads from Pine Creek. The old workings consist of two shafts (>5m), one open cut (11 x 2 x 1.5m) and a few small pits (Plate 17).

The mine was inspected and described by Parkes (1892) and Jensen (1919) but does not appear on any maps of the Pine Creek area. The only record of production is 30t of silver-lead ore in 1908 (NT Mines and Mineral Resources Report, 1908). Visually it appears that about 100t of ore and mullock has been extracted.

The mine lies within tightly folded and sheared phyllites and metagreywackes of the Burrell Creek Formation (Figure 17). In thin section the phyllites consist of 85% sericite, 5% chlorite, 5% quartz and 5% hematite (NTGS 9724- Appendix 1). Bedding strikes northwest (320°) and dips steeply (65°) to the northeast.

The silver-lead mineralisation lies within a north-northwest (345°) trending quartz filled shear zone which dips subvertically (75°) to the east (Figure 17). The quartz-galena lode is 0.5-1m wide and can be traced about 80m along strike.

Cerussite is the dominant ore mineral observed at the surface, while galena is dominant at depth. A chip sample taken by Parkes (1891) assayed 1oz/t Ag and 33% Pb, while a chip sample taken recently from the open cut returned 100g/t Ag and 26% Pb and from a mullock heap next to a shaft assayed 200g/t Ag and 23.2% Pb.

The wallrock consists of partly chloritised and silicified slate, phyllite and medium to fine grained metagreywacke. This old mine appears to carry good grades and has not been tested at depth. If diamond drilling proved the existence of high grade lode at depth, then this deposit could be of interest to small-scale operators.

Plate 17 Jensen's Pb-Ag workings; Shaft No2 and open cut (background).

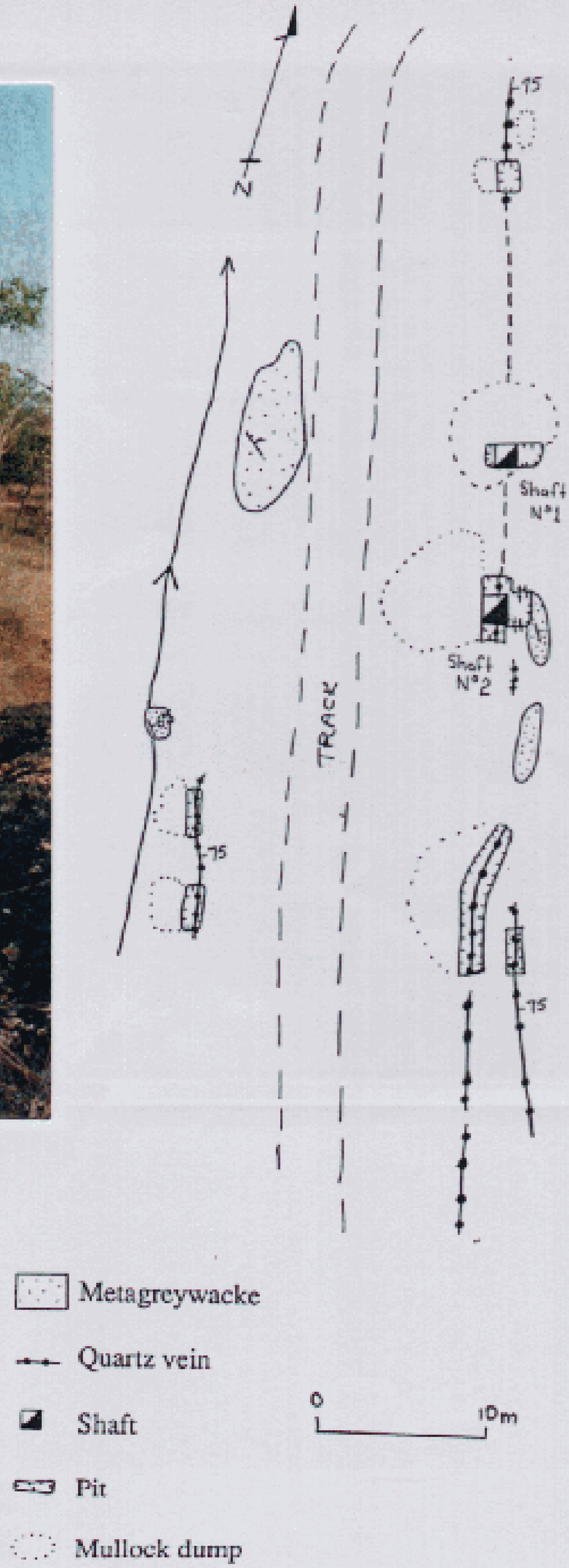


FIGURE 17 Jensen's Pb-Ag mine; geology and workings.

Davis Creek

The Davis Creek silver-lead prospect (GK 725 988) is about 1400 m north-northeast of the Golden Dyke Mine open cut. Access is by the Sandy Creek road which connects the old Stuart Highway with the Fountain Head road.

This small prospect does not appear on any maps covering the area, but was investigated and described by Ellis (1926), a government geologist with the Northern Territory Mines Branch. The prospect was worked in the early 1920s, although no records of production exists.

The old workings consist of two small open cuts and a 2.5m (8 ft) deep pit, now largely infilled . It appears from the size of the workings that about 10t of silver-lead ore has been extracted.

The geology in the vicinity has been mapped in detail by Nicholson (1978). The prospect lies within faulted amphibolites of the Zamu Dolerite on the western limb of the Golden Dyke Dome. The amphibolites strike northwest to northeast around the nose of a subsidiary anticline, with dips in the order of 45 to 65°.

The mineralisation occupies a quartz filled fault which trends northeast (030°) and dips steeply (65°) to the northwest. This particular fault has a strike length of about 3.5km, but the mineralized lode outcrops along the surface for 32m. Patchy coarse grained galena is the principal primary ore mineral with minor pyrite. Cerussite is prominent on surface exposures, along with boxwork textures in the coarse grained, porcellaneous quartz gangue.

Sampling along the length of the 0.5m thick lode returned 65.5% Pb and 192g/t Ag (Ellis, 1926). Assays up to 63.5% Pb and 260g/t Ag have also been recorded. Although this pod of mineralisation is of a very high grade, the lode is known to rapidly thin at depth, which is the reason why the prospect was abandoned (Ellis, 1926).

Basin 6

Introduction

The Basin 6 silver-lead prospect (HK 058 763) lies about 6.5 km north of Pine Creek. Access involves driving 4km north along the Mount Wells road from the intersection with the Kakadu Highway, then turn west and travel 1.5km. The hilly terrain will only allow one to take a 4-wheel drive 700m west.

An old shaft (now infilled), and several prospecting pits constitute the workings (Plate 18). Several costeans were bulldozed, a soil survey and geophysics (I.P. and resistivity) were conducted over the area following several lead, zinc and copper anomalies obtained by a regional stream sediment survey by United Uranium N.L. (Cox, 1969).

Geology

The prospect lies within tightly folded shales, metagreywackes, ferruginous metasediments and cherts of the Mount Bonnie Formation, 1km west of Allamber Springs Granite (a pink, coarse grained, equigranular biotite granite).

Plate 18 Basin 6 Pb-Ag prospect; old workings lie to the left of the costean.

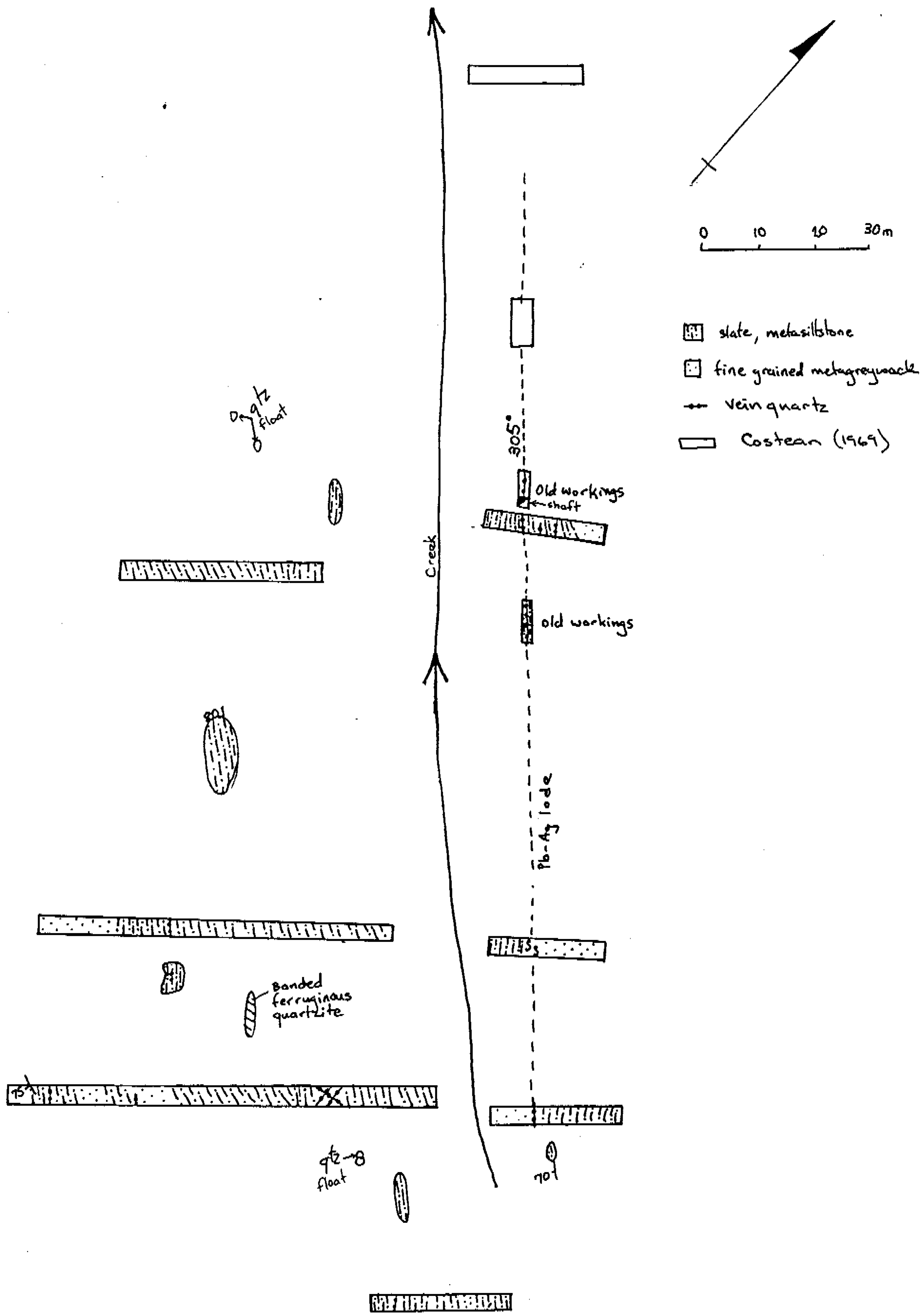


FIGURE 18 Basin 6 Pb-Ag prospect (Modified after Cox, 1969).

In thin section the shales are lithic slates composed of 60% sericite (very fine schistose matrix), 25% quartz (fine grained framework detrital grains and very fine matrix supporting grains), 10% rock fragments (lensoidal cherty grains commonly 1 mm in size), with minor K-feldspar and opaque oxides (NTGS 9679, Appendix 1).

Bedding strikes northwest (300-310°) and dips very steeply (60-80°) to the southwest (Figure 18). Faulting is evident with associated quartz filled fracture zones and brecciated, silicified shales. A north-northwest (340°) fault which contains minor lead mineralisation can be traced over 500 m along strike, while numerous gossanous quartz veins, (up to 500 m in length), extend north of the old workings.

Mineralisation

Mineralisation at Basin 6 is found within the fractures and shear zones. Two areas of mineralisation have been observed. The eastern area (Figure 18), on the old workings where pyrite, galena and cerrusite-bearing vein quartz occupies a 1m wide, northwest (305°) trending vertical shear zone. The ore is in the form of two narrow lenticular lodes (15 and 10cm in width) about 0.9 m apart. Ore samples from the lode assayed up to 620 g/t Ag and 61% Pb (Cox, 1969). Chip samples from the costean next to the old shaft averaged 40 g/t Ag, 5.2% Pb and 0.47% Zn.

The other area is located to the northwest, on a shear zone that extends some 700m. Three costeans were cut, one of which exposed a 2m zone of silicified greywacke and quartz containing minor amounts of galena, cerussite, pyrite and arsenopyrite (Cox, 1969). Samples taken over this zone averaged 100 g/t Ag, 2.9% Pb and 0.33% Zn.

Wallrock alteration is limited to minor pervasive and vein controlled silicification. Surface mineralisation is sporadic, and only low tonnage potential at depth exists.

Quests

Introduction

Quests silver-lead prospect (HK 063 629) is about 6.5 km south of Pine Creek. Access is via an old track which runs southwest from the Lucknow silver-lead mine.

The old prospect was recently discovered by Mr A Quest, a local prospector. Several rock chip samples were taken and assayed by Mr Quest; the best assay returned 13% Pb and 50g/t Ag (Quest, 1988). The working consists of numerous small open cuts, the largest of which is 6.5 x 5 x 3m (Figure 19). It appears that about 50 t of ore and mullock was removed, although no records of production exist.

Geology

The prospect lies within isoclinally folded volcanic arenite and altered basic volcanics of the Burrell Creek Formation. The volcanic arenites are medium to coarse grained, poorly sorted rocks composed of 25% quartz (embayed monocrystalline mainly), 40% rock fragments (chert-sericite, chert, mica schist), 15% feldspar (altered to sericite), 10% sericite (matrix), 5% hematite, 3% biotite with accessory muscovite (NTGS 9701- Appendix 1). The altered volcanics are microporphyritic basalts which have been pervasively altered to a fine grained epidote-quartz-chlorite rock (NTGS 9700- Appendix 1).

Bedding strikes north (005°) and dips subvertically (82°) to the east, forming the western limb of a tight, southerly plunging syncline which has been mapped to the south by the BMR using a volcanolithic conglomerate marker bed. Nearest granite outcrop is the Umbrawarra Leucogranite which lies about 5km to the southwest. Two other large plutons lie within 6 km; to the northwest and east.

Mineralisation

The mineralisation lies within an altered basalt-quartz breccia zone which is about 1m wide and trends northeast (040°), dipping subvertically (70°) to the northwest. Cerussite and pyromorphite are dominant on the surface, with fine to medium grained galena at depth.

The shear zone can be traced for 150m along strike and is associated with weak to pervasive chloritization of the wallrocks. The volcanic host suggests the possibility of a volcanogenic sulphide deposit at depth, similar to the copper occurrences in Daly River Mineral Field. Further investigation of this prospect, using geophysics (electrical and electromagnetic methods) and perhaps some drilling is required to determine the tonnage potential.

About 600m east of Quests Ag-Pb prospect is another silver-lead occurrence which was discovered by Mr Quest. Samples containing up to 90% galena can be obtained from a vertical northwest (340°) trending lode which can be traced over 30m. A small 6 x 3 x 1.5m exploration pit has removed most of the high grade oxidized ore which reportedly returned an assay of 82% Pb and 13oz/t Ag.

The ore visible at present consists of cerussite coated, massive coarse grained secondary galena containing minor quartz and chalcopyrite inclusions (NTGS 9526- Appendix 1). Wallrocks are phyllites which strike 285° and dip 80° south. Quartz veining is common in the vicinity of the lode.

Another silver-lead mine (known as Jones's Mineral Claim), at Pine Creek, near gold section No 214 (Sagabiel lease) is reported to have produced 127t of ore in 1904 and a few more tons in 1905 and 1907. (NT Mines and Mineral Resources Report, 1904; Balfour, 1978).

COPPER

Copperfield

Introduction

The Copperfield copper mine (HK 036 650) is located about 5.5 km southwest of the Pine Creek township, 4 km along the gravel road to Umbrawarra Gorge from the Stuart Highway. Mining activity was intermittent, between 1875 and 1917, producing about 3,450 tonne of ore grading ~25% copper (United Uranium, 1967). Most of the ore was obtained from the 30m thick oxidation zone.

The old workings (Plate 19) consist of at least 15 shafts , the deepest being 40m (down to primary ore), and an open cut 30x2x4m in dimmensions (Figure 20).

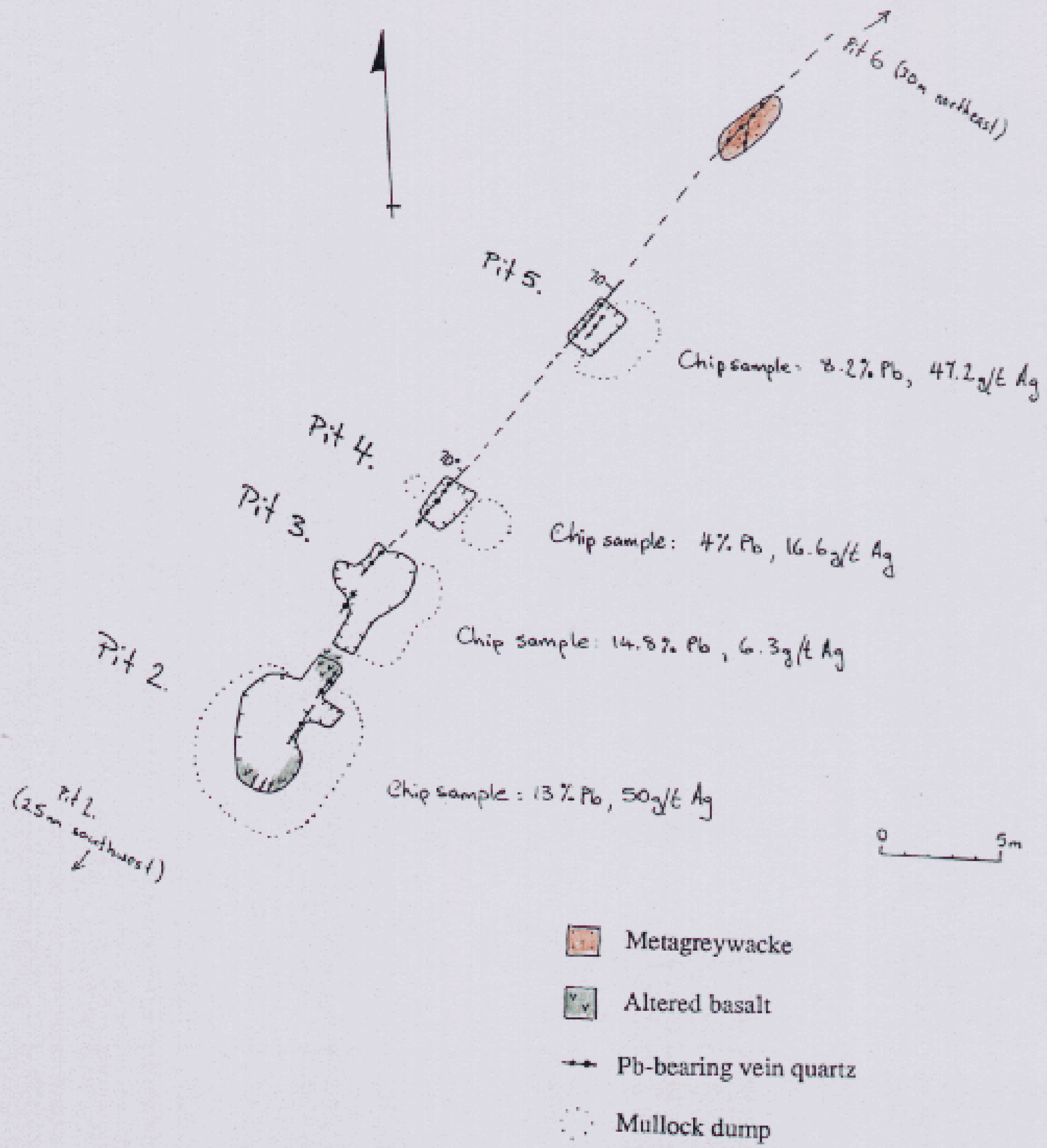


FIGURE 19 Quests Pb-Ag prospect.

