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OUTOKUMPU EXPLORATION AUSTRALIA PTY LIMITED

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ANNUAL REPORT TO 26 MAY, 1991
EL 14/89 - CORINNA, TASMANIA
Volume 1 of 2

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(W. Herrmann 22 March 1991; 25 pages, 3 appendices, 7 figures).
3. Report on the petrographic examination of ironstones and associated metamorphic rocks from the Arthur Metamorphic Complex, NW Tasmania.
(J. Stoltz, 26 November 1990; 66 pages).

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1. INTRODUCTION

This report contains details of the exploration carried out on Exploration Licence 14/89, Corinna, for the twelve months ended 26 May 1991.

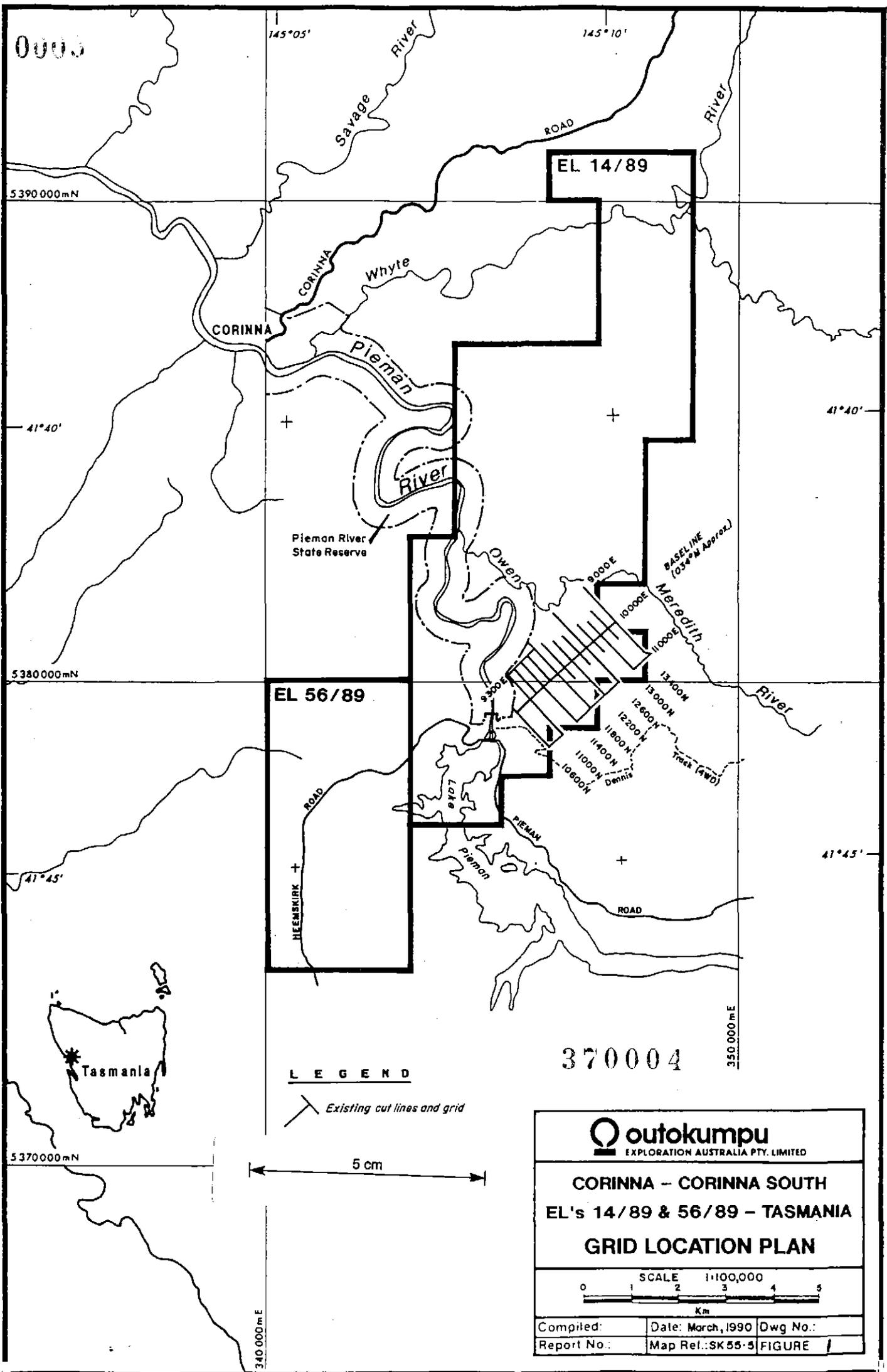
EL 14/89 was granted to Outokumpu Exploration Australia Pty. Limited on 27 May 1989.