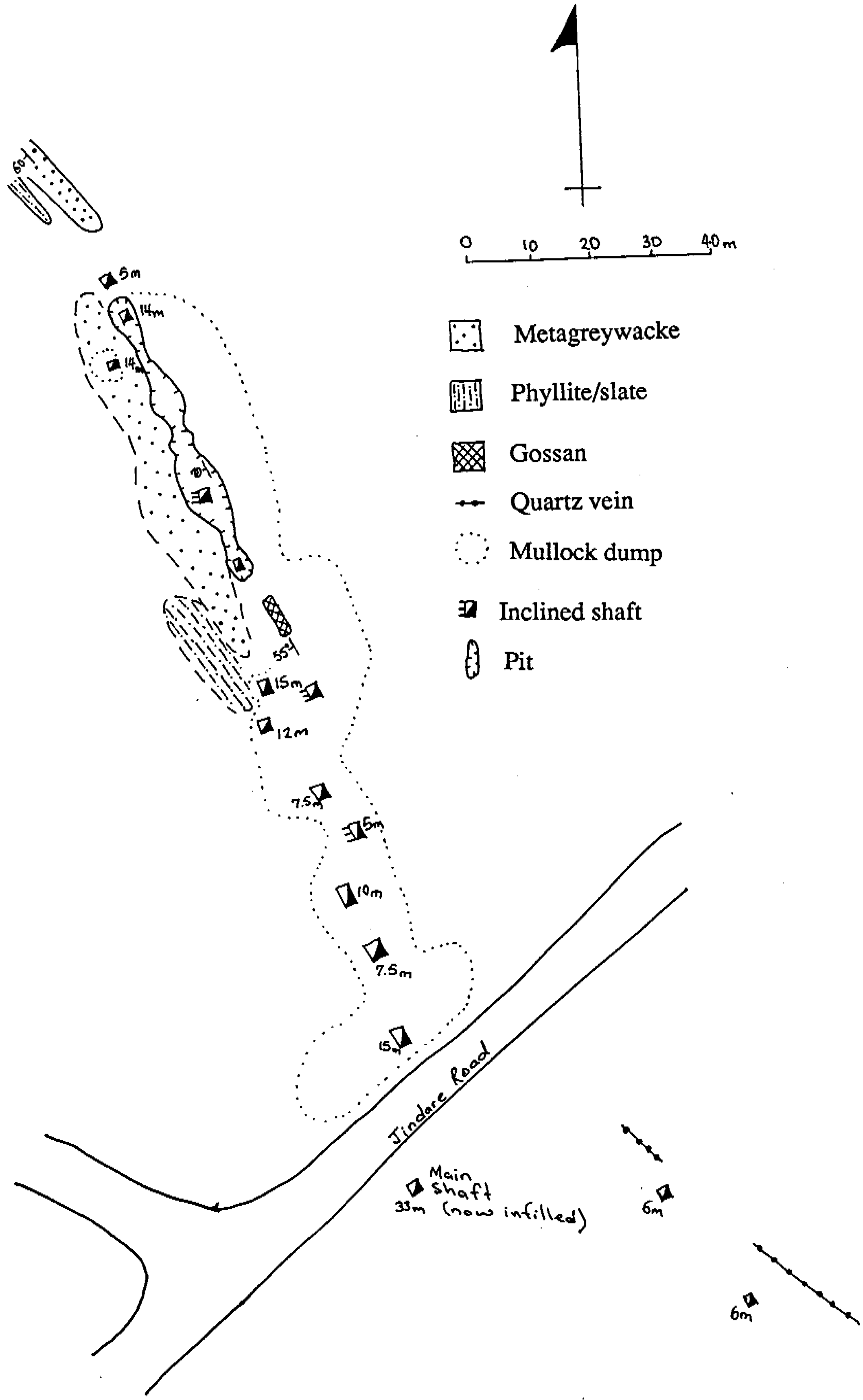


FIGURE 20 Geological plan of the Copperfield mine. (Modified after Herbert, 1990)

Plate 19 Old workings at the Copperfield copper mine; looking south.

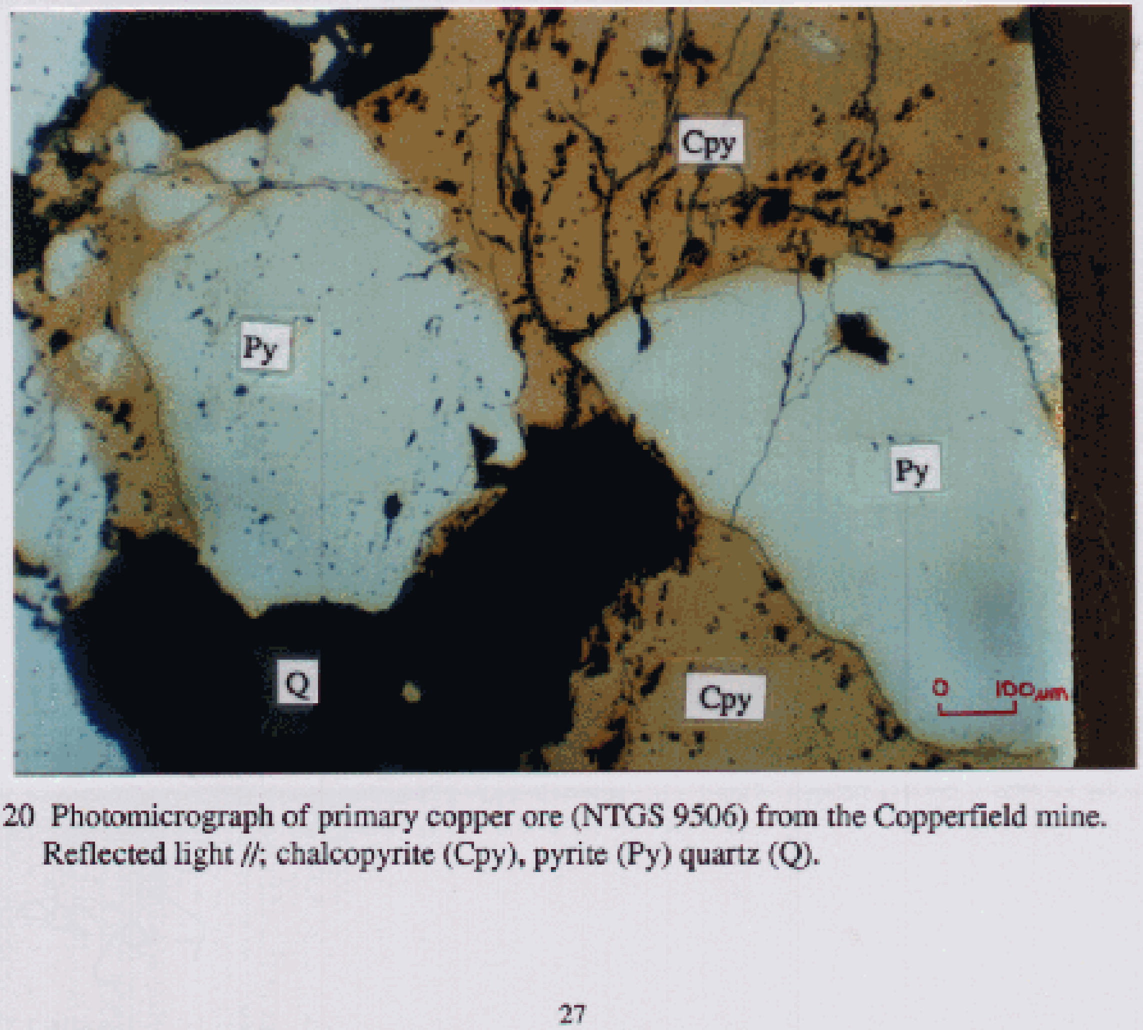


Plate 20 Photomicrograph of primary copper ore (NTGS 9506) from the Copperfield mine. Reflected light //; chalcopyrite (Cpy), pyrite (Py) quartz (Q).

The copper lode was discovered as far back as 1872, but sheer isolation prevented it from being worked. Mining started a few years later when the property passed into the hands of Mr C.G. Miller, who immediately sunk several shafts, including the Main Shaft (18m), No 1 North Shaft (11m) and No 1 South Shaft (18m) when the railway came through (Report on N.T. Mines and Mineral Resources, 1888; in Balfour, 1978). By 1891 511t of ore grading 28% Cu was raised and shipped to Newcastle (Parkes, 1892).

The second phase of production (1915-17) was associated with the southern extension of the lode which was 1.5m wide. Several hundered tonnes of copper ore grading 12-26% Cu was raised from a 50m (163ft) shaft (Reports on N.T. Mines and Mineral Resources, 1915-17; in Balfour, 1978)

In 1971 United Uranium N.L. conducted an I.P. and resistivity survey over the mine area, acccompanied by geological mapping, rock chip sampling and diamond drilling (two holes). Results delineated weak geophysical anomalies coinciding with the breccia shear zone, although no significant copper mineralisation was intersected at depth (Smith and Goudie, 1971).

In 1986 Pine Creek Goldfields Pty Ltd (PCG) conducted a grid-based magnetometer survey following an encouraging gold assay (6.94 g/t) from a rock chip sample adjacent to the workings. The survey results however, did not detect the known portion of the lode (Stephenson, 1986).

Geology

The Copperfield copper mine lies within slightly hornfelsed metagreywackes and phyllites of the Burrell Creek Formation, about 2.5 km southeast of the Tabletop Granite. The metagreywackes in the area are typically medium to coarse grained, fairly homogeneous, well compacted, metasediments.

In thin section the rocks are composed of quartz grains (55-65%) of sedimentary origin, which are subangular in shape, and largely recrystallized in the form of microcrystalline quartz. The relativlely unmetamorphosed grains have ragged (reabsorbtion) grain boundaries commonly lined with sericite. The feldspar grains (10-15%) are altered in varying degrees to sericite and clay.

The sericite/illite and chlorite flakes (10-20%) are considered to be totally recrystallized flakes that were constituents of the sedimentary rock prior to metamorphism (Lau, 1975). While the biotite (5-10%) and muscovite (5%) are totally metamorphic in origin. Several small, detrital, subangular grains of opaque oxide (trace-2%) disseminated thoughout the rocks are often weathered, and display patches of red-brown limonite.

Graded bedding and dropstone structures have been preserved in the greywackes at several localities. The bedding strikes northeast (335°) and dips about 50° to the west. Block jointing and quartz veining in greywacke units is also common.

Outcropping north of the main workings are several discontinuous (up to 30m long) quartz-limonite and quartz-breccia veins within silicified wallrocks which possibly represent extentions of the lode system.

Mineralisation

The mineralisation at the Copperfield mine consists of copper sulphides and carbonates within and close to a conformable quartz-filled breccia zone. The main gossanous lode strikes north-northwest (335°) and dips steeply (50-60°) to the west. At the surface the width of the lode averages about 1m (0.9-1.5m), and can be traced over 200 m along strike. The lode system appears to have been produced by shearing, with the open cut occupying a gape zone produced by twisting and warping of the wallrocks (pers comm. Herbert, 1990).

Pyrite is the dominant sulphide at depth, forming coarse subhedral grains which may be fracture filling, or irregular fragments within the coarse, granoblastic quartz gangue. Chalcopyrite may be present within pyrite either as exsolutions or fracture filling (NTGS 9506- Appendix 1) or occur separately as irregular coarse gained, fracture and void filling crystals (Plate 20). Chalcocite with lesser covellite and bornite are the dominate ore minerals within the supergene zone. Workings indicate that the grade and width of the lode decreases at depth.

United Uranium N.L. (1967) has estimated a possible 90,000 t of ore remaining, grading 6.1% Cu and 185g/t Ag. Further RAB drilling and rock chip sampling has been recently (1989) completed by PCG, to determine the gold -bearing potential (pers comm. Herbert, 1990).

This deposit is typical of the vein type copper occurrences throughout the Pine Creek Geosyncline, which generally occupy fault or shear zones within 3km of outcropping granite plutons.

Enterprise No 2 (ML613a)

Introduction

The Enterprise No 2 copper prospect (HK 040 677) is about 2.5 km southwest of the Pine Creek township. Access to the prospect is by a vehicle track some 750 m southwest from the T intersection of the gravel road to Brian May's property and a gravel road to the Enterprise Gold Mine. The prospect is currently (1988) owned by Mr M J Oates, but has not been worked for several years.

The prospect was investigated during 1974-75 by the Northern Territory Geological Survey (Newton, 1975) which conducted geological mapping and a diamond drilling programme of 5 holes totalling 402 metres, which targeted possible enrichment of two copper bearing quartz veins at depth. Results indicate that there is no significant mineralisation at depth.

The workings consist of a 6 m shaft (Plate 21) and two shallow costeans. Two parcels of ore totalling 28.5 t were treated at the Mt Wells battery for evaluation purposes in 1974 (Newton, 1975). Results were not encouraging, with grades averaging about 1% Cu.

Geology

The Enterprise No 2 Cu prospect lies within hornfelsed arenites of the Burrell Creek Formation in the contact aureole of the Tabletop Granite. The wallrock is dark grey, medium to fine grained, hornfelsic volanic arenite, which in thin section (NTGS 9502- Appendix 1) reveals a fairly homogeneous, well compacted, moderately sorted

Plate 21 Shaft site at the Enterprise No2 copper prospect.

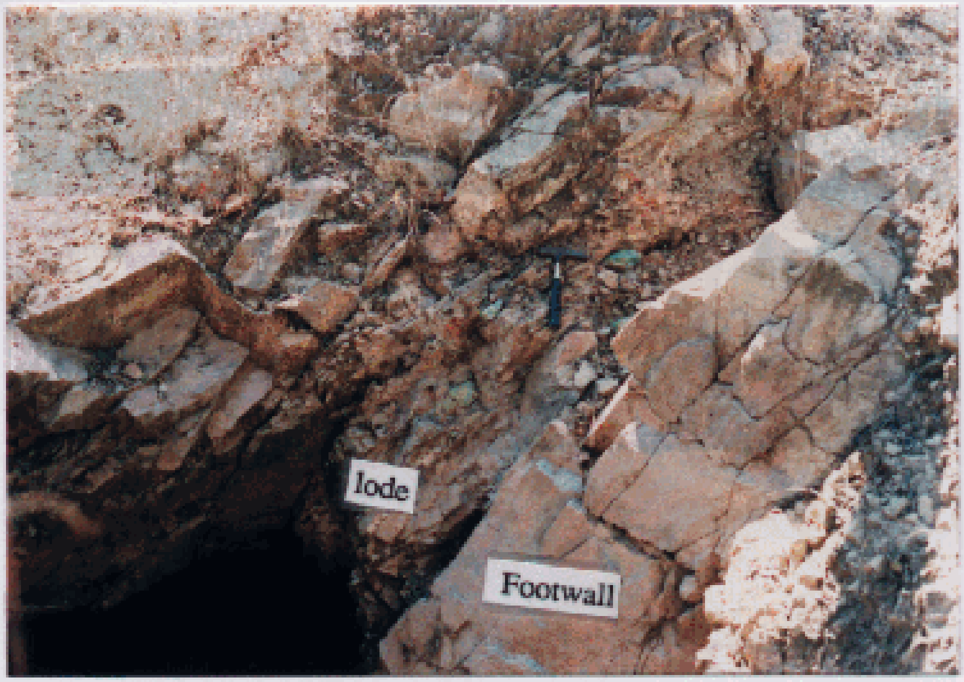


Plate 22 Copper-bearing quartz lode expose in the shaft at the Enterprise No2 copper prospect.

metasediment composed of 45% quartz (discrete, subangular monocrystalline, framework grains), 30% rock fragments (quartzitic and cherty-serictic composition, with a granoblastic-interlobate texture), 10% feldspar and 5% chlorite (schistose matrix).

Several exposures of leucocratic, medium to coarse grained pyrrhotite-bearing aplite can be observed in the creek south of the shaft, which intrudes the hornfels (Figure 21). These aplites are the granites described by Newton (1975) in the drilling logs.

In thin section (NTGS 9679- Appendix 1) the aplite is of adamellite composition and consists of 40% K-feldspar (originally microcline, now largely altered to sericite), 30% quartz, 20% plagioclase, 7% biotite (disseminated, ragged grains often altered to olive green chlorite), 3% calcite (replacing feldspars) with minor zircon and opaques (pyrrhotite, scheelite and pyrite). Jointing in the area is typically north-south, dipping steeply to the west.

Mineralisation

The main copper-bearing quartz vein strikes north-northeast (010-020°) and outcrops discontinuously over a strike length of 330m (Newton 1975). Where the shaft is located the vein is about 0.5 m thick and dips 60° to the west (Plate 22). Malachite is the main copper mineral present, commonly staining the joint surfaces of vein quartz. Azurite, chalcocite and chrysocolla were seen on the dumps, while cuprite and koechlinite ($Bi_2O_3.MoO_3$) have been recorded by Newton (1975).

The mineralisation at depth is largely in the form of veinlets and disseminations of chalcopyrite within the granoblastic quartz gangue, however stockwork veinlets exist in the brecciated wallrock. Wallrock alteration is in the form of selective and vein controlled sericitization, silicification and chloritization.

The best drillhole intersection obtained by Newton (1975) was 0.5m (35.5-36.0m) grading 1.6% Cu from a quartz vein which contained veinlets of chalcopyrite, along with minor chalcocite and bornite, in DDH 1. Minor K-feldspar enrichment was also recorded in aplites adjacent to quartz veins.

A second quartz vein is exposed about 100m west of the shaft and appears to outcrop again in the creek (Figure 21) where it contains malachite and minor cuprite, chalcocite and koechlinite (Newton 1975). The failure to intersect significant grades in the main copper lode at depth in the drilling program serverly downgrades any ecomomic potential for copper-bearing quartz veins in the area.

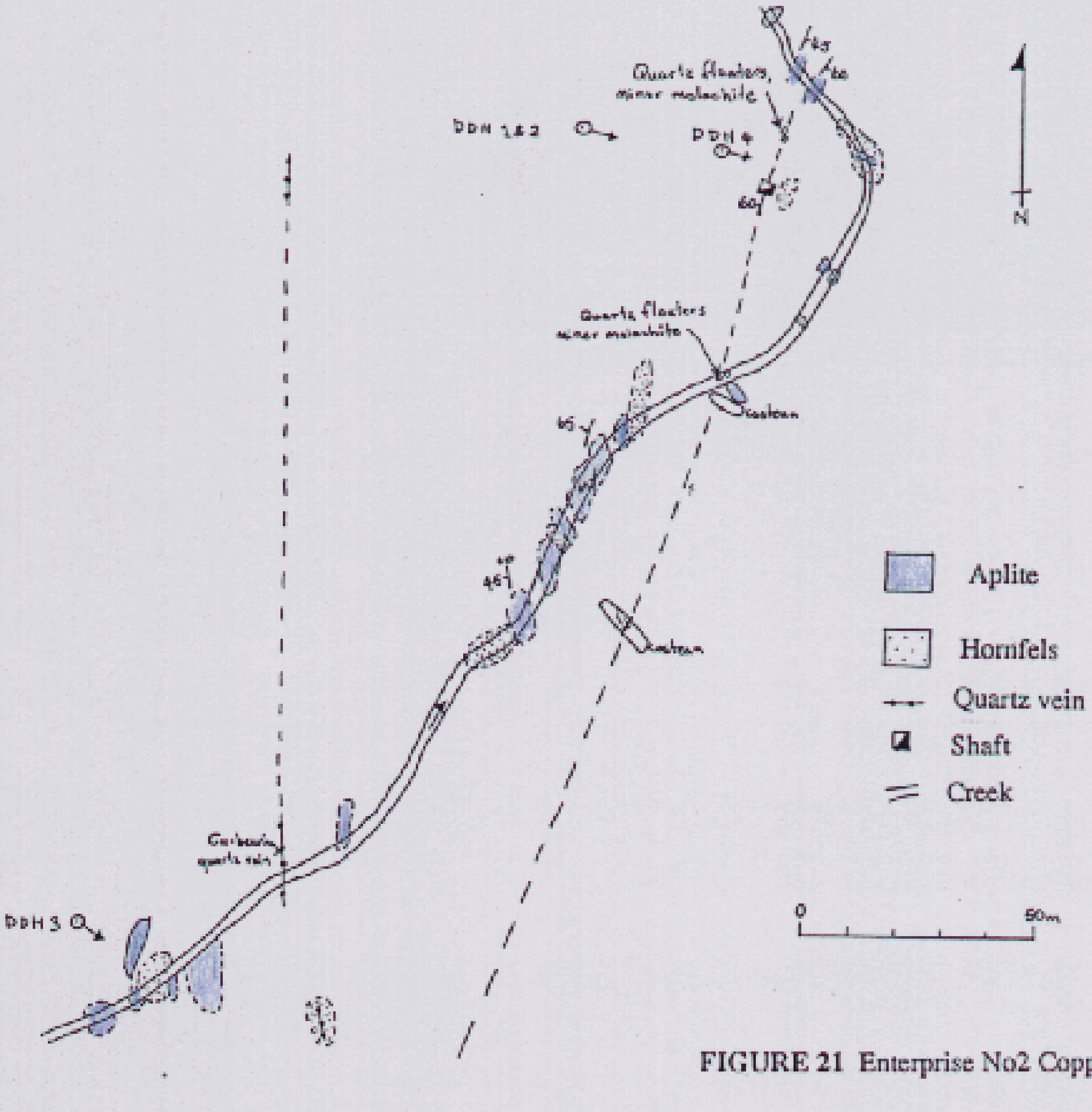


FIGURE 21 Enterprise No2 Copper prospect.

The Jar

Introduction

The Jar copper prospect (GL 717 053) is located about 5.5km southwest of Grove Hill Siding and can be reached by taking the Fountain head road to the Sandy Creek turn-off, travel south on the gravel road for about 3km then turn west and cross-country for about 3.5km.

The old workings consist of a series of shallow north trending pits and 2 shafts (one about 6m deep, the other infilled) which cover a strike distance of approximately 75m (Figure 22). About 1 500-2 000 t of ore and waste has been extracted (Ivanac, 1970).

The unrecorded, old Chinese workings were discovered during a regional survey by Central Pacific Minerals (CPM) in 1970 (Baarda, 1973). Geological mapping, geochemical soil and weathered bedrock sampling, costeaning, ground geophysics (Magnetic, S.P. and EM surveys) and percussion drilling were carried out by CPM (Ivanac & Darby, 1970; Shields & Pietsch 1971; Baarda, 1973). While the BMR had conducted a self-potential and EM survey over the area (Bullock, 1971).

CPM concluded that although the mineralized zone was persistent along strike, the grade proved too erratic and reserves insufficient to warrant further development of the prospect.

Geology

The Jar copper prospect lies on the western limb of a north-northeast trending anticline. Metagreywackes and slates of the Burrell Creek Formation are exposed in the area. Bedding strikes northeast (020°) and dips 55° to the west.

Outcrop is sparse in the vicinity of the mineralisation and often covered by alluviated areas and scree. Medium to fine grained quartzwackes commonly form the wallrock. In thin section (NTGS 9551- Appendix 1) the quartzwackes appear as a fairly homogeneous, loosely packed aggregate of monocrystalline quartz (32%), siliceous and chloritic rock fragments (35%), sericitised feldspar (5%) and accessory tourmaline grains within a siliceous-sericite matrix (25%).

Mineralisation

The mineralisation at the Jar copper prospect consists of a 1 m wide north-northwest trending copper bearing shear zone within silicified metagreywackes. The mineralized zone is discontinuously exposed over 700m and consists of quartz-limonite and boxwork gossanous material containing malachite, azurite, chalcocite and rare cuprite. Malachite is the princpal ore mineral, typically massive to botryoidal in form and often occurring as veinlets in fractured wallrock or staining on quartz veins.

Percussion drilling suggests that mineralisation near the costeans is confined to narrow veinlets of hematite and quartz in choritic shale over a width of <3 m (Ivanac & Darby, 1970). Two holes drilled to intersect the mineralisation below the costeans obtained values of 2 500 to 4 200ppm Cu over a 3m interval, with one 1.5m sample assaying 5.2% Cu (Baarda, 1973).

The Jar copper prospect appears to be a hydrothermal vein type deposit. While quartz veining is quite common in the area and associated with zones containing mineralisation, there is not as much quartz veining as there is on more typical hydrothermal vein type deposits. Small veinlets of granite have however been observed by CPM geologists in the area (Ivanac & Darby, 1970).

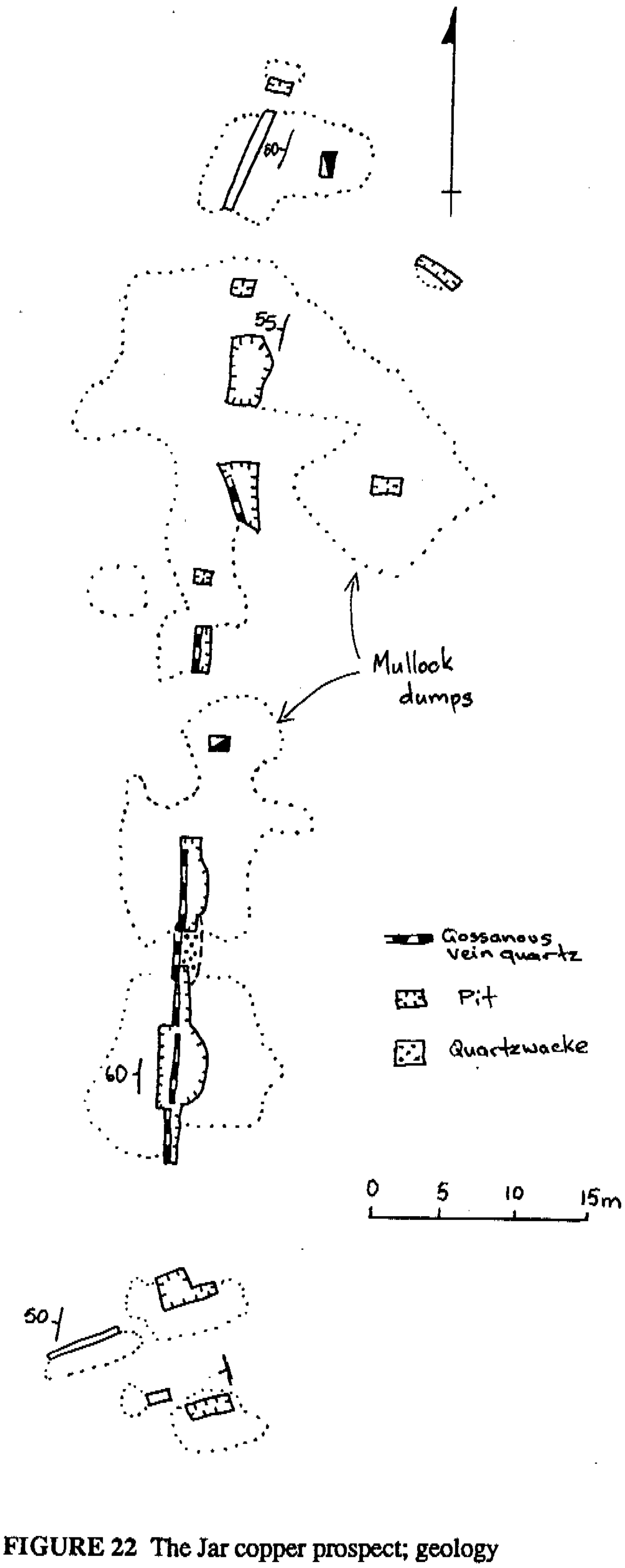


FIGURE 22 The Jar copper prospect; geology and workings (Modified after Shields & Pietsch, 1971).

Saunders Creek

The Saunders Creek copper prospect (GL 820 010) is located about 6 km east of the Mount Bonnie open cut. Access is by a poorly defined track which leaves the Mount Wells-Fountain Head road about 500m west of the Saunders Creek crossing.

The prospect was briefly inspected by the Enterprise Exploration Company Pty Ltd in 1956 during an appraisal of Pickfords silver-lead prospect, located about 250m to the north. Total recorded production is 20t of ore grading 15-20% Cu which was mined in 1955 (Thomas, 1956).

The old workings consists of two shafts, now collapsed which were sunk 9m (30') and a small open cut (5 x 1.5 x 1m). Workings were abandoned due to the heavy inflow of ground water.

In 1959 the BMR conducted a reconnaissance stream sediment survey to delineate areas of base metal mineralisation (Corbett, 1960). Several samples were taken from Saunder's Creek and its tributaries. Only samples taken in the vicinity of the copper occurrence gave anomalous results (Corbett, 1960).

The copper prospect lies within altered quartz dolerites (Zamu Dolerite), which strike northwest (340°) and dip steeply (50°) to the southwest. The dolerites form a bouldery ridge which rises about 15-20 m above the creek.

The mineralisation is located in sheared and chloritized amphibolites in the form of malachite coatings at the surface and disseminated chalcopyrite in 0.3-0.4 m quartz veins at depth (7.5m). A 1.5m wide shear zone which strikes northwest (315°) and dips 70° to the northeast can be traced for 15m along the surface.

This shear zone appears to be the southern extension of the shear which hosts the lead-silver mineralisation at Pickfords. Quartz veining is common, in the form of thin and irregular white veins within fractured amphibolites. Chloritisation and silicification is visible on the wallrocks.

Granite Mine

The Granite Mine copper prospect (GK 852 861) is located about 5km south of the Emerald Springs Roadhouse. Access is poor, and involves 5-6 kilometers of cross-country driving.

The prospect was inspected by Watts (1969), following a request by Mr T V Collins, holder of the Authority to Prospect over the area. A mention is also given in the NT Mines and Mineral Resources Report in 1904 which states that a few Chinese sunk a shaft on a copper lode in granite country 8 miles southwest (?) of Spring Hill which returned 5t of ore grading 50% Cu (Balfour, 1978).

The workings (Figure 23) consist of numerous small open cuts and pits from which about 200t of ore and mullock has been extracted. A chip sample taken from one of the mullock heaps assayed 20.8% Cu and 0.236g/t Au (NTGS 9807).

The copper prospect lies within biotite-hornblende granites of the McMinns Bluff Granite. In thin section (NTGS 9811- Appendix 1) the granite consists of 40% microcline, 20% quartz, 20% plagioclase (partially sericitised), 10% biotite, 5% chlorite and 2% hornblende.

The mineralisation is contained within a 1-1.5m wide vein quartz-breccia lode (Plate 19) which occupies a vertical, northeast (040°) trending shear zone which can be traced over 250m along strike (Watts, 1969).

Plate 23 Old workings at the Granite copper mine; looking northeast.

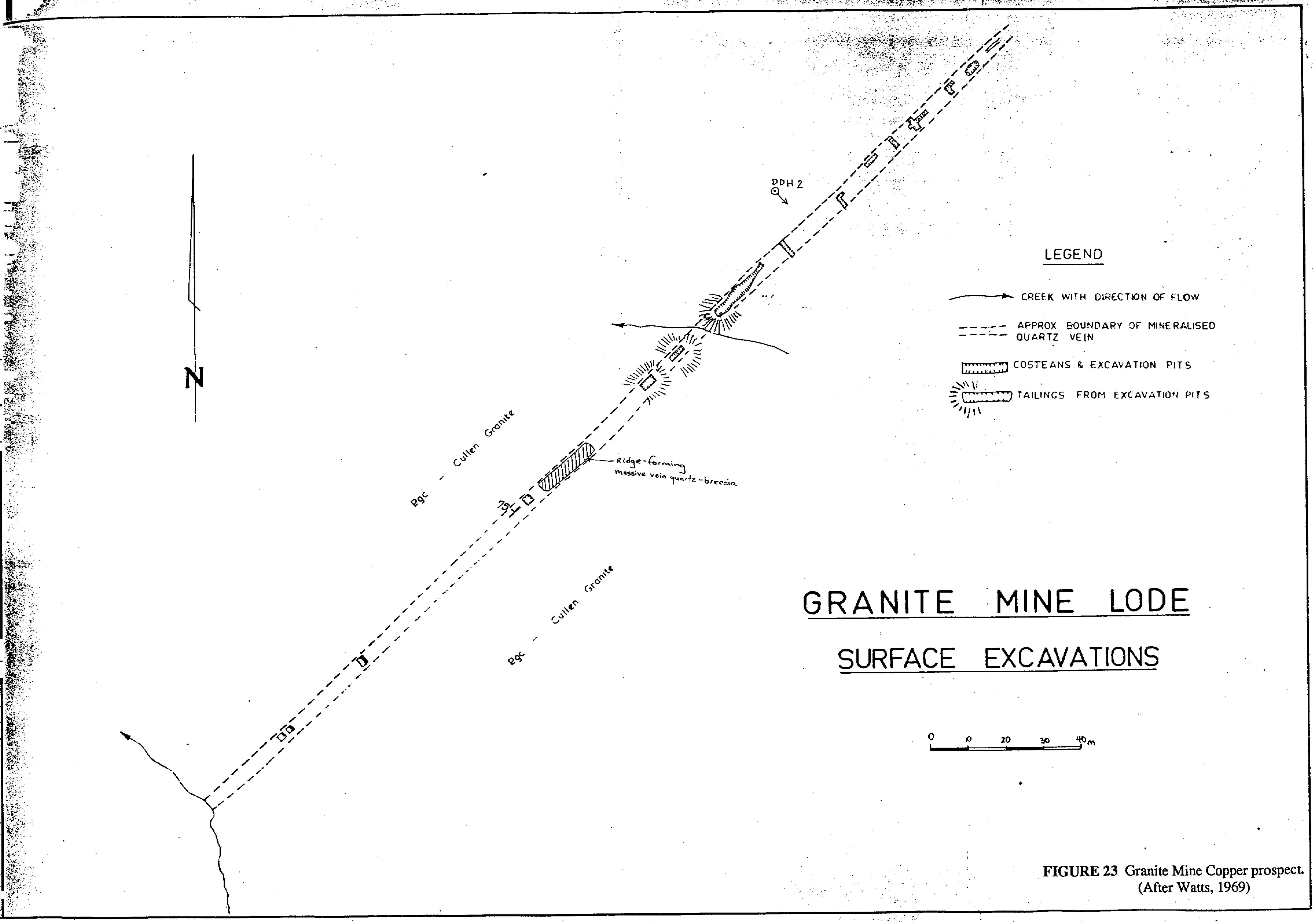


FIGURE 23 Granite Mine Copper prospect. (After Watts, 1969)

Examination of the outcrops suggests that the lode actually dips very steeply (75°) to the northwest (Figure 24).

On the surface, the mineralisation consists of malachite, chalcocite and chrysocolla within a quartz-chlorite-feldspar gangue. At the southern end of the lode hematite appears to be the dominant gangue mineral (Watts, 1969). In thin section the copper mineraliztion is located in vein quartz as veinlets (up to 2mm) and disseminated aggregates, along with hydrothermal chlorite (Mg-Al rich variety) in brecciated and partially recrystallized granite (NTGS 9805 & 9807- Appendix 1).

Silicification and chloritisation of the wallrocks is clearly visible at the surface and in drill core samples. It appears that two shallow diamond drillholes have been sunk to west of the lode, however there are no known records or results.

Heatley's

Heatley's copper workings (GK 742 991) are located about 2.5 km southwest of the Mount Bonnie mine open cut. See page 12 for access directions.

The nature of the copper mineralisation has been briefly described in a report by Ivanac & Darby (1970) and examined by Nicholson (1978). The workings consist of four small pits, the largest 8 x 2 x 1 m in dimensions. There are no records of production.

The pits lie within subvertically (85°) dipping Gerowie Tuff on the eastern limb of the Golden Dyke Dome. The Gerowie Tuff in this area consists of a sequence of interbedded tuffaceous pelites, phyllites and tuffaceous cherts or ashstones. The tuffaceous pelites are light grey laminated shales with angular and moderately sorted grains of quartz (60%), plagioclase (20%) and K feldspar (20%). The ashstones are usually well laminated rocks with 5-10% angular grains of quartz, plagioclase and microcline within a matrix (90-95%) of quartz, albite and biotite (Nicholson, 1978).

The lower 75 m ("Burrell Creek Facies") of the Mount Bonnie Formation lies within the Heatleys area (Figure 8). Two feldspathic greywacke-mudstone horizons, both 30-40 m thick, separated by about 50 m of interbedded phyllite and ashstone are exposed to the northeast of pits No3 and 4.