In November 1990, an application was made to the Department for a vacant area adjoining the northeast boundary of EL 14/89, with a corresponding relinquishment of 19 sq km from the western portion of EL 14/89. Granting of this application is pending.

2. SUMMARY OF WORK COMPLETED TO 27 MAY 1990

During the first year of tenure, the following work was conducted for EL 14/89:-

- * Review of previous company exploration for the area.
- * Establishment of a new grid (Owen Meredith Grid) with NW-SE crosslines at 400m intervals over 2.8km of strike extent of the Bowry member northeast from Reece Dam. The grid lines were cut, surveyed and pegged at 25m intervals.
- * Geological mapping and rock chip sampling of all new grid lines was carried out, with other sampling along creek traverses and road cuttings. 35 rock chip samples were analysed for a suite of elements.
- * Petrographic samples (total 17) were submitted to Minpet Services for description.
- * A preliminary ground magnetometer survey was conducted on the grid at 5m station spacing.
- * The Owen Meredith grid was extended by infill lines at 200m line spacing.



0000

145°05'

145°10'

5390000mN

ROAD

EL 14/89

CORINNA

CORINNA

Whyte

Pieman

River

Pieman River State Reserve

41°40'

41°40'

5380000mN

EL 56/89

Owen

BASELINE (054°M Approx.)

Meredith

River

41°45'

41°45'



Tasmania

LEGEND

Existing cut lines and grid

370004

350.000mE

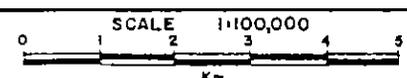
5370000mN

340.000mE

5 cm

Outokumpu
EXPLORATION AUSTRALIA PTY. LIMITED

**CORINNA - CORINNA SOUTH
EL's 14/89 & 56/89 - TASMANIA
GRID LOCATION PLAN**



Compiled:	Date: March, 1990	Dwg No.:
Report No.:	Map Ref.: SK 55-5	FIGURE 1

3. SUMMARY OF WORK COMPLETED TO 26 MAY 1991

- * The extended grid (200m spaced infill lines) was surveyed by ground magnetometer in May-June 1990 to locate ironstone targets. Magnetic measurements were taken at 5m intervals.
- * Soil geochemical sampling of the B/C horizon was carried out at 25m intervals across the Bowry Member on all grid lines between 11000N and 13400N. A total of 409 samples were assayed for Cu, Pb, Zn, Au.
- * Geological mapping of the detailed grid was completed and a further 7 petrographic and 21 rock chip geochemical samples were collected.
- * Assay results from 56 rock chip samples were received and a report was received on the petrography of 17 rock samples from the Bowry Formation from Minpet Services. A more detailed petrographic report was received from J. Stolz (University of Tasmania) for the previously described rock samples and an additional 7 samples in November, 1990.
- * The Owen Meredith grid was extended 1.4 km to the north-east during January-February, 1991.
- * Geological mapping, rock chip sampling and a ground magnetic survey was carried out during late February, 1991 on the extended grid. The magnetic survey located several ironstone horizons. 32 rock chip samples were collected and assayed for Cu, Pb, Zn, Ag, Au, Fe, Mn. 15 stream sediment samples (-80#) were collected in a trial survey of Doctors Creek and Owen Meredith River and assayed for Cu, Pb, Zn, Ag, Fe, Mn. 15 panned concentrate samples were taken from the same sites and assayed for Au. Visible gold was obtained in the sites downstream from the Bowry Member, probably originating in banded ironstones adjacent to the eastern contact of the unit.