Two major and two minor sills of Zamu Dolerite are exposed in the area. The rock is typically green-grey, medium grained and equigranular in hand specimen, and composed of dark green, ragged actinolite anhedra (60-70%), oligoclase to andesine feldspar (An_{30-40}), quartz, biotite with accessory sphene, magnetite and pyrrhotite. A remanant subophitic texture is often visible.

The mineralisation consists of malachite and azurite-bearing quartz veinlets within fractured shales. In pit No 1 quartz veining is both concordant and discordant to bedding. The mineralized zone trends northeast (060°), dips 75° south, and is about 0.5m wide and 5m long.

In pit No 3 quartz stringers (up to 7cm wide) are largely conformable to bedding. While in pit No 4 a 4 m wide joint controlled stockwork zone can be observed in silicified shales. Pit No 2 was not inspected, but is known to host a conformable quartz vein which has returned 6.2% Cu and the wallrocks 4.0% Cu (Nicholson, 1978).

Brecciation and silicification is evident to varying degrees at each pit.

Lewis' Prospect

Introduction

Lewis' Prospect (GL 965 029) lies about 4km southeast of Mt Wells. Access is via a track down to the McKinlay River which leaves the road to Mt Wells (Figure 25).

During a geochemical survey in 1972 by the NTGS (Willis, 1973) within ML 387A and 388A, four separate ferruginous quartz veins were examined. Assay results from the grab samples were encouraging, so the survey was followed up by two diamond drill holes to test the mineralisation associated with the most persistent and promising vein (V1). However, only minor mineralisation was encountered in diamond drill hole 1 (47.5-50.0m: 4080ppm Cu, 2250ppm Pb, 2660ppm Sn, 470ppm Zn), while diamond drill hole 2 did not intersect the shear (Willis, 1974).

Geology

Metagreywackes, hornfels and slates of the Burrell Creek Formation host the limonitic quartz veins at Lewis' Prospect. The McKinlay Granite (a pink-green, medium to coarse grained, porphyritic, hornblende-biotite granite) is exposed about 1km to the southeast. Bedding and quartz veining strike north-south (350°) and dip steeply (60-80°) to the east (Figure 25). Four significant quartz veins (V1, V2, V3, V4) were mapped by Willis (1973).

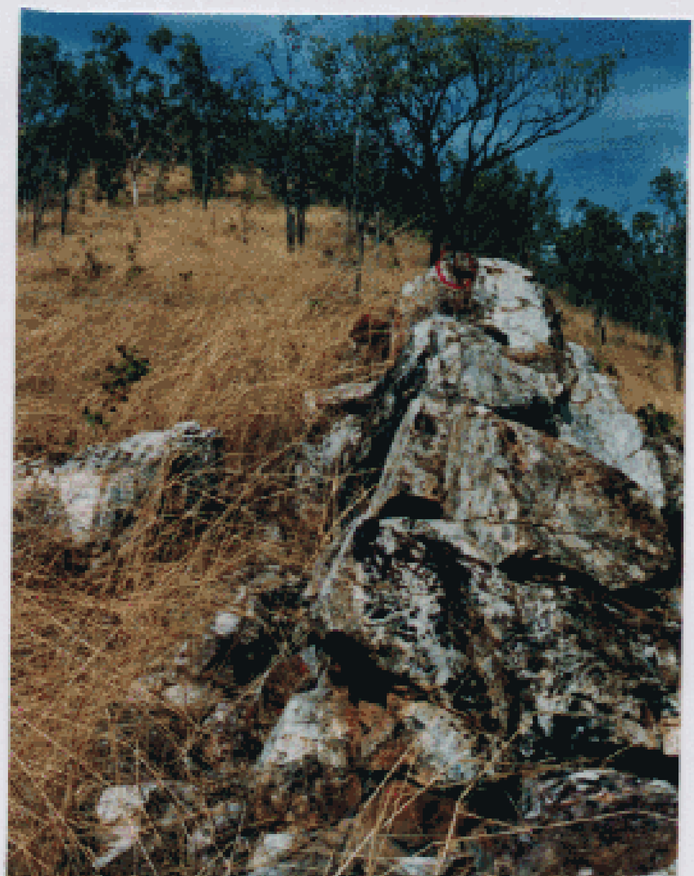


Plate 24 Gossanous quartz vein (V1), Lewis' Prospect.

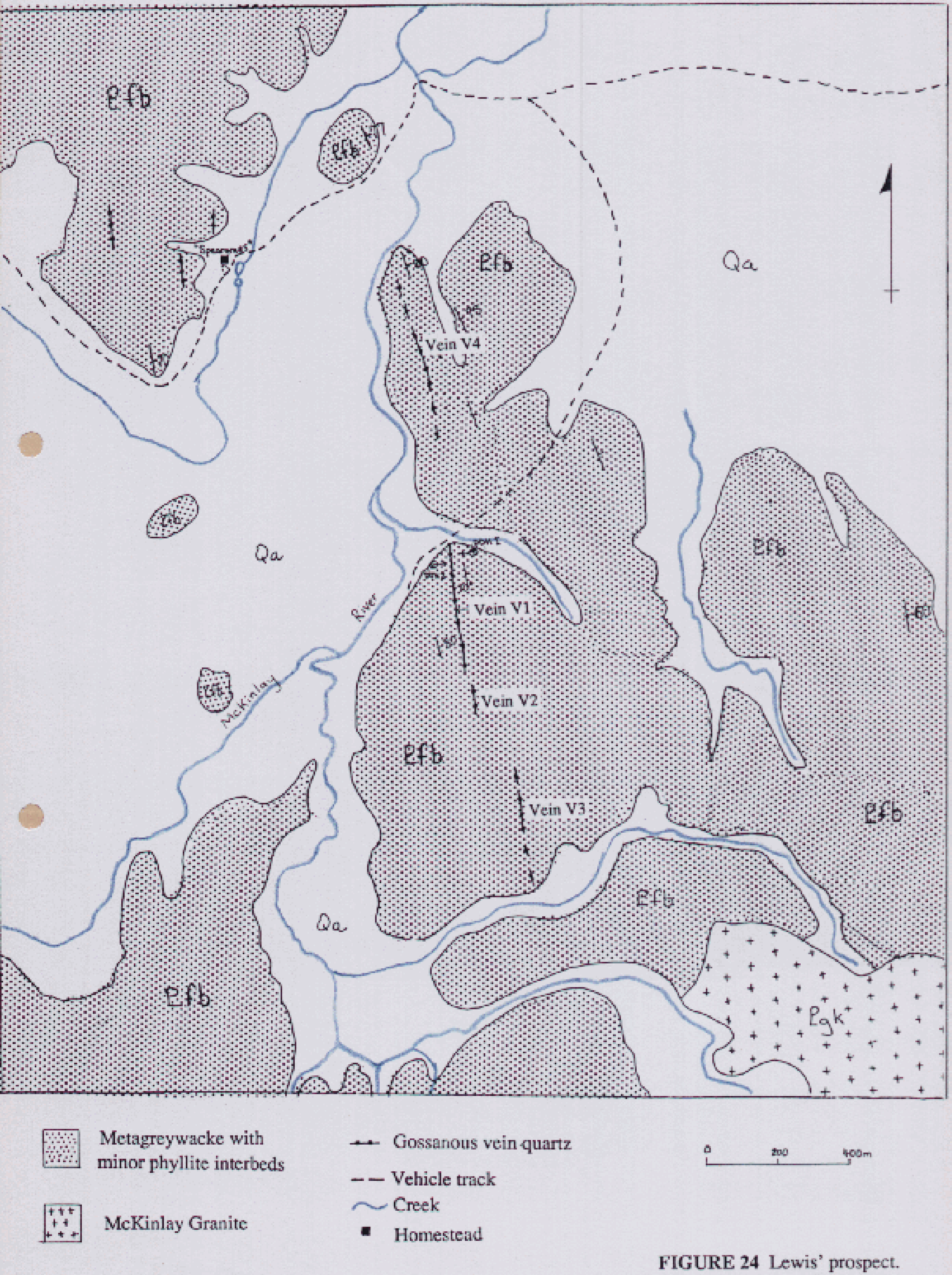


FIGURE 24 Lewis' prospect.
(After Willis, 1973)

Mineralisation

The mineralisation at Lewis' Prospect is present within a fault which on the surface is represented by a series of discontinuous gossanous quartz veins (Plate 20) containing brecciated wallrock (greywacke) fragments. The main outcropping vein (V1) occupies the crest of a prominent ridge and can be continuously traced along strike for 430m. The vein width varies from 0.6 to 3m, strikes north-south, and dips about 70° to the east.

At the surface the vein consists of coarse, white granoblastic quartz, limonite (with boxworks after pyrite), and greywacke fragments. Grab samples assayed up to 1120ppm Cu, 5660ppm Pb, 198ppm Zn, 1000ppm Bi, 1.3% Sn and 28ppm Ag (Willis, 1973).

The other veins (V2,V3,V4) are smaller and less persistent, but similar in composition and orientation. Chip sampling (NTGS 9542) of the veins revealed fine pyrite and rare galena within a fine milky quartz gangue, with some of the sulphides concentrated around host wallrock (grey patches) inclusions.

Diamond Drill Hole 1 intersected a chloritised shear zone within metapelites between 46 and 56m mark, which contained minor mineralisation (pyrite + chalcopyrite), and is thought to represent the gossanous quartz-greywacke breccia vein exposed on the surface (Willis, 1974). The two shears are however, lithologically quite distinct. A 60cm thick (77.6-78.2m) quartz vein containing minor sphalerite and galena was intersected below the chloritic shear zone. But this interval was not assayed, and may represent the quartz vein exposed at the surface.

The potential of Lewis' Prospect appears very low given the poor base metal and precious metal assays obtained from surface and subsurface sampling. The vein does however, represent the typical blocky, gossanous quartz-breccia veins which carry base metal mineralisation which have been economically exploited in the past.

Burrundie

The Burrundie copper prospect (GK 836 994) is located about 9 km west-southwest of the old Burrundie Siding. Access appears difficult, so the prospect was not inspected.

This prospect was investigated in 1971 by IMC Development Corp under a Joint Venture agreement with Jingellic Minerals NL, holder of the mining tenements over the prospect.

Geological mapping, rock chip sampling and diamond drilling was carried out by IMC Development Corp with poor results (Mookhey, 1971). Geologically the prospect lies within metasediments of the Koolpin Formation and intrusive rocks assigned to the Zamu Dolerite which strike north-northwest and dip very steeply (70°) to the west.

The Koolpin Formation in the area consists of dark green to black, carbonaceous and partly pyritic slates, banded iron-silicate rocks with chert nodules and abundant pyrite (laminae and disseminated), and massive marble with traces of disseminated pyrite (Maddocks, 1985). The Zamu Dolerite consists of amphibolites in which the pyroxene constituents have been completely uralitised to irregular laths of actinolite, and the plagioclase constituent has been either completely saussuritised to very fine grained carbonate, ablite and epidote, or retained as diffusely twinned laths of feldspar An_{40} (Maddocks, 1985). Opaques include leucoxene after skeletal ilmenite dissemination and trace to minor amounts of pyrrhotite and pyrite.

The metasediments and amphibolites are displaced by a major normal cross-fault, which trends east-northeast (060-080°) and dips 75-82° to the south, with a left lateral displacement of 60m. A second normal step fault lies 75m to the south. Siliceous, kaolinitic and limonitic breccia zones, up to 30m wide, are present (Mookhey, 1971).

On the surface, copper mineralisation is present within banded gossanous rock (chip sample assayed 24.6% Cu) formed from the weathering of sulphide bearing, banded-iron silicate units of the Koolpin Formation. At depth, the copper mineralisation is very minor and largely confined to vein quartz breccia within amphibolites. Best intersection returned 0.2% Cu over 0.65m (DDH B1 15.55 - 16.20m).

Minor sphalerite within vein quartz in carbonaceous shale was also intersected in DDH B1 (198.40 - 198.95), which assayed 0.36% Zn.

UNNAMED COPPER OCCURRENCES

A minor copper prospect (**GL 747 015**) lies about 4 km northeast of the Golden Dyke mine open cut. Access is good, but involves a 700m walk on foot to the site of the workings.

The prospect was located by Peter Nicholson during a mapping honours project (Nicholson, 1978). There are no records of production or previous exploration. Workings consists of a small collapsed pit and an open cut with a 5m inclined shaft (Figure 26).

This prospect lies within steeply dipping (60°E) laminated quartzitic siltstones (NTGS 9692- Appendix 1) and volcanic lutites of the Gerowie Tuff, which occupy the eastern limb of the Golden Dyke Dome. Granite subcrops assigned to the McMinns Bluff Granite are found 5 km to the south.

The mineralisation lies within a conformable quartz breccia lode which strikes northwest (346°) and dips steeply (55-60°) to the east. The lode is about 1m wide and can be traced on the surface for 10m. Malachite is the dominant ore mineral on the surface, typically infilling fractures and voids within the vein quartz and wallrock. Minor chalcocite and azurite are also present. A chip sample assayed 9.5% Cu (Nicholson, 1978).

In thin section (NTGS 9681-Appendix 1) the wallrock appears to be veined meta-lutite, which consists of 45% sericite (forming a fine matrix with a distinct foliation), 30% quartz (fine siliceous matrix and minor dispersed grains), 10% K-feldspar, 5% rock fragments (chert-sericite), 5% metamorphic muscovite (0.1 to 0.5mm) and 5% malachite (vein controlled).

Nicholson (1978) has located another copper occurrence (**GL 740 013**) about 2.5km further north, near the Good Shephard Gold Mine. The host rocks are metasediments of the Koolpin Formation which strike northwest (345°) and dip 72° to the east. An examination of a polished sample showed that pyrite (with hematite rims), chalcopyrite and

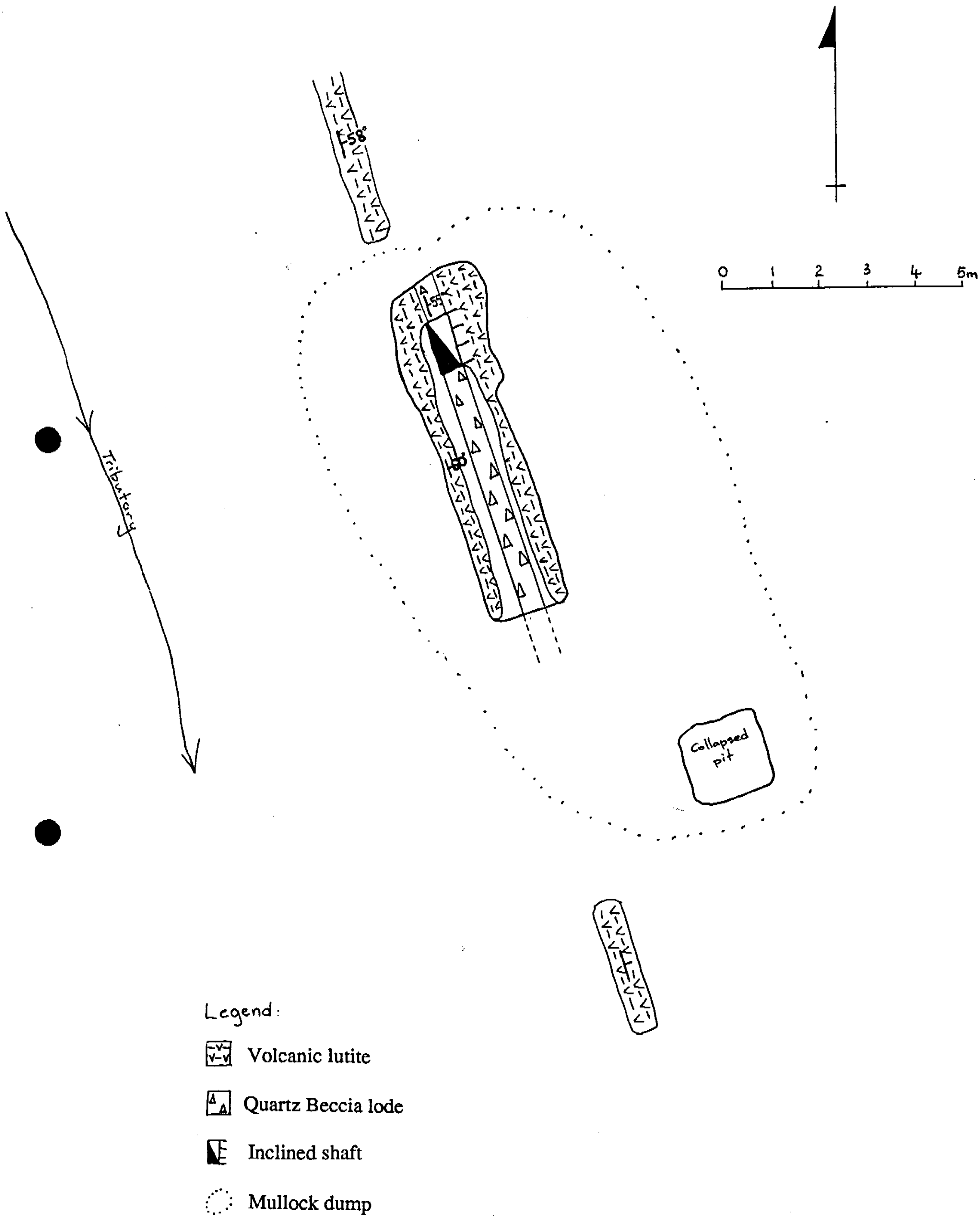


FIGURE 25 N2 copper prospect; geological sketch.

covellite were originally deposited (Nicholson, 1978). A chip sample assayed 16% Cu and 5g/t Ag.

A significant copper prospect (**GL 753 041**) is located about 700m southwest of the Iron Blow Mine open cut. Access is by a track to the Iron Blow Mine and then by foot up to the workings near the crest of a north striking ridge.

No information is available concerning the history of this prospect. The workings consist of several small open cuts, the largest 9 x 4 x 2m in size (Figure 26). Visual inspection of the excavations indicates that approximately 200t of ore and mullock has been removed.

The copper prospect lies within tightly folded volcanic lutites and chloritic phyllites of the Gerowie Tuff, which have been displaced by the Hayes Creek Fault. The rock units have been folded to form a tight north-trending anticline (northern part of the Golden Dyke Dome). Bedding strikes northeast (045°) and dips moderately (40°) to the northwest.

The nearest granite subcrop (McMinns Bluff Granite) is located about 7.5 km to the south; a pink-green coarse porphyritic hornblende-biotite granite in outcrop.

The mineralisation occupies a major northeast trending quartz-filled fault (Hayes Creek Fault), which has a strike length of 15 km. The mineralized section of the fault strikes 030° and dips 75° to the northwest. The workings indicate that the lode is up to 2m wide in places and can be traced over 80m along strike.

Malachite staining on quartz veins and fractured wallrock is common, particular at the northern end where a grab sample assayed 20.2% Cu (NTGS 9516). Wallrock alteration is predominantly vein controlled silicification. A second quartz reef is located about 15-20 m to the west, which can be traced discontinuously over 40 m (Figure 26).

A minor copper occurrence (**GK 928 988**) is located about 3km south of the old Burrundie Siding next to an abandoned miner's hut. Malachite is visible on hematitic quartz veins which are conformable to bedding. A small 6 x 2 x 1m open cut has exposed an east-west trending shear within tightly folded slates, litharenites and cherts of the Mount Bonnie Formation. Bedding strikes east-west (090°) and dips 40° to the south.

Two copper occurrences are located northeast of Pine Creek, about 8km east of Mount Saunders. The occurrences were examined by Willis (1972) following a request from an interested prospector.

The first occurrence (**HK 229 972**) is situated in creek exposures of the Allamber Springs Granite. Minor malachite, azurite and chrysocolla staining is apparent within north trending quartz veinlets.

The second occurrence (**HK 225 984?**) is located within hornfelsed interbedded limestones and shales of the Masson Formation. Minor blebs of chalcopyrite and pyrite within marble have been recorded by Willis (1972). Bedding strikes northeast (045°) and dips 55° southeast. Willis (1972) recommended a follow-up geochemical auger survey to delineate any possible economic base metal skarn deposits.

A minor copper occurrence (**HK 024 866**) has been recorded 5 km southwest of Mount Porter. In 1967, during the laying of the railway to Frances Creek, a thin vein carrying pyrite and chalcopyrite was observed in a fresh cutting (Barrell, 1968). Follow up stream sediment sampling results were not encouraging, however a malachite-bearing sample assayed 0.5% Cu.

The copper-bearing vein is located within andalusite hornfels of the Burrell Creek Formation which also contains pegmatite and aplite dykes. The occurrence lies about 50-100m west of the Mount Porter Granite contact.

A minor copper prospect (**GK 888 663**) which appears on the Cullen Mineral Field map (Stuart-Smith, 1987) is situated within a northeast (025°) trending quartz filled shear within the Tabletop Granite. This prospect was not inspected due to difficult access.

About 400m west (**HK 032 650?**) of the Copperfield workings, a 5.5m (18ft) deep shaft has been sunk on a northwest (335°) trending copper lode which dips very steeply to the west. About 10t of copper ore is reported to have been extracted from this encouraging prospect (Parkes, 1892).

Another copper prospect (**HK 036 645**) is located about 800m to the south-southwest of the main Copperfield Mine workings. The prospect was briefly inspected by Jensen (1919), but there are no production records. The workings (Figure 27) consist of three shafts (deepest is down to 8m) and two open cuts (the largest 2x13x2m in size). From the size of the workings it appears that about 100t of copper ore has been extracted.

Geologically the prospect lies within a tightly folded turbidite sequence of the Burrell Creek Formation which strikes east (075°) and dips 50° to the west. Exposures of pink to grey, fine to medium equigranular granite are found 2.5km to the northwest.

The copper mineralisation lies within a cross-cutting lode (vein quartz breccia) which strikes northeast (060°) and dips to the north at 60-65°. The quartz lode ranges from 0.6-1.2m in width and occupies a fault which can be traced 30m along strike. Minerals obseved in the mullock dumps include pyrite, chalcopyrite, chalcocite, malachite and chysocolla. Medium grained meta-litharenites form the wallrock, which are commonly silicified and fractured.

Two minor copper occurrences (**HK 065 617** and **066 618**) are located about 8 km south of Pine Creek within two parallel north-northwest trending quartz-breccia infilled faults.

The westerly occurrence consists of a small (4 x 1.2 x 0.8 m) pit sunk on a 0.8m wide malachite staining quartz breccia lode which trends 345° and dips 85° to the west. The lode can be continuously traced for over 500m along strike. The vein quartz is coarse grained, white and vitreous with angular pebble-sized quartz greywacke inclusions.

The easterly occurrence consists of two small exploration pits sunk on a narrow (0.2m) malachite-bearing quartz vein. The quartz vein occupies a shear zone which trends 340° and dips 85° to the west, and can be traced over 60m along strike. The quartz-greywacke wallrock carries minor stockwork mineralisation and vein controlled silicification.

Both of these occurrences lie within tightly folded quartz-greywackes of the Burrell Creek Formation which

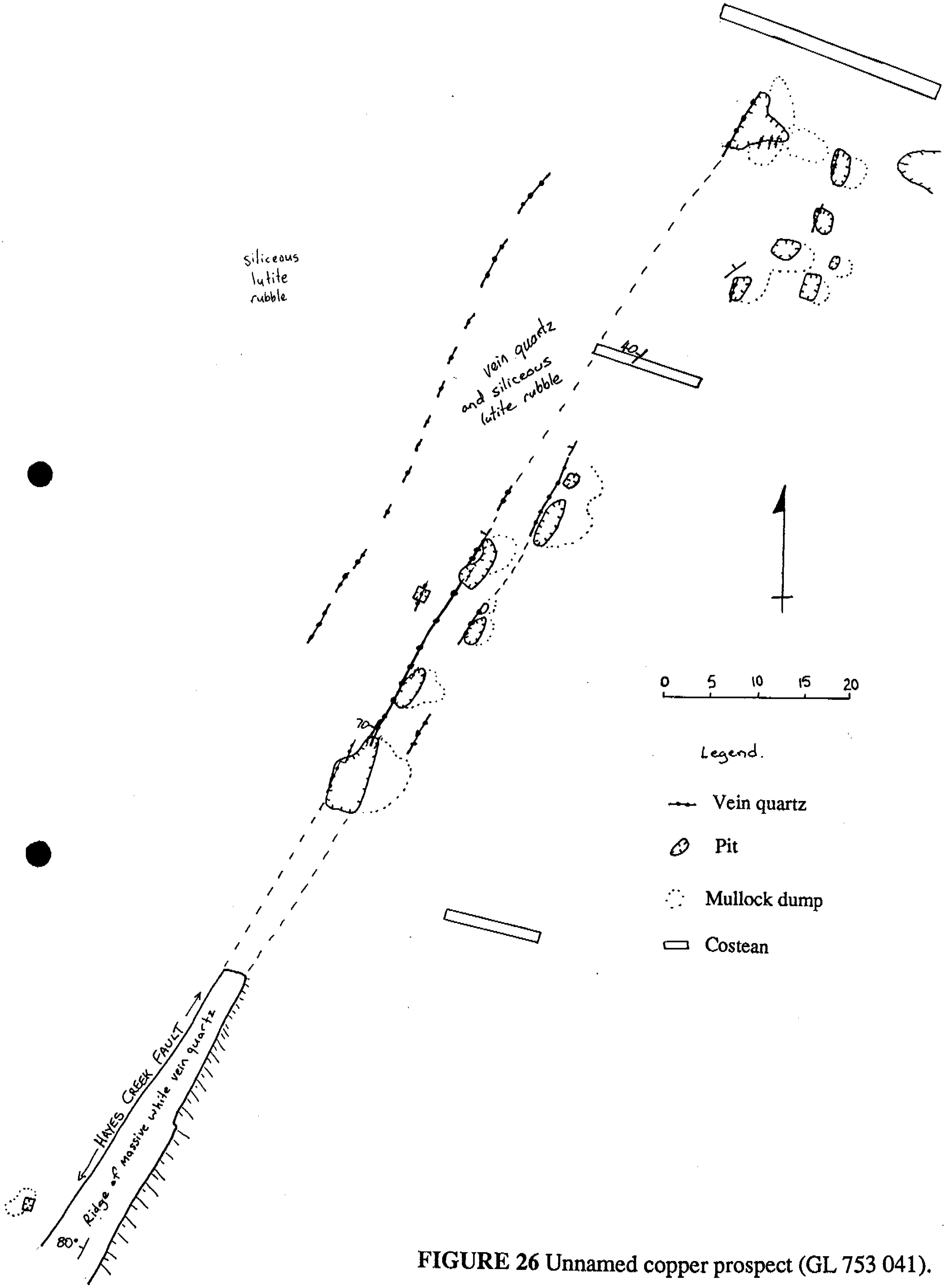


FIGURE 26 Unnamed copper prospect (GL 753 041).

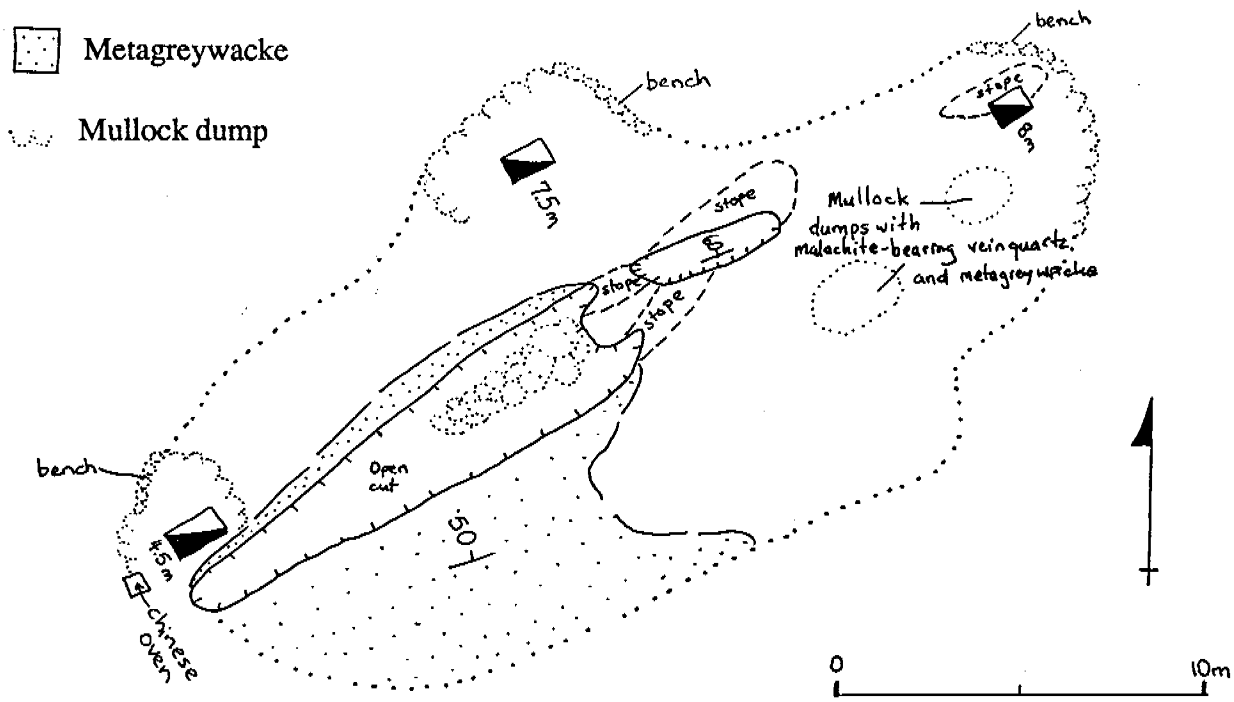


FIGURE 27 Unnamed copper prospect (HK 036 645).

strike 330° and dip 40° to the southwest. A pervassive foliation strikes 285° and dips 80° to the north.

Another small copper prospect (**HK 095 595**) lies about 11 km south of Pine Creek, some 100m west of the Stuart Highway. The prospect has no production records and does not appear on any geological maps. Some workings on "an andesite dyke impregnated with stockworks of copper ore in quartz" are mentioned in a report by Jensen (1919) at this location.

It appears that about 60 t of ore and mullock has been removed from a small open cut and adit (Figure 28). The adit seems to extend some 8m to the south. A small prospecting pit has been dug 20m south of the collapsed open cut.

The prospect is located in a tightly folded and sheared turbidite sequence of the Burrell Creek Formation about 3km west of the McCarthy's Granite. Fine to medium grained litharenites from the wallrocks whcih strike northwest (330°) and dip steeply (70°) to the southwest.

The copper mineralisation lies within a vertical fault zone which trends northwest (320°) and can be traced over 3km along strike (Vann, 1987). The mineralised zone is about 1.2m wide, and consists of malachite and chalcocite beaing quartz veins and stockworks within brecciated and silicified litharenites (Plate 21). A chip sample from the mullock dump assayed 12.4% Cu and 98g/t Ag (Vann, 1987).

There is another small copper prospect (**HK 135 564**) about 16 km southeast of Pine Creek. The exact location is not known, as a search for the workings in this vicinity proved fruitless.

This prospect was investigated by the BMR (Crohn, 1965) following a request from Mr Palmer of Pine Creek. A copper bearing quartz-filled shear, 0.9m wide is situated at the contact of hornfelsed Burrell Creek Formation and a fractionated quartz-feldspar porphyry from the McCarthy's Granite.

Two pits, one 3m (10ft) deep and the other 1.2m (4ft) deep have been sunk on a northwest (300°) trending shear zone which dips steeply (60°) to the southwest. Patchy malachite and possible cuprite with boxworks is seen on the surface. A chip sample taken across the lode exposed in the deeper pit assayed 7.4% Cu (Crohn, 1965).

A small copper prospect (**HK 150 507**) lies about 21 km southeast of Pine Creek. The prospect can be reached by turning southwest off the "new" Stuart Highway on to the old Stuart Highway at a point 20km south of Pine Creek. Then turn west again on to a track after 1km. After about 600m a 1m wide quartz vein crosses the track which can be continuously traced for a kilometre southeast, to the old workings.

The workings (Figure 29) consist of several small pits, an open cut (6.2 x 2 x 1.5m) and a partially collapsed shaft (3.5m). There are no records of past production, exploration or existence of this prospect. Visually it

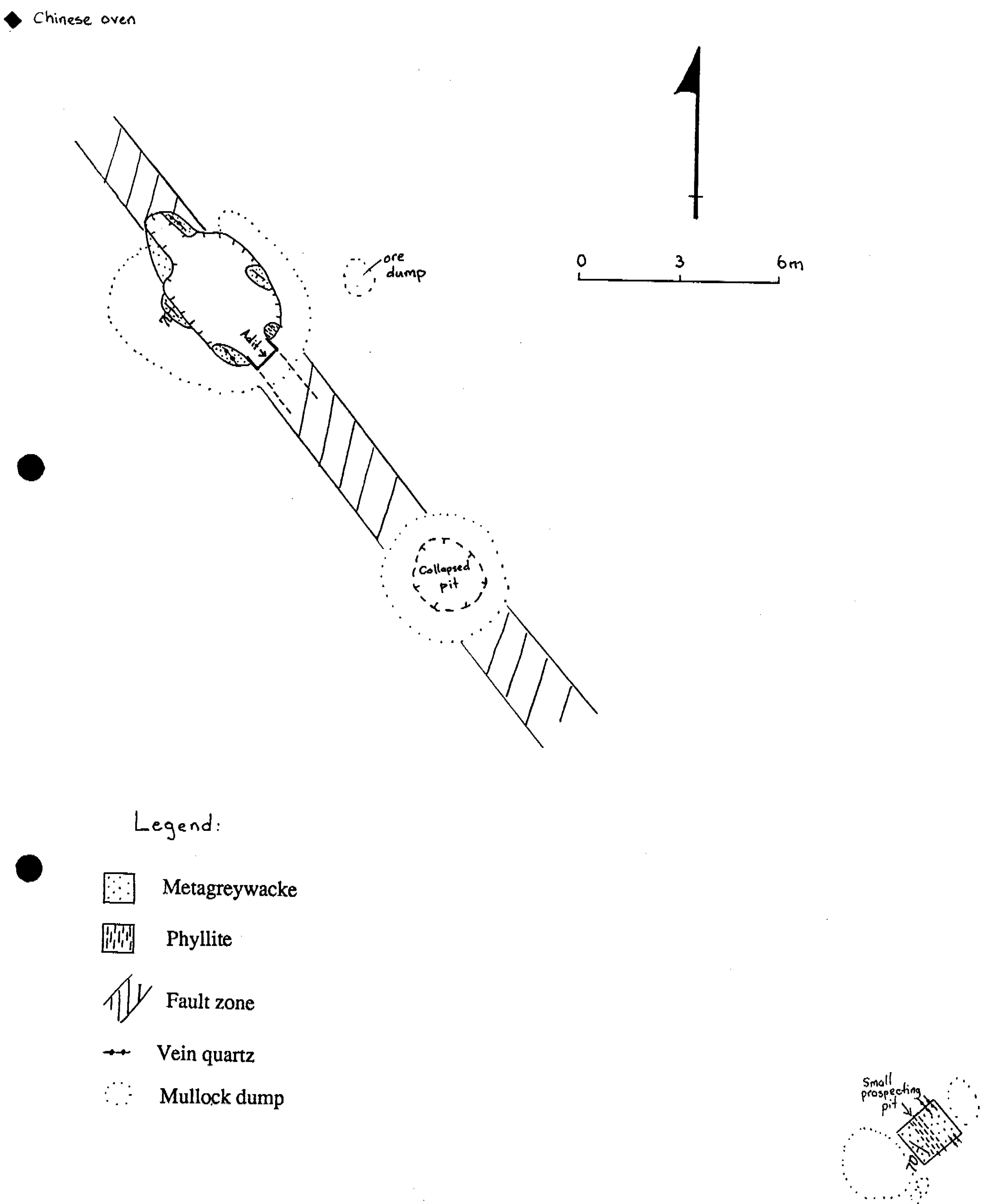


FIGURE 28 Unnamed copper prospect (HK 095 595).

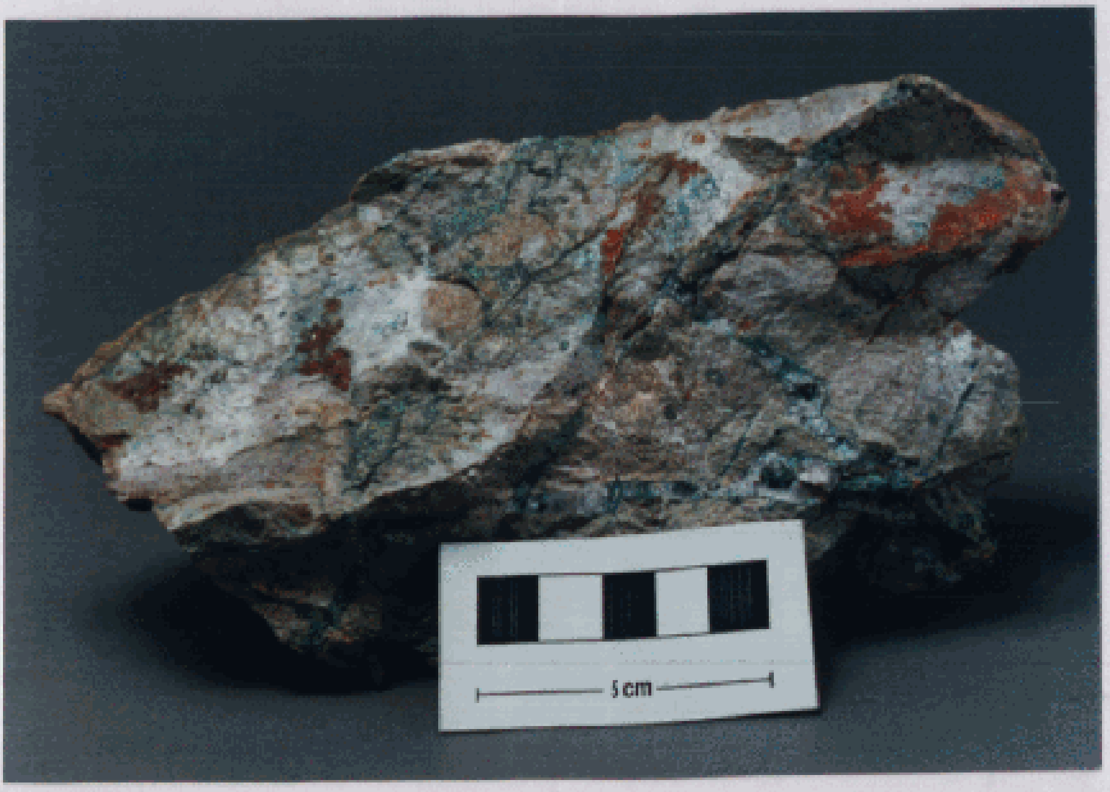


Plate 25 Copper-bearing vein quartz stockworks within greywacke host; from unnamed copper prospect at HK 095 595.