4. CONCLUSIONS & RECOMMENDATIONS

The exploration to date on EL 14/89 has yielded a greater understanding of the geological setting of ironstone deposits in the area, with two distinct types of ironstones defined:-

- * Banded siliceous ironstones, which occur in association with disseminated/lenticular magnetite and pyrite in mafic albite + chlorite + quartz schists in a narrow zone at the eastern contact of the Bowry Member. These ironstones, and to a lesser extent the surrounding schists, contain weak chalcopyrite and gold mineralisation. Petrographic textural and outcrop observations are consistent with an interpretation that these ironstones originated as sedimentary iron formations. They are reflected in relatively weak ground magnetic anomalies.

- * Massive ironstones, consisting essentially of magnetite with some pyrite, occurring in close spatial association with sodic leucogranite and magnesian silicate and tourmaline bearing rocks of apparently metasomatic/metamorphic origin close to the western margin of the Bowry member. These ironstones occur in lenses of substantial tonnage, with thickness up to 20m, producing large magnetic anomalies. Iron content is around 70% but with low base metal and gold values.

Exploration of the Bowry Member is loosely based on the Starra type Cu/Au ironstone ore deposit model. Indications from relatively sparse outcrop chip samples are that the massive ironstones are essentially barren of copper and gold and that the banded ironstones and associated schists are weakly mineralised in these metals.

The exploration problem currently is to determine if this style of mineralisation has potentially economic grade/tonnage characteristics. Techniques to systematically identify and test zones of higher grades in the banded ironstones need to be determined.

The proposed methods being considered are magnetic and IP surveying in combination with outcrop mapping and sampling to trace the zone of interest, followed by systematic close-spaced c-horizon soil/bedrock geochemical sampling to define targets.

5. PROPOSED EXPLORATION

A proposal for further exploration at Corinna is based on:-

1. The success of the work to date in defining the prospective horizon of the Bowery Member.
2. The development of the current ironstone hosted copper-gold geological model to date, with the previous geological and geophysical work on the area and the identification of copper-gold geochemical values in and associated with the ironstones in the sequence.
3. The application for the additional areas containing thick sequences of banded iron formation.

The programme will involve conducting IP, Sirotem or EM37 surveys over the presently defined banded ironstones to assist in the development and refinement of the geological model. This work is planned to locate conductive copper sulphide bodies associated with the banded ironstones either in the magnetic highs or lows or in structurally complex areas.

The drilling of three or four short (50m) wacker drillholes into the geological and geophysically developed target models is proposed at the end of field season.

strongly weathered
bedrock only

APPENDIX 1

EL 14/89 - Corinna:Exploration Progress Report July 1990.

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Report No: R72.4

File No: 2.72.9

EL 14/89 - CORINNA
Exploration Progress Report
July, 1990

for Outokumpu Exploration Australia P/L
 77 Pacific Hwy. North Sydney 2060
by W.Herrmann, RSD 1066 Devonport 7310
date 25 July 1990

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1. SUMMARY

An initial exploration programme involving grid cutting, geological mapping, rock chip and B/C horizon geochemical sampling and ground magnetic surveys has been undertaken over the southern part of EL 14/89.

The results indicate the presence of a number of narrow, apparently stratiform bodies of magnetite rich ironstones within a narrow belt of amphibolites, mafic to felsic schists and minor quartzites, dolomite-magnesite marble and sodic leucogranite, known as the Bowry Member.

Geochemical results to date have been unremarkable and the origin and economic significance of the ironstone bodies remains a matter of conjecture.

2. INTRODUCTION

Exploration Licence 14/89 occupies an area of about 42 sq km and covers about 15 km of strike length of the southern part of the Arthur Metamorphic Complex, between Brown Plains and Lake Pieman in northwestern Tasmania.

The licence was granted to Outokumpu Exploration Australia P/L on 26 May, 1989.

This report presents the details and results of the mineral exploration programme carried out during the first year of tenure. This programme was partly undertaken and partly supervised by W.Herrmann under a contract arrangement with Outokumpu.

3. EXPLORATION PHILOSOPHY

Outokumpu's exploration programme is intended to assess the southern part of the Arthur Metamorphic Complex for a variety of possible exploration targets including:

- * Besshi type stratiform Cu-Zn massive sulphides
- * Cu-Au deposits associated with magnetite ironstones
- * Metasomatic tin-tungsten deposits
- * Carbonate associated Cu deposits

Exploration in the first year of tenure has been focussed mainly on:

- * an attempt to develop an understanding of the regional geology and styles of known and possible mineralization in the area,
- * delineation and sampling of the magnetite rich ironstones within the Bowry Formation.

4. REGIONAL GEOLOGY

The regional geological setting of the Arthur Metamorphic Complex has been discussed in reasonable detail in a previous report (Herrmann, 1989) from which the following summary has been reproduced.

The Arthur Metamorphic Complex (AMC) is a narrow linear zone of strongly deformed and regionally metamorphosed rocks trending north northeasterly across northwestern Tasmania. It separates two sequences of unmetamorphosed late PreCambrian sediments; the Rocky Cape Group to the west representing a stable continental shelf facies, and the Burnie/Oonah Formation to the east representing deeper water turbidites. The metamorphic rocks within the Complex are divided into two "sequences":

The western most (Timbs Group) consists of chlorite-mica-carbonate schists, amphibolites and dolomite-magnesite marble of the greenschist to amphibolite facies of regional metamorphism. They are believed to have compositional similarities, especially in the tholeiitic nature of the amphibolites, to the clastic-carbonate-mafic volcanic sequence of the Ahrberg Group which unconformably overlies the Rocky Cape Group west of the southern part of the AMC.

The eastern metamorphic sequence consists mainly of psammo-pelitic schists and quartzite compositionally similar to the Burnie/Oonah Formations with which they appear to have a transitional eastern boundary.