Plate 26 Old workings at unnamed copper prospect (HK150 507).

appears that about 50t of ore and mullock was removed from the lode (Plate 26), to mine some high grade (20-30% Cu) secondary copper ore.

The copper-bearing quartz-breccia is hosted by pink coarse porphyritic biotite granites of the McCarthy's Granite, at the intersection of two faults containing quartz-breccia. Exposures of the Lewis Springs Syenite and Fingerpost Granodiorite have been mapped to the north and south, respectively, by the BMR (Stuart-Smith et al., 1987).

The mineralisation consists of malachite infilling fractures, voids as well as coating coarse white, vein quartz at the surface, whilst disseminated chalcopyrite and pyrite occur at depth. The copper-bearing quartz-breccia occupies a vertical, north-trending fault which can be continuously traced over 800m. Multiple veins between 5-60cm wide form a stockwork zone over 2m across in the open cut.

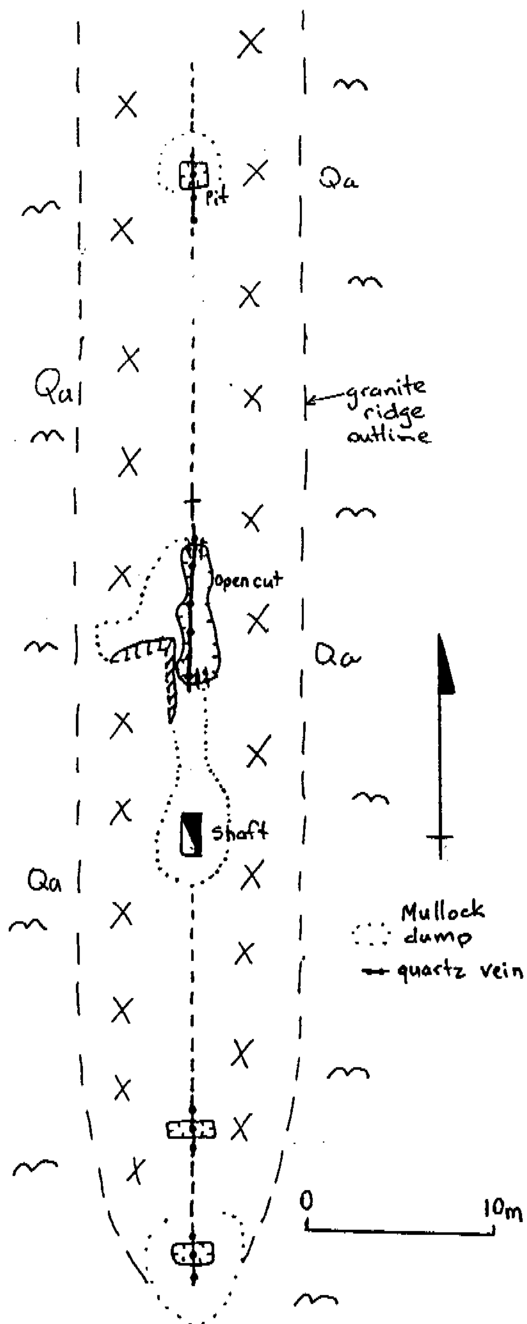


FIGURE 29 Unnamed copper prospect (HK 150 507).

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APPENDIX 1

MINERAGRAPHIC

AND

PETROGRAPHIC

DESCRIPTIONS.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9668 Field Number: 9668

Locality: Iron Blow DDH1 315'5"

Grid Reference: GL 761 044

1:100 000 sheet name/number: PINE CREEK

Field rock name: Hornfels

Laboratory rock name: Metasiltstone

Formation: Mount Bonnie Formation

PETROLOGY DATA Compiled by: P.F.

Minerals present:

Quartz....................60%
Calcite...................20%
Muscovite.............10%
Opaques................10%

Petrological description/remarks:

SEE REPORT BY PONTIFEX (ATTACHED).

9668

Extremely fine and compact, phlogopite-sericite-quartz schist, incorporating small, vaguely layered lenses of calcite $\pm$ quartz, chlorite, pyrite, pyrrhotite, sphalerite, rutile and sphene; rare epidote. Probable metasiltstone.

At least 60 % of this rock consist of compact, extremely fine and somewhat diffuse quartz micromosaic, incorporating a subequal abundance of commonly oriented sericite and lesser phlogopite. It is therefore not really a chert, as suggested in your notes. A strong schistosity is defined by the micas.

This extremely fine schist contains numerous lenses, 1 mm to 4 mm long, mostly of fine crystalline carbonate, but enclosing minor quartz, lesser fine sphene and/or rutile, or pyrite $\pm$ pyrrhotite, rare chlorite and muscovite.
These lenses have a layered distribution.

Minor sphalerite is also locally present, also rare K-spar (as indicated by the yellow stain), and there are rare grains of epidote. A few grains of probable albite occur in these lenses, and the host schist could also contain some feldspar, but is too fine to positively identify.

Some of the lenses are aligned within the schistosity and may represent disrupted veins; however, the rock would appear to be a meta-siltstone incorporating small lenses of probably chemical sediment.

Note: The very minor grains showing intense yellow stain are K-spar, the minor diffuse paler stain probably reflects sericite.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9671 Field Number: 9671

Locality: Iron Blow DDH2 498'

Grid Reference: GL 761 044

1:100 000 sheet name/number: PINE CREEK

Field rock name: Volcanic arenite

Laborátory rock name: Quartz wacke

Formation: Mount Bonnie Formation

PETROLOGY DATA

Compiled by: P.F.

Minerals present:

Quartz.......................40%	Matrix..................30%
Rock fragments........15%	Opaques................3%
Altered feldspar.......10%	Biotite.................... 2%

Petrological description/remarks:

Fairly homogeneous, poorly sorted, loosely packed aggregate of mainly quartz grains within a sericitic matrix.

Quartz- mainly subangular to angular monocrystalline grains, 0.1 to 0.5mm in size.
- average size is about 0.2mm, many grains have reabsorbed edges and some have embayed outline indicating a volcanic province as the source.

Rock fragments- mainly polycrystaline quartzite/chert grains, 0.2-1mm in size.

Feldspar- largely altered to sericite and clay.

Matrix- sericite and clay.

Opaques- irregular agglomerations within matrix, possible alteration product of mafic mineral.

Biotite- forms isolated grains up to 0.3mm in size.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9548 Field Number: 9548

Locality: Iron Blow open cut

Grid Reference: GL 761 044

1:100 000 sheet name/number: PINE CREEK

Field rock name: Slate

Laboratory rock name: Chloritic slate

Formation:

PETROLOGY DATA Compiled by: P.F.

Minerals present:

Chlorite....................40%
Quartz.......................30%
Sericicite.................20%
Limonite...5%
Carbonaceous material.......................5%

Petrological description/remarks:

Very fine grained chloritic slate with lenses of vein quartz.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9830 Field Number: 9830

Locality: Iron Blow DDH S/16 132.5m

Grid Reference: GL 761 044

1:100 000 sheet name/number: PINE CREEK

Field rock name: Massive sulphide ore

Laboratory rock name: Massive granulose Fe-Zn-Cu sulphide ore

Formation:

PETROLOGY DATA Compiled by: P.F.

Minerals present:

Pyrrhotite	30%	Galena	1%
Sphalerite	25%	Carbonate	10%
Arsenopyrite	15%	Quartz	2%
Chalcopyrite	10%	Muscovite	2%

Petrological description/remarks:

Medium to fine grained massive sulphide ore with a complicated granular texture.

Pyrrhotite- aggregate forming medium to fine grained subhedra, which are often altered.
- minor corrugation lamellae; some subhedra contain arsenopyrite inclusions.

Sphalerite- fine to medium grained subhedra with chalcopyrite (minor arsenopyrite and pyrrhotite) inclusions.

Arsenopyrite- fine to very fine euhedra to subhedra within pyrrhotite, sphalerite and gangue rich areas.

Chalcopyrite- forms irregular areas which may contain pyrrhotite and arsenopyrite inclusions.
- usually associated with sphalerite.

Galena- fine anhedra commonly intergrown with pyrrhotite and sphalerite.

Carbonate- fine intergranular grains.

Muscovite- fine (av. 150μm) random flakes within the opaques (mainly pyrrhotite)

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9841　　Field Number: 9841

Locality: Iron Blow DDH2 453'

Grid Reference: GL 761 044

1:100 000 sheet name/number: PINE CREEK

Field rock name: Altered wallrock containing disseminated sulphides.

Laboratory rock name: Pyrrhotite-bearing hydrous skarn

Formation: Mount Bonnie Formation

PETROLOGY DATA

Compiled by: P.F.

Minerals present:

Carbonate................35%	Sphalerite...................4%
Pyrophyllite.............35%	Chalcopyrite.............3%
Pyrrhotite................20%	Galena.......................accessory

Petrological description/remarks:

Fine to medium grained, granoblastic hydrous skarn rock.

Carbonate- fine to medium grained granoblastic subhedra (probably calcite).
- interlocking (polygonal) texture is also common.

Pyrophyllite- fine to medium radiating flakes and aggregates, often replacing carbonate grains.

Pyrrhotite- prismatic euhedra to subhedra (up to 1.5mm), randomly orientated and commonly associated with pyrophyllite.
- also intergrown with chalcopyrite.

Sphalerite- fine to medium grained subhedra often intergrown with pyrrhotite.
- contains chalcopyrite inclusions.

Chalcopyrite- forms medium grained subhedra intergrown with pyrrhotite, and tiny inclusions (exsolutions) within sphalerite.

Galena- irregular inclusions within chalcopyrite and pyrrhotite.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9842 Field Number: 9842

Locality: Iron Blow DDH1 373'7"

Grid Reference: GL 761 044

1:100 000 sheet name/number: PINE CREEK

Field rock name: Calc-silicate wallrock

Laboratory rock name: Sphalerite-bearing hydrous skarn

Formation: Mount Bonnie Formation

PETROLOGY DATA

Compiled by: P.F.

Minerals present:

Calcite......................60%	Serpentine..............5%
Muscovite...............15%	Sphalerite...............5%
Rock fragments......13%	Opaques.................2%

Petrological description/remarks:

Calcite- forms medium to coarse (av. 1mm) anhedra replacing rock (metasiltstone) fragments.

Muscovite- fine (av. 0.3mm) randomly orientated flakes and aggregates, usually replacing calcite. Probable hydrothermal origin.

Rock fragments- metasiltstone (quartz-chlorite-sericite slate).

Serpentine- fine (0.1-0.05mm) aggregates replacing rock fragments and often enclosed by calcite.

Sphalerite- forms fine (av 0.2mm), red brown, anhedral grains and aggregates, largely within carbonate areas. Often intergrown with muscovite.

Opaques- pyrite and pyrrhotite.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9845 . Field Number: 9845

Locality: Mount Bonnie DDH1 288' 7"

Grid Reference: GL 759 013

1:100 000 sheet name/number: PINE CREEK

Field rock name: Massive sulphide ore

Laboratory rock name: Massive granular Fe-Zn-Cu sulphide ore

Formation: Mount Bonnie Formation

PETROLOGY DATA

Compiled by: P.F.

Minerals present:

Pyrrhotite......................55%	Carbonate................20%
Chalcopyrite..................8%	Muscovite...................8%
Sphalerite.......................7%	Arsenopyrite.............3%

Petrological description/remarks:

Pyrrhotite- medium grained (av. 0.5mm) subhedra forming aggregates which enclose the other sulphides and gangue.

Chalcopyrite- appears to replace sphalerite and form aggregates several millimeteres across.

Sphalerite- fine (0.2mm), red brown, subhedra with chalcopyrite inclusions.
- commonly intergrown with chalcopyrite and pyrrhotite.

Carbonate- fine (0.1mm) subhedra grains.

Muscovite- fine flakes with a preferred orientation, often enclosed in pyrrhotite.

Arsenopyrite- may form coarse (up to 1.2mm) euhedra or very fine grained aggregates.

Sulphides appear to replace carbonate grains.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9834   Field Number: 9834

Locality: Mount Bonnie DDH

Grid Reference: GL 759 013

1:100 000 sheet name/number: PINE CREEK

Field rock name: Massive sulphide ore

Laboratory rock name: Massive granular Fe-Zn-Cu-Pb sulphide ore

Formation: Mount Bonnie Formation

PETROLOGY DATA   Compiled by: P.F.

Minerals present:

Pyrrhotite...............30%	Galena.....................5%
Sphalerite..............15%	Arsenopyrite...........5%
Chalcopyrite.........15%	Carbonate.............30%

Petrological description/remarks:

Medium to fine grained, massive granoblastic sulphides within carbonate gangue.

Pyrrhotite- forms medium (up to 1mm) grains which are intergrown with the other sulphides and gangue. Monoclinic variety.
- often partially altered and cotaining inclusions of galena, chalcopyrite and sphalerite.

Sphalerite- fine (av. 0.2mm) grained, red brown anhedra with tiny chalcopyrite inclusions (exsolutions) particularly along grain boundaries and cleavage planes
- may also contain irregular galena inclusions.

Chalcopyrite- fine anhedra which may form aggregates up to 1mm across.
- often associated with sphalerite. May contain pyrrhotite and sphalerite inclusions.

Galena- forms fine grained (up to 0.5mm) skeletal anhedra often associated with sphalerite. Rare tetrahedrite inclusions.

Arsenopyrite- fine (up to 0.3mm) euhedra within gangue and intergrown with sulphides.
- may aggregate around edges of pyrrhotite.

Carbonate- fine (0.12mm) anhedra; replaced by sulphides.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9843 Field Number: 9843

Locality: Mount Bonnie DDH1 293'4"

Grid Reference: GL 759 013

1:100 000 sheet name/number: PINE CREEK

Field rock name: Sulphide-bearing wallrock

Laboratory rock name: Arsenopyrite-bearing hydrous skarn

Formation: Mount Bonnie Formation

PETROLOGY DATA

Compiled by: P.F.

Minerals present:

Arsenopyrite.................40%	Carbonate.......................40%
Sphalerite.......................4%	Muscovite......................10%
Pyrrhotitte......................3%	Chalcopyrite....................1%
Galena............................2%	

Petrological description/remarks:

Arsenopyrite- fine to medium (av. 0.2mm), disseminated to aggregated euhedra and subhedra.

Sphalerite- fine (0.2-0.3mm), disseminated subhedra within gangue and sometimes pyrrhotite-rich areas. Contains minor chalcopyrite inclusions.

Pyrrhotite- very fine (0.05-0.1) euhedra to subhedra, disseminated in gangue.
- some grains are replacing muscovite flakes or found in arsenopyrite aggregates.

Galena- fine disseminated anhedra.

Chalcopyrite- fine anhedra intergrown with pyrrhotite grains.

Carbonate- fine (0.1mm) granular (interlobate granoblastic) texture.
- coarser grains (up to 0.5mm) are found in vugs which may contain sulphides±muscovite.

Muscovite- fine to medium (av. 0.2mm), randomly oriented flakes which often show partial replacement by pyrrhotite.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9548 Field Number: 9848

Locality: Mount Bonnie DDH2 296'3"

Grid Reference: GL 759 013

1:100 000 sheet name/number: PINE CREEK

Field rock name: Pyritic skarn

Laboratory rock name: Pyritic calc-silicate rock

Formation: Mount Bonnie Formation

PETROLOGY DATA

Compiled by: P.F.

Minerals present:

Pyrite........................43%
Sphalerite..................5%
Marcasite.................2%
Carbonate.................30%
Quartz........................20%

Petrological description/remarks:

Fine grained, granular massive sulphides within granoblastic gangue.

Pyrite- fine subhedra to euhedra which may be disseminated or agreggated.

Sphalerite- fine (0.1mm) anhedra with minor chalcopyrite inclusions.
- mainly within the carbonate-quartz gangue.

Marcasite- very fine aggregates replacing pyrite.

Carbonate- fine (av. 0.3mm) granoblastic grains intergrown with quartz and sulphides.

Quartz- fine to medium (av. 0.3mm) granoblastic grains which often contain sulphide inclusions.

Paragenesis- 1. Quartz 2. Calcite 3. Sulphides

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9833 Field Number: 9833

Locality: Mount Bonnie DDH S/10 51.5m

Grid Reference: GL 759 013

1:100 000 sheet name/number: PINE CREEK

Field rock name: Banded ferruginous quartzite

Laboratory rock name: Banded hematite-chlorite quartzite

Formation: Mount Bonnie Formation

PETROLOGY DATA Compiled by: P.F.

Minerals present:

Quartz...................35%	Biotite.............................7%
Hematite...............30%	Calcite............................5%
Chlorite................15%	Pyrite..............................8%

Petrological description/remarks:

Fine grained, banded ferruginous quartzite rock.

Quartz- fine (50μm) granoblastic (recrystallised) grains.

Hematite- fine (0.1-0.2mm) spherical clots with feathery rims; commonly aligned into bands (lamellae) which are about 1mm thick.

Chlorite- fine aggregates often associated with hematite bands.
- sometimes form radiating flakes.

Biotite- very fine, green, raggered flakes closely associated with hematite bands.

Calcite- irregular fine (01.-0.2mm) blebs, often associated with hematite bands.

Pyrite- fine subhedra forming aggregates adjacent to hematite bands within the quartz-rich bands.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9835 Field Number: 9835

Locality: Mount Bonnie DDH S/37 41.7m

Grid Reference: GL 759 013

1:100 000 sheet name/number: PINE CREEK

Field rock name: Calc-silicate rock

Laboratory rock name: Hydrous skarn

Formation: Mount Bonnie Formation

PETROLOGY DATA

Compiled by: P.F.

Minerals present:

Carbonate..................85%
Serpentine...................5%
Talc..............................3%
Phlogopite.......................3%
Opaques.........................2%

Petrological description/remarks:

Carbonate- fine granular anhedra to coarse euhedra with strong cleavage traces.