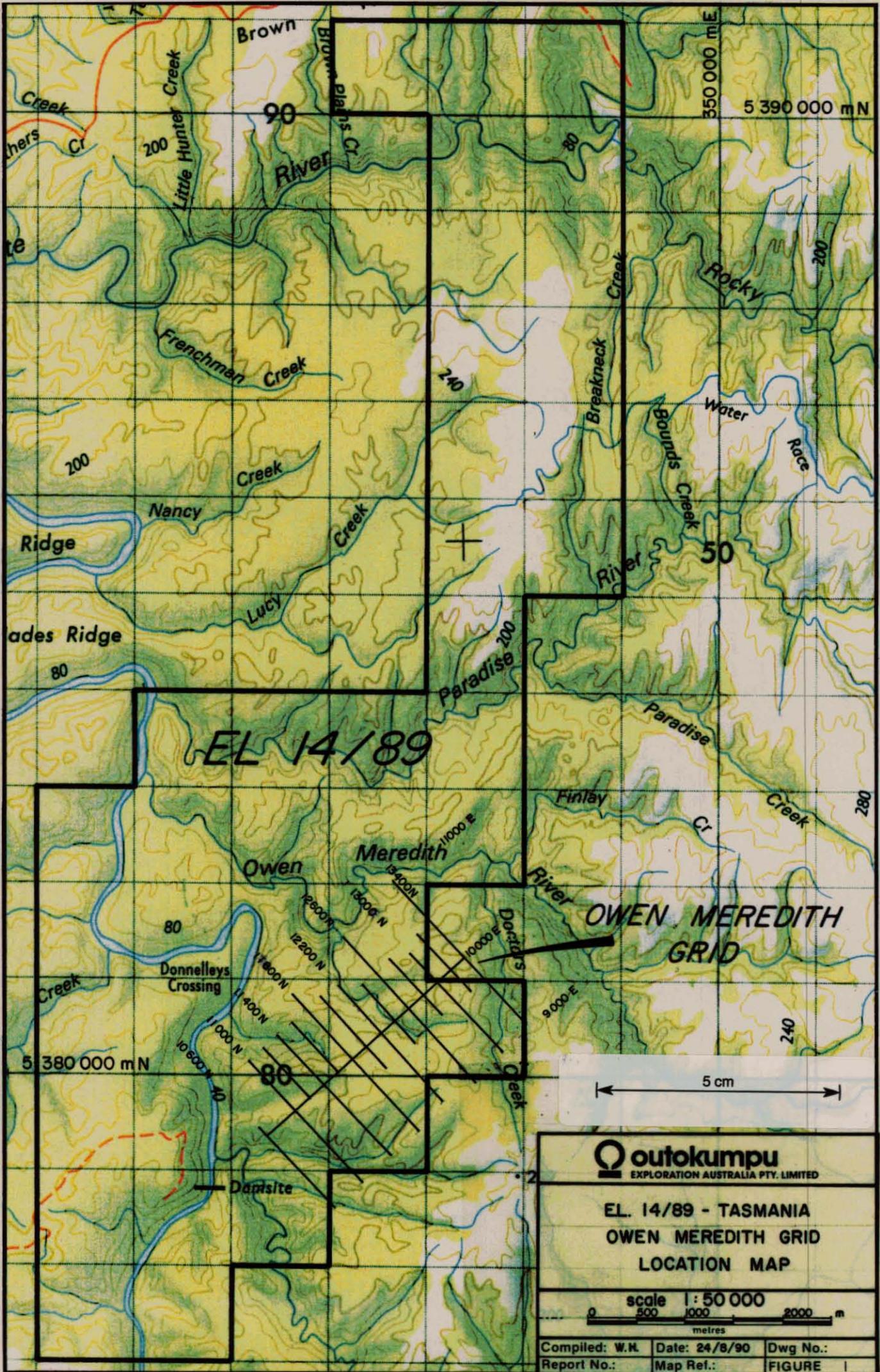
On the basis of the Timbs-Ahrberg lithological correlation and the similarity of the Ahrberg Group to the EoCambrian ? sequences of the Smithton Trough and western Dundas Trough (which are interpreted to have formed in continental margin rift basins) it is hypothesized that the AMC represents a similar EoCambrian ? rift assemblage which was deformed and metamorphosed after the Middle Cambrian.

The Arthur Metamorphic Complex is host to several large magnetite-pyrite deposits which appear to be stratiform and localized within the eastern most part of the Timbs Group (known as the Bowry Member). Minor copper, zinc and gold mineralization is associated with the ironstones. The ironstone deposits and the hypothetical tectonic setting have some characteristics with similarity to the Starra Cu-Au ironstone deposits of western Queensland and the massive sulphide deposits of Besshi style in Japan.

Although none of the known ironstone deposits contain remotely economic base or precious metal grades the previous exploration for these targets has not been exhaustive and there remains some scope for further exploration based on interpretation and follow up of existing aeromagnetic survey data as well as systematic geological mapping which appears to have been substantially neglected in the past.

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5. PREVIOUS EXPLORATION

During the years 1986 - 1987 the Electrolytic Zinc Co. of Australia carried out exploration for base metals and gold under their EL 22/85 which had substantially similar boundaries to the current EL 14/89.

(Refs: Mathison, 1986; Mathison and Ferguson, 1987)

EZ Co. carried out:

- compilation of previously known geology and mineral occurrences,
- literature review of historical gold occurrences,
- reconnaissance geological mapping and rock chip sampling on east-west cut lines spaced at 1 km intervals,
- -80# stream sediment and panned concentrate geochemical sampling,
- limited ground magnetic traverses.

The results of these surveys showed little encouragement for gold mineralization; although several of the panned concentrate samples were found to be significantly anomalous it was concluded that these could be attributed to reworking of gold from unconsolidated Tertiary gravels.

The -80# stream sediment sampling programme was not exhaustive but failed to indicate significant anomalies; all base metal values were low, mostly below 50ppm.

Rock chip sampling indicated fairly widespread weak copper anomalies, in the range ~ 400-800ppm, usually in association with mafic schists also containing upto around 10-15% iron (as magnetite ?) and occasionally zinc upto about 500ppm. However, these did not have a particular focus and seemed to more or less represent high background values in some of the mafic rocks, particularly of the Bowry Member.

Some, but not all, of the ironstones, with 20-60% Fe, were also anomalous in copper, (>400ppm, max: 3200ppm) and rarely weakly anomalous in zinc (Max:~500ppm). None of the ironstones were found to be anomalous in gold.

The ground magnetic survey was incomplete (due to instrument failure) but the distribution of ironstone rock chip samples coupled with (Geoex, 1982) aeromagnetic data allowed a reasonable delineation of the ironstone formations which seemed to be confined to the Bowry Member, usually close to its eastern margin, crossing diagonally northeastwards through the southern part of EL 22/85 and then following a northerly trend just outside the eastern boundary of the licence.

The EZ Co., insufficiently encouraged by the gold results to continue exploration alone, then sought joint venture partners but, failing in this endeavour, relinquished the licence in late 1988.

6. 1989-90 EXPLORATION PROGRAMME AND RESULTS

Following a review and assessment of EZ Co's. data it was concluded that the scattered weak base metal anomalies did not warrant follow up.

However, on the basis of a possible analogue to the Starra type Cu-Au deposits, it was determined that the ironstones should become the focus for investigations.

Accordingly, the following work was undertaken during the period January - May, 1990:

- * Establishment of a new grid system; with NW-SE crosslines at 200m intervals over 2.8 km of strike extent of the Bowry Member northeast from Reece Dam. (Fig: 2)

This grid has been named the "Owen Meredith Grid" in honour of the pioneer prospector, even though it lies just to the south of the river of that name.

Land tenure constraints on the extent of the grid were as follows:

Southwestwards: The HEC requested that no operations (other than geological mapping) be carried out within 600m radius of Reece Power Station.

Westwards: Boundary of the Pieman River State Reserve.

Northeastwards: Eastern boundary of EL 14/89.

The grid lines were cut, surveyed and pegged (at 25m intervals) under contract by "Tas Gridding" (G.Mallinson, A.Brumby and others) who reported the cutting progress to be very slow, average about 350m/day/2 man team, due to the thick post (1982) wildfire regrowth of cutting grass, tea tree, Bauera etc. entangled with a multitude of downed, partly burnt logs and exacerbated by fairly long walking distances from nearest points of vehicular access.

- * Geological mapping and rock chip sampling of all new grid lines, some strategic creek traverses and exposures in road cuttings around Reece Dam and along Heemskirk Road for some 1.5 km to the west.
Rock chip samples were analysed for a suite of elements as detailed in Section 6.2
The mapping was carried out by the writer, ably assisted, at times, by T.Coff and D.Were.
- * Petrographic study of 17 rock specimens to assist the geological interpretation.
- * Ground magnetometer survey (@ 5m station spacing) of the new grid, (Appendix I; C.Anderson & Associates, 1990)
The survey was carried out in two parts: initially by M.Millard of Adelaide, assisted by D.Were of Myalla and subsequently by B.Stedman of Sister's Beach.

- * B/C horizon soil geochemical sampling at 25m intervals across the Bowry Member on all lines between 11000N and 13400N; analysis for Cu, Pb, Zn, Au. (Total: 409 samples)
The sampling was carried out under contract by Mooreville Exploration (C.Cooney) utilizing cup type hand auger; sample depths ranged from 0.3-1.0m, averaging around 0.7m.

6.1 Geology

Figure 3 shows a geological interpretation based on the mapping carried out this season. Geological outcrop over the area is generally poor to non existent and hence the geological boundaries shown are regrettably very interpretative. The geological contacts are rarely exposed, never traceable and the structural relationships remain obscure.