Serpentine- felted masses and veinlets replacing rock fragments (?).

Talc- irregular masses associated with serpentine veinlets.
- herringbone texture is present in some aggregates.

Phlogopite- fine flakes often associated with pyrrhotite grains.

Opaques- mainly fine pyrrhotite subhedra.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9844 Field Number: 9844

Locality: Mount Bonnie DDH1 325'10"

Grid Reference: GL 759 013

1:100 000 sheet name/number: PINE CREEK

Field rock name: Amphibolite

Laboratory rock name:

Formation: Zamu Dolerite?

PETROLOGY DATA

Compiled by: P.F.

Minerals present:

Slate.................40%	Opaques..................15%	Fluorite....................accessory
Tremolite..........30%	Chlorite......................3%	
Phlogopite.......10%	Quartz.........................2%	

Petrological description/remarks:

Slate- very fine phlogopite and chlorite/serpentine (?) flakes with a weak crenulation cleavage.

Tremolite- coarse needles (av. 3mm) which are randomly orientated.
- some grains contain very fine fluorite inclusions.

Phlogopite- secondary fine to coarse flakes associated with the opaques and tremolite.

Chlorite- secondary hydrothermal flakes, associated with tremolite and opaques.

Opaques- mainly pyrrhotite aggregates within tremolite-rich areas.
- some fine to medium grained, sphalerite anhedra within pyrrhotite aggregates.

Quartz- fine, drusy euhedra between pyrrhotite and tremolite grains.

Paragenesis- 1. Tremolite 2. Quartz 3. Opaques 4. Phlogopite 5. Fluorite

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9670 Field Number: 9670

Locality: Heatleys Pb-Zn prospect; HPDDH2 343'

Grid Reference: GK 741 984

1:100 000 sheet name/number: PINE CREEK

Field rock name: Volcanic lutite

Laboratory rock name: Meta-quartz siltstone

Formation: Koolpin Formation

PETROLOGY DATA

Compiled by: P.F.

Minerals present:

Quartz....................75%	Garnet................2%
Biotite....................10%	Opaques............1%
Muscovite............10%	Apatite..............2%

Petrological description/remarks:

SEE DESCRIPTION BY PONTIFEX (ATTACHED).

9670

Meta quartz siltstone, weakly schistose due to minor oriented fine biotite; also minor scattered very fine garnet, muscovite, pyrite.

This is a compact, very fine-grained and somewhat massive rock in hand specimen, but the thin section reveals minor but widespread oriented biotite (7 %) which imparts a weak schistosity. At least 80 % of the rock consist of a meta-quartz silt to fine sandstone aggregate, average size about 0.1 mm.

As noted, a weak schistosity is defined by small flakes of biotite, but there are equally abundant, slightly larger muscovite flakes which are essentially unoriented. Accessory (5 %) very small crystals of garnet, 20-70 microns in diameter, are scattered, and locally enclose patches of chlorite or pyrite grains. Not all the pyrite is rimmed by garnet, however. Sparse garnet also occurs in thin veins predominantly composed of quartz. These garnets are clouded by very small indeterminate inclusions.

An irregular patch some 4 mm in mean diameter is rich in coarse unoriented muscovite flakes and partly altered unoriented biotite. Sparse graphitic dust is dispersed. Rare stringers of adularia cut the rock.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9538 Field Number: 9538

Locality: McKinlay Pb-Ag mine, Shaft No4.

Grid Reference: GK 963 916

1:100 000 sheet name/number: PINE CREEK

Field rock name: Galena-bearing quartz lode

Laboratory rock name: Fe-Pb sulphide-bearing vein quartz

Formation: Burrell Creek Formation

PETROLOGY DATA

Compiled by: P.F.

Minerals present:

Quartz.......................50%	Rock fragments.................20%
Pyrite........................10%	Sphalerite.............................3%
Galena......................10%	Chalcopyrite..........................2%
Arsenopyrite.............5%	

Petrological description/remarks: Polished block section.

Pyrite- fine to medium grained (up to 2mm) subhedra within the quartz gangue and galena. Some grains may contain fine galena inclusions.

Galena- skeletal anhedra within fracture quartz gangue.
- some grains may contain tiny arsenopyrite and sphalerite inclusions.

Arsenopyrite- very fine (10-200μm) disseminated euhedra commonly concentrated in the rock fragments. Few grains may have skeletal sphalerite inclusions.

Sphalerite- fine (av. 0.1mm) anhedra, mainly within galena.
- most grains contain abundant chalcopyrite inclusions.

Chalcopyrite- mainly as minute (10μm) inclusions within sphalerite grains.
- occasional larger blebs (up to 0.1mm) may be found.

Rock fragments- chloritic phyllite and metagreywacke clasts, with a preferred orientation.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9527B Field Number: 9527B

Locality: Flora Belle Pb-Ag mine, mullock dump next to Bechervaise's Shaft.

Grid Reference: GK 974 884

1:100 000 sheet name/number: PINE CREEK

Field rock name: Sulphide-bearing vein quartz

Laboratory rock name: Pyritic quartz-siderite breccia

Formation: Burrell Creek Formation

PETROLOGY DATA Compiled by: P.F.

Minerals present:

Quartz......................60%
Siderite....................25%
Pyrite.......................15%
Sphalerite.........................trace
Chalcopyrite.....................rare

Petrological description/remarks: Polished block section.

Quartz- white to translucent, fine to medium, granoblastic grains.
- hydrothermal vein-type.

Siderite- medium to coarse grained blebs within quartz.
- seems to be paragenetically earlier than the vein quartz.

Pyrite- arsenical pyrite variety, fine to medium, subhedra up to 3mm (av. 0.5mm), disseminated through the gangue.
- finer grains are often euhedral.

Sphalerite- very fine (50μm) anhedral inclusion within 0.5mm pyrite subhedra.
- contains tiny chalcopyrite exsolution blebs.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9815 Field Number: 9815

Locality: Flora Belle Pb-Ag mine, from stope below watertable.

Grid Reference: GK 974 884

1:100 000 sheet name/number: PINE CREEK

Field rock name: Massive galena ore

Laboratory rock name: Fine grained massive galena ore

Formation: Burrell Creek Formation

PETROLOGY DATA Compiled by: P.F.

Minerals present:

Galena	Arsenopyrite	Siderite
Pyrite	Chalcopyrite	Quartz
Tetrahedrite	Pyrargyrite	Rock fragments

Petrological description/remarks: Polished thin section.

SEE PONTIFEX DESCRIPTION (ATTACHED).

9815

Massive galena with minor associated gangue of siderite and quartz (vein), locally enclosing breccia fragments of fine sericite schist; numerous pyrite crystals in the galena; rarer inclusions of tetrahedrite, arsenopyrite, chalcopyrite, trace pyrargyrite.

This small ore sample was prepared as a polished thin section as requested. At least 70% of it consists of massive sulphide. In some areas this is seen to be crowded with abundant, small 0.1 mm to 1 mm inclusions of carbonate and rarer quartz, but these areas incorporate poorly defined layers of the same sulphide (galena) with only very minor inclusions of gangue.

Several irregular domains on the edge of the sample consist of sulphide, quartz and carbonate forming an apparent vein mosaic, in subequal abundance; and incorporating several breccia blocks of very fine sericite schist, interpreted as country rock. Carbonate is locally abundant and coarse crystalline. All carbonate appears to be siderite.

In reflected light the sulphide, in all modes of occurrence is seen to be predominantly galena. Pyrite crystals (15-20% of the whole rock), range in size from 0.02 mm to 0.3 mm. Most of these are scattered, and locally clustered, as random inclusions in the galena, and in the smaller areas of quartz-siderite gangue.

Minor sulphides (or sulphosalts), almost exclusively as inclusions in galena are as below, (listed in approximate order of decreasing abundance) :

* tetrahedrite, bleb-like grains 0.01 mm to (rarely) 0.3 mm maximum dimension, randomly scattered through galena, but without any specific association.

* arsenopyrite, as minute euhedral crystals about 0.02 mm size, to sparse, but coarser and somewhat disrupted crystals 0.8 mm maximum dimension.

* chalcopyrite, several grains only, about 0.2 mm size, as inclusions in galena, (next to tetrahedrite).

* trace inclusions of pyrargyrite, maximum size 0.05 mm, (bluish-grey in colour and with red internal reflection). This mineral is identified partly on optical properties, also on the provided information that this sample comes from the Fora Bell, Ag-Pb Mine.
  [Some Ag may also be contained in tetrahedrite however.]

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9515 Field Number: 9515

Locality: Mount Wigley Pb mine

Grid Reference: HK 087 617

1:100 000 sheet name/number: PINE CREEK

Field rock name: Galena-bearing vein quartz

Laboratory rock name: Galena-bearing vein quartz

Formation: Burrell Creek Formation

PETROLOGY DATA Compiled by: P.F.

Minerals present:

Quartz.......................85%
Galena......................10%
Rock fragments.........5%

Petrological description/remarks: Polished block section.

Quartz- medium grained, white granoblastic vein quartz.

Galena- fine to medium, skeletal anhedra often closely associated with rock fragments. Smaller grains weathered to cerussite.
- some grains infill voids within the quartz gangue.

Rock fragments- metagreywacke, minor chloritic phyllite.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9512 Field Number: 9512

Locality: Lucknow Pb-Ag mine, open cut.

Grid Reference: HK 070 632

1:100 000 sheet name/number: PINE CREEK

Field rock name: Galena-bearing vein quartz

Laboratory rock name:

Formation:

PETROLOGY DATA Compiled by: P.F.

Minerals present:

Quartz..........................85%
Galena.........................15%

Petrological description/remarks: Polished block section.

Quartz- white, granoblastic; hydrothermal vein-type.

Galena- fine to coarse grained anhedra, infilling fractures and vugs within the quartz gangue.
- grains may contain tetrahedrite and sphalerite inclusions.

Sphalerite- fine, rounded anhedral inclusions within galena.
- contains tiny exsolution blebs of chalcopyrite.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9721 Field Number: 9721

Locality: Lucknow Pb-Ag mine

Grid Reference: HK 070 632

1:100 000 sheet name/number: PINE CREEK

Field rock name: Metagreywacke

Laboratory rock name: Meta-volcanic arenite

Formation: Burrell Creek Formation

PETROLOGY DATA Compiled by: P.F.

Minerals present:

Quartz............................30%	Biotite......................5%
Rock fragments...........40%	Chlorite....................5%
Feldspar.......................15%	Sericite.....................5%

Petrological description/remarks:

Fairly homogeneous, well compacted, moderately sorted fine grained arenite composed of altered volcanic rock fragments, quartz and feldspar framework grains within a very fine chlorite-sericite matrix.

Quartz- fine, angular to subrounded, mainly monocrystalline grains with reabsorbed boundaries.
- few grains have embayed outlines, suggesting a volcanic source.

Rock fragments- three compositional types recognised; (1) quartzite, (2) quartz-sericite, (3) chlorite-biotite. Possibly derived from acid volcanic source.

Feldspar- mainly plagioclase displaying albite and pericline twinning.
- few K-feldspar grains.

Biotite- minor fine green flakes as framework grains, with very fine flakes in the matrix.
Chlorite- very fine flakes within the matrix and volcanic rock fragments.
Sericite- as for chlorite.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9722a Field Number: 9722a

Locality: Lucknow Pb-Ag mine

Grid Reference: HK 070 632

1:100 000 sheet name/number: PINE CREEK

Field rock name: Meta-greywacke

Laboratory rock name: Altered litharenite

Formation: Burrell Creek Formation

PETROLOGY DATA Compiled by: P.F.

Minerals present:

Quartz..........................30%	Hematite....................5%	Muscovite.................access.
Rock fragments...........40%	Biotite.........................5%	
Sericite.........................15%	Chlorite......................5%	

Petrological description/remarks:

Fairly homogeneous, well compacted, moderately sorted, medium to fine grained arenite composed of quartz and rock fragment framework grains within a fine sericite-chlorite matrix.

Quartz- subangular to subrounded, mainly monocrystalline grains (av. 0.2mm).

Rock fragments- Three compositional types are recognised; (1) quartzite, (2) quartz-sericite, (3) sericitic.

Sericite- fine felted masses replacing feldspars (?) and rock fragments.

Hematite- dusty coatings on rock fragments and quartz framework grains.

Biotite- fine flakes found at the rims of quartz grains; indicating reabsorption.

A pervassive *stylolitic cleavage* is also evident.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9720a Field Number: 9720a

Locality: Lucknow Pb-Ag mine

Grid Reference: HK 070 632

1:100 000 sheet name/number: PINE CREEK

Field rock name: Altered metagreywacke

Laboratory rock name: Medium to fine grained litharenite

Formation: Burrell Creek Formation

PETROLOGY DATA

Compiled by: P.F.

Minerals present:

Quartz..........................20%	Biotite..........................5%
Rock fragments..........60%	Sericite........................5%
Chlorite.........................5%	Feldspar.....................5%

Petrological description/remarks:

Fairly homogeneous, well compacted, moderately sorted, fine to medium grained arenite composed of rock fragments and quartz framework grains with a chlorite-sericite matrix.

Quartz- angular to rounded framework grains up to 0.7mm (av. 0.2mm) which are usually monocrystalline, some with reabsorbed boundaries.

Rock fragments- several types are recognised including; sericitic, quartz-sericite, fine cherty quartzite and sericite-chlorite.

Chlorite- fine flakes within matrix and rock fragments.

Biotite- mainly fine grains within the matrix.

Sericite- as for chlorite.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9525 Field Number: 9525

Locality: Lucknow Pb-Ag mine

Grid Reference: HK 070 632

1:100 000 sheet name/number: PINE CREEK

Field rock name: Slate

Laboratory rock name: Chlorite-sericite phyllite

Formation: Burrell Creek Formation

PETROLOGY DATA Compiled by: P.F.

Minerals present:

Sericite.....................50%	Quartz................................5%
Chlorite...................40%	Limonite............................5%

Petrological description/remarks:

Very fine grained chlorite-sericite phyllite with a pervasive crenulation cleavage.
Rock contains a 0.2mm wide opaque-bearing quartz veinlet with limonitic alteration zone.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9678 Field Number: 9678

Locality: Union Reefs Pb-Ag prospect

Grid Reference: GK 987 862

1:100 000 sheet name/number: PINE CREEK

Field rock name: Massive sulphide ore

Laboratory rock name: Massive Pb-Zn-Fe-Bi sulphide ore

Formation: Burrell Creek Formation

PETROLOGY DATA

Compiled by: P.F.

Minerals present:

Sphalerite	20%	Quartz	30%
Galena	12%	Siderite	15%
Bismuthinite	12%	Tetrahedrite	1%
Pyrite	10%	Chalcopyrite	trace

Petrological description/remarks:

SEE DESCRIPTION BY PONTIFEX (ATTACHED).

9678 Massive to weakly layered granular aggregate of pyrite, sphalerite, galena, bismuthinite, quartz, siderite; minor tetrahedrite, arsenopyrite, trace chalcopyrite.

This ore sample has a granulose aggregate structure, with a grainsize commonly between 0.1 mm and 2 mm; also, it is layered on a scale of 6 mm to 15 mm with variable concentrations of (different) sulphides, and of quartz in different layers.

The relatively ore-rich layers contain up to 65 % sulphides as individual grains/crystals, and more common as somewhat irregular aggregates, of:

pyrite	)	
sphalerite	)	
galena	)	abundant
* bismuthinite	)	
tetrahedrite	)	
'arsenopyrite'	)	very minor
chalcopyrite	)	trace

(*Bismuthinite forms a solid solution series with stibnite, thus the exact composition of this mineral needs checking by SEM, probe, or selected chemical analyses.)

Pyrite occurs as subhedral to euhedral single crystals commonly in loose aggregates. The sphalerite, galena and bismuthinite rarely occur as single crystals, but mostly in highly irregular aggregates, in which they are quite complexly intergrown, on a scale of several microns through to 1 mm, and these composite aggregates more or less enclose pyrite.

'Arsenopyrite' occurs as scattered single crystals, up to 1 mm size, within the above aggregates. [This mineral may in fact be loellingite ($FeAs_2$) or safflonite ($(Co,Fe,Ni)As_2$), which have essentially the same optical properties.]

Tetrahedrite occurs as small (0.1 mm) grains generally enclosed within galena.

Chalcopyrite occurs as sparse minute exsolution blebs in sphalerite.

One sulphide-rich layer is strongly dominated by coarse tan-coloured sphalerite, with only very minor and much finer associated galena and bismuthinite.

The major gangue mineral within these sulphides is quartz, in texturally heterogeneous aggregates of stressed, partly recrystallised and deformed grains. Lesser amounts of carbonate, probably siderite, are also aggregated with the sulphides.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9527 Field Number: 9527

Locality: Union Reefs Pb-Ag mine

Grid Reference: GK 987 862

1:100 000 sheet name/number: PINE CREEK

Field rock name: Green slate

Laboratory rock name: Chlorite-talc slate

Formation: Burrell Creek Formation

PETROLOGY DATA Compiled by: P.F.

Minerals present:

Chlorite..................50%	Siderite.....................10%
Talc........................20%	Quartz........................3%
Sericite..................15%	Iron oxides.................2%

Petrological description/remarks:

Very fine lepidoblastic rock with siderite veinlets along cleavage planes.

Chlorite- very fine flakes interleaved with sericite and talc.

Talc- same as for chlorite.

Sericite- same as for chlorite.

Siderite- mainly within fine veinlets (0.2mm wide) along cleavage planes, some stretched vugs (?) as well. Veinlets carry some opaques (possibly sphalerite and pyrite).

Quartz- fine grains within some of the siderite veinlets.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9539 Field Number: 9539

Locality: Union Extended Pb-Ag mine

Grid Reference: HK 005 923

1:100 000 sheet name/number: PINE CREEK

Field rock name: Weathered primary ore

Laboratory rock name: Fractured metagreywacke with Cu-Pb-Zn sulphide bearing vein quartz

Formation: Burrell Creek Formation

PETROLOGY DATA Compiled by: P.F.

Minerals present:

Rock fragments...............75%
Vein quartz......................20%
Chalcopyrite......................3%
Galena.................2%
Sphalerite.............access.

Petrological description/remarks: Polished block section.

Fractured metagreywacke wallrock containing chalcopyrite-galena-sphalerite-bearing quartz veins.

Rock fragments- weathered (limonite stained) fine grained metagreywacke.

Vein quartz- white, medium grained, granoblastic.

Chalcopyrite- medium to coarse (up to 3mm) grained subhedra within vein quartz.
- reaction rims containing covellite (weathering to bornite) common.

Galena- fine irregular anhedra, disseminated through quartz vein.
- minor alteration to cerussite.

Sphalerite- dark brown, fine subhedra along edges of chalcopyrite grains.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9540 Field Number: 9540

Locality: Union Extended Pb-Ag mine

Grid Reference: HK 005 923

1:100 000 sheet name/number: PINE CREEK

Field rock name: Metagreywacke with quartz vein

Laboratory rock name: Sheared quartzwacke with quartz vein

Formation: Burrell Creek Formation

PETROLOGY DATA

Compiled by: P.F.

Minerals present:

Chlorite..................40%	Rock fragments.............10%
Quartz....................20%	Biotite................................7%
Feldspar.................20%	Carbonate..........................3%

Petrological description/remarks:

Rock is composed of foliated chlorite and biotite which incorporates numerous attenuated lenses of coarse, polycrystalline quartz, feldspar and cherty rock fragments, elongated parallel to the schistocity.

Chlorite- fine grains, flakes and aggregates with often anomalous Berlin brown birefringence.
- some grains are slightly oxidised with limonite stains on the edges.

Quartz- angular polycrystalline grains comprise the augen (?).
- coarse polygonal grains comprise the veins.

Feldspar- fine to medium grains of plagioclase, partly altered to sericite.

Rock fragments- subangular cherty clasts.

Biotite- fine to medium flakes disseminated with chlorite.

Carbonate- medium grained anhedra within quartz vein.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9543P Field Number: 9543P

Locality: Pickfords Pb-Ag prospect

Grid Reference: GL 819 013

1:100 000 sheet name/number: PINE CREEK

Field rock name: Sulphide-bearing vein quartz

Laboratory rock name: Galena-bearing vein quartz within fractured tuff.

Formation: Gerowie Tuff

PETROLOGY DATA Compiled by: P.F.

Minerals present:

Quartz.........................40%	Galena....................10%
Rock fragments..........35%	Sphalerite.............access.
Feldspar......................15%	Chalcopyrite........access.

Petrological description/remarks: Polished block section.

Heterogeneous ore rock composed of tuff wallrock fragments, vein quartz with disseminated feldspar (?) and galena.

Quartz- white, granoblastic grains forming veinlets within fractured tuff.

Rock fragments- dark grey to black, very fine grained fragments.

Feldspar- fine to coarse, disseminated, irregular pink grains, possibly orthoclase.

Galena- fine to coarse (up to 4mm) skeletal anhedra within tuff and vein quartz.
- usually infills fractures and other voids, some grains have sphalerite inclusions.

Sphalerite- mainly fine anhedral inclusions within galena, some in gangue also.

Chalcopyrite- rare isolated anhedra up to 0.5mm with covellite rim.
- also forms tiny exsolution blebs within sphalerite.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9724 Field Number: 9724

Locality: Jensen's Pb-Ag mine

Grid Reference: HK 069 706

1:100 000 sheet name/number: PINE CREEK

Field rock name: Sandy shale

Laboratory rock name: Sericitic phyllite

Formation: Burrell Creek Formation

PETROLOGY DATA

Compiled by: P.F.

Minerals present:

Sericite...................85% Quartz.......................5%
Chlorite....................5% Hematite..................5%

Petrological description/remarks:

Hematite stained and quartz veined sericitic phyllite.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9679   Field Number: 9679

Locality: Basin 6 Pb-Ag prospect

Grid Reference: HK 058 763

1:100 000 sheet name/number: PINE CREEK

Field rock name: Quartz veined shale

Laboratory rock name: Quartz veined lithic slate

Formation: Mount Bonnie Formation

PETROLOGY DATA   Compiled by: P.F.

Minerals present:

Sericite	60%	Feldspar	3%
Quartz	25%	Opaques	2%
Rock fragments	10%		

Petrological description/remarks:

Dark grey, quartz veined slate.

Sericite- forms a fine schistose matrix.

Quartz- forms scattered fine (0.02-0.2mm), monocrystalline detrital grains and very fine grains within the matrix.
- coarser, up to 0.5mm (av. 0.2mm), white, granoblastic grains make-up the quartz veins which are up to 5mm wide.

Rock fragments- lensoidal, commonly 1mm in size, of chert composition.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9700 Field Number: 9700

Locality: Quest's Pb-Ag prospect

Grid Reference: HK 063 629

1:100 000 sheet name/number: PINE CREEK

Field rock name: Altered mafic rock

Laboratory rock name: Altered picritic basalt

Formation: Burrell Creek Formation

PETROLOGY DATA

Compiled by: P.F.

Minerals present:

Chlorite..........................40%	Quartz.......................5%
Epidote..........................20%	Clinozoisite............5%
Plagioclase....................25%	Chromite................3%

Petrological description/remarks:

SEE DESCRIPTION BY PONTIFEX (ATTACHED)

9700

Microporphyritic picritic basalt; completely pervasive alteration to extremely fine epidote-quartz-chlorite; accessory, very small chromite crystals.

Abundant phenocrysts in this rock, 0.4 - 2 mm long, have been altered to various combinations of quartz, chlorite and locally, clouded clinozoisite.

Many of these phenocrysts, especially those without clinozoisite, contain extremely small euhedral crystals of chromite. This characteristic, together with their outline, suggest that thay were olivine, and the host rock therefore a picritic basalt.

Original pyroxene phenocrysts were probably quite abundant, but it is unlikely that plagioclase was an abundant phenocryst mineral.

The groundmass has been altered to extremely fine mixed chlorite + quartz, and appears to have been relatively mafic. Probable pyroxene microlites about 0.1 mm long have been replaced by relatively coarse chlorite.

A quartz xenocryst with marginal fritting is present, and rare stringers of quartz and chlorite cut the rock.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9701 Field Number: 9701

Locality: Quest's Pb-Ag prospect

Grid Reference: HK 063 629

1:100 000 sheet name/number: PINE CREEK

Field rock name: Coarse grained metagreywacke

Laboratory rock name: Coarse grained meta-volcanic arenite.

Formation: Burrell Creek Formation

PETROLOGY DATA Compiled by: P.F.

Minerals present:

Rock fragments.................40%	Sericite................10%
Quartz...............................25%	Hematite................5%
Feldspar...........................15%	Biotite....................3%

Petrological description/remarks:

Fairly homogeneous, well compacted, poorly sorted, medium to coarse grained arenite composed of rock fragments, quartz, and feldspar framework grains with a sericitic matrix.

Rock fragments- mainly chert-sericite and fine quartzite type clasts, up to 2mm in size.
- generally subrounded and poorly sorted.

Quartz- medium to coarse, monocrystalline grains up to 1mm.
- embayed outlines are recognised on some, indicating a volcanic source.

Feldspar- usually altered to sericite.

Sericite- very fine flakes in the matrix and replacing feldspars.

Biotite- fine, green, scattered flakes.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9526 Field Number: 9526

Locality: Pb occurrence 600m east of Quest's Pb-Ag prospect

Grid Reference: HK 069 629

1:100 000 sheet name/number: PINE CREEK

Field rock name: Galena lode

Laboratory rock name: Massive medium grained galena ore

Formation: Burrell Creek Formation

PETROLOGY DATA

Compiled by: P.F.

Minerals present:

Galena....................95%
Quartz......................3%
Chalcopyrite............2%
Tetrahedrite................access.
Sphalerite....................access.

Petrological description/remarks:

Galena- massive medium grained aggregate with quartz, chalcopyrite, sphalerite and tetrahedrite inclusions.

Quartz- white, fine to medium, granoblastic grains.

Chalcopyrite- fine to medium anhedra inclusions in galena.

Tetrahedrite- very fine blebs within galena.

Sphalerite- late microveinlets and fine inclusions within galena.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9506 Field Number: 9506

Locality: Copperfield copper mine ore dump

Grid Reference: HK 036 650

1:100 000 sheet name/number: PINE CREEK

Field rock name: Pyritic quartz vein

Laboratory rock name: Fe-Cu sulphide bearing vein quartz

Formation: Burrell Creek Formation

PETROLOGY DATA Compiled by: P.F.

Minerals present:

Pyrite...................70%
Quartz.................25%
Chalcopyrite.........5%

Petrological description/remarks: Polished block section

Pyrite- medium to coarse, subhedra and irregular fragments often cracked and pitted, within a quartz gangue.

Quartz- white, medium grained, granoblastic crystals; hydrothermal vein type.

Chalcopyrite- mainly fine irregular anhedra infilling fractures within pyrite aggregates.
- some alteration to covellite (especially along hairline cracks).

Hand specimen shows chalcocite and bornite replacing some of the larger chalcopyrite aggregates.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9508 Field Number: 9508

Locality: Copperfield copper mine, wallrock.

Grid Reference: HK 036 650

1:100 000 sheet name/number: PINE CREEK

Field rock name: Metagreywacke

Laboratory rock name: Sericitized meta-volcanic arenite

Formation: Burrell Creek Formation

PETROLOGY DATA Compiled by: P.F.

Minerals present:

Quartz.......................40%	Feldspar................10%
Rock fragments........25%	Iron oxides............15%
Chlorite....................10%	Biotite......................2%

Petrological description/remarks:

Fairly homogeneous, poorly sorted, well packed, medium grained arenite composed of quartz, rock fragments and altered feldspar grains within a siliceous-sericitic groundmass.

Quartz- mainly monocrystalline, subangular, slightly weathered grains up to 0.5mm in size (av. 0.2mm), with weak undulose extiction and sericite along some grain boundaries (indicating resorption).

Rock fragments- chert-sericite or quartzitic composition.
- mostly altered to sericite, chlorite and clay.

Feldspar- originally K-feldspar now altered to sericite and clay.

Chlorite- irregular patches replacing rock fragments or in matrix.
- some flakes appear Mg-Al rich type (Berlin brown birefringence).

Iron oxides- mainly disseminated limonite and hematite grains.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9679 Field Number: 9679

Locality: Enterprise No2 copper prospect.

Grid Reference: HK 040 677

1:100 000 sheet name/number: PINE CREEK

Field rock name: Altered aplite

Laboratory rock name: Aplite of adamellite composition.

Formation: Tabletop Granite

PETROLOGY DATA Compiled by: P.F.

Minerals present:

K-feldspar	40%	Biotite	10%
Quartz	30%	Zircon	access.
Plagioclase	20%	Apatite	access.

Petrological description/remarks:

SEE DESCRIPTION BY PONTIFEX (ATTACHED).

9679 Aplite of adamellite composition; plagioclase altered to sericite and biotite to chlorite; also a quartz-chlorite patch, containing scheelite, carbonate and rutile.

This rock has a fairly typical aplitic (fine hypidiomorphic granular aggregate) texture, with most crystals 0.2 to 1 mm size. The gross mineralogical composition is that of an adamellite. Rare phenocrysts of plagioclase, up to 4 mm long, are scattered. The mineralogy is approximately :

Quartz	25-30%
Orthoclase	40-45%
Plagioclase + sericite	20-25%
Biotite + chlorite	7%
Zircon + apatite	accessory
Scheelite, rutile, anatase	trace

The plagioclase is mostly altered to sericite and the minor random biotite flakes are altered to chlorite with associated minute titanium minerals.

A patch of chlorite and quartz, 10 mm in diameter occurs at one end of the thin section. This is a coarse grained probably hydrothermal aggregate, containing a grain of scheelite 3 x 1.5 mm, fractured and veined by carbonate. Also, a lath 0.5 mm x 9 mm of very fine crystalline rutile/anatase with sparse interstitial carbonate occurs in this chlorite clot. The origin of this lath is uncertain.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9680 Field Number: 9680

Locality: Enterprise No2 copper prospect.

Grid Reference: HK 040 677

1:100 000 sheet name/number: PINE CREEK

Field rock name: Altered aplite

Laboratory rock name: Sericitised aplite of adamellite composition

Formation: Tabletop Granite

PETROLOGY DATA Compiled by: P.F.

Minerals present:

K-feldspar...............45%
Plagioclase.............20%
Quartz....................15%
Biotiite...........10%

Petrological description/remarks:

SEE DESCRIPTION FOR NTGS 9679

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9502 Field Number: 9502

Locality: Enterprise No2 copper prospect

Grid Reference: HK 040 677

1:100 000 sheet name/number: PINE CREEK

Field rock name: Altered hornfels

Laboratory rock name: Hornfelsed volcanic arenite

Formation: Burrell Creek Formation

PETROLOGY DATA Compiled by: P.F.

Minerals present:

Quartz	45%	Chlorite	5%
Rock fragments	30%	Iron oxides	5%
Feldspar	10%	Clay	5%

Petrological description/remarks:

Fairly homogeneous, well compacted, moderately sorted, medium grained arenite with a weak foliation and stylolitic cleavage.

Quartz- discrete, subangular grains up to 0.5mm (av. 0.2mm), often with re-absorbed grain boundaries, some have embayed outlines.

Rock fragments- interlobate grains of mainly quartz-sericite composition.
- probably of acid volcanic origin.

Feldspar- totally replaced by fine mottled sericite.

Chlorite- fine flakes within matrix.
- slightly oxidised Fe-rich type (Berlin blue anomalous birefringence) forms the chlorite veinlets.

Wallrock alteration: Chloritization (pervasive and vein type), Sericitisation (pervasive) and silicification (vein controlled).

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9551 Field Number: 9551

Locality: The Jar copper prospect

Grid Reference: GL 717 053

1:100 000 sheet name/number: PINE CREEK

Field rock name: Metagreywacke

Laboratory rock name: Sericitised quartzwacke

Formation: Burrell Creek Formation

PETROLOGY DATA Compiled by: P.F.

Minerals present:

Rock fragments.............35%	Feldspar...............5%
Quartz............................32%	Tourmaline...........2%
Matrix............................25%	Opaques...............1%

Petrological description/remarks:

Fairly homogeneous, loosely packed, fine to medium grained arenite composed of quartz and rock fragments within a siliceous-sericitic matrix.

Quartz- subangular, mainly monocrystalline grains, averaging 0.2mm in size.

Rock fragments- mainly grains of cherty-sericitic-chloritic composition.

Feldspar- probably K-feldspar, now completely sericitised.

Tourmaline- fine (50-100μm), pleochroic green-grey to clear subhedra.

Matrix- very fine sericite and chert.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9807 Field Number: 9807

Locality: Granite Mine coppper prospect

Grid Reference: GK 852 861

1:100 000 sheet name/number: PINE CREEK

Field rock name: Copper-bearing quartz vein

Laboratory rock name: Malachite-chalcocite bearing quartz vein.

Formation: McMinns Bluff Granite

PETROLOGY DATA Compiled by: P.F.

Minerals present:

Quartz....................60%
Malachite..............20%
Chalcocite............15%

Petrological description/remarks: Polished thin section.

Quartz- fine irregular grains which commonly surround chalcocite; later stage medium to coarse grained granoblastic-type (drusy to rosette textured).

Malachite- replaces chalcocite; fibrous and radiating in places.

Chalcocite- generally fine to medium grained subhedra, paramorphically from hexagonal (orthorhombic) crystals suggest a hypogene origin.
- cleavage parallel to the (001) plane is clearly visible.
- associated with vuggy (late stage) quartz.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9805 Field Number: 9805

Locality: Granite Mine copper prospect

Grid Reference: GK 852 861

1:100 000 sheet name/number: PINE CREEK

Field rock name: Chloritic aplite-breccia

Laboratory rock name: Chloritised, recrystallised granite

Formation: McMinns Bluff Granite

PETROLOGY DATA

Compiled by: P.F.

Minerals present:

Quartz...............60%	Malachite............2%
Chlorite.............30%	Sericite................2%
Iron oxide...........6%	

Petrological description/remarks:

Fairly heterogeneous rock.

Quartz- fine to coarse granoblastic mosaic, hydrothermal origin.

Chlorite- fine commonly Mg-Al rich type (Berlin brown anomalous birefringence).
- possibly replacing biotite and feldspars.
- later Fe-rich variety (Berlin blue birefringence) associated with fractures.

Iron oxides- fine skeletal anhedra.

Malachite- radiating aggregates within quartz vugs.

Sericite- fine flakes associated with vein quartz.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9812 Field Number: 9812

Locality: Granite Mine copper prospect

Grid Reference: GK 852 861

1:100 000 sheet name/number: PINE CREEK

Field rock name: Chloritic quartz-breccia

Laboratory rock name: Veined and brecciated granite

Formation: McMinns Bluff Granite

PETROLOGY DATA

Compiled by: P.F.

Minerals present:

Quartz....................60%
Chlorite.................15%
K-feldspar.............15%
Vugs..................3%
Opaques............2%

Petrological description/remarks:

Fairly heterogeneous rock.

Quartz- white, coarse grained granoblastic; mainly hydrothermal-type.
- also a fine recrystallised mosaic-type.

Chlorite- fine hydrothermal flakes; associated with fractures microcline.

K-feldspar- fractured microcline (originally coarse laths).
- with chlorite represent original granitic material.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9811 Field Number: 9811

Locality: Granite Mine copper prospect.

Grid Reference: GK 852 861

1:100 000 sheet name/number: PINE CREEK

Field rock name: Hornblende-biotite granite

Laboratory rock name:

Formation: McMinns Bluff Granite

PETROLOGY DATA

Compiled by: P.F.

Minerals present:

K-feldspar............40%	Biotite................10%
Plagioclase...........20%	Chlorite...............5%
Quartz...................20%	Hornblende.........2%

Petrological description/remarks:

K-feldspar- coarse grained microcline with cross-hatch twinning.

Quartz- coarse grained anhedra.

Plagioclase- partially sericitised laths with multiple twinning.
- some grains contain muscovite inclusions.

Biotite- coarse, pleochroic (green to colourless) flakes with minor chlorite alteration.

Chlorite- replaces biotite and hornblende grains.

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9670 Field Number: 9670

Locality: Heatleys Pb-Zn prospect; HPDDH2 343'

Grid Reference: GK 741 984

1:100 000 sheet name/number: PINE CREEK

Field rock name: Volcanic lutite

Laboratory rock name: Meta-quartz siltstone

Formation: Koolpin Formation

PETROLOGY DATA Compiled by: P.F.

Minerals present:

Quartz....................75%	Garnet................2%
Biotite....................10%	Opaques............1%
Muscovite.............10%	Apatite..............2%

Petrological description/remarks:

SEE DESCRIPTION BY PONTIFEX (ATTACHED).

PETROLOGY REPORT SHEET

SAMPLE DATA

Slide Number: 9681 Field Number: 9681

Locality: N2 copper prospect

Grid Reference: GL 747 015

1:100 000 sheet name/number: PINE CREEK

Field rock name: Fractured tuff with malachite veins.

Laboratory rock name: Veined meta-lutite

Formation: Gerowie Tuff

PETROLOGY DATA

Compiled by: P.F.

Minerals present:

Sericite.....................45%	Rock fragments......................5%
Quartz.......................30%	Muscovite...............................5%
Feldspar...................10%	Malachite................................5%

Petrological description/remarks:

Sericite- forms a fine foliated matrix.

Quartz- very fine grains within the matrix with a few coarser dispersed grains.
- medium to coarse polygonal grains within hydrothermal veinlets.

Feldspar- fine K-feldspar?

Rock fragments- fine clasts of chert-sericite composition.

Muscovite- fine (50-100μm), disseminated flakes; metamorphic origin.

Malachite- veinlets and colloform radiating aggregates.