However, it is apparent that the gross lithological layering has a northeasterly strike trend and dips moderately to steeply to the southeast (average about 50-60 degrees), which is broadly co-planar with the principal foliation or schistosity.

The entire southeastern part of the grid appears to be underlain by a fairly monotonous assemblage of **psammo-pelitic metasilstones and phyllites**.

They vary in composition from psammitic to semi-pelitic, are frequently thinly laminated and have a ubiquitous slaty cleavage or foliation parallel to the compositional layering which is commonly offset by a crenulation cleavage.

The principal foliation generally trends NE-SW with a moderate southeasterly dip although local contortions and minor folds are fairly common. The crenulation cleavage generally has a north to northwest trend and steep dips, >60 degrees.

The metamorphic grade is not high; micas are generally fine grained with the texture best described as phyllitic; some of the psammitic rocks probably retain a relict clastic granular fabric.

They are undoubtedly of metasedimentary origin and as recognised by previous workers appear to be regionally metamorphosed equivalents of the Oonah Formation. No facing evidence has been observed during this mapping programme.

In the vicinity of Reece Dam, these psammo-pelitic metasediments contain a number of semi conformable bodies of **dolerite**. In a few places a medium to coarse ophitic fabric is retained but in general the mafic rocks are extremely sheared and in weathered outcrops resemble felsic schist. The strain appears to have been extremely localized, especially close to the margins of the presumably intrusive, bodies. A good example of this occurs 100m north of Reece Power Station (rock specimens A104636, '637) where the core of the dolerite remains relatively pristine with

only a moderate cleavage but the marginal zone is totally sheared, strongly foliated, apparently rather silicified and megascopically resembles a quartz-albite ?-chlorite-sericite schist. The less altered dolerites can usually be distinguished from amphibolites by their lack of magnetite.

This (psammo-pelitic metasedimentary and dolerite) assemblage is structurally underlain to the northwest by a 200 - 500m wide belt of rocks dominated by amphibolites and mafic schists with subordinate quartzite, dolomite-magnesite marble, ironstones, sodic leucogranite and felsic schist. This has previously (Mathison & Ferguson, 1987 and etc.) been termed the Bowry Member and is reportedly ubiquitous along the eastern margin of the Timbs Group within the AMC. Mathison and Ferguson (1987) regarded it as the uppermost member of the Timbs Group and considered that it was probably (stratigraphically) overlain by the Oonah Fmn.

Turner (1989) noted that the sequences were "possibly" conformable but perhaps also faulted. This contact, in the Owen Meredith Grid area, is exposed in Doctor's Creek where it is sharp and evidently concordant with both layering and foliation in the adjacent rock types and marked by a 10cm band of delicately layered quartz+magnetite +/- pyrite rock.

Northwestwards, the mainly amphibolitic Bowry Member is structurally underlain by an assemblage of semi pelitic quartz + muscovite +/- chlorite +/- biotite schists. The contact is not well exposed but seems to be a fairly abrupt transition. These schists are generally more micaceous, coarser grained and more foliated (perhaps of slightly higher metamorphic grade) than the phyllites and metasiltstones of the Oonah Fmn. equivalents and they are fairly easily distinguished from them in the field. Nevertheless, the compositional ranges seem to be broadly comparable with both groups evidently of a metasedimentary origin.

These northwestern pelitic schists may be part of the Bowry Fmn but more likely represent part of the Timbs Group schists which appear to form the major lithotype of the Arthur Metamorphic Complex.

The contact with amphibolites is not exposed but could be broadly conformable; foliation in the pelitic schists parallels the local trend.

North of Heemskirk Road, at the western end of Figure 3, rocks in a structurally analogous position; i.e. northwest of the Bowry Member, consist of interbedded semi pelitic schists, quartzite and dark (carbonaceous?) dolomitic siltstone with several bodies of (meta) dolerite; they appear to be of lower metamorphic grade than schists of the northwestern part of the grid and rather resemble the Oonah equivalents although this may be in part due to the leached nature of the exposures in road cuttings. I have not carried out sufficient mapping in this area to fully assess the possible implications.

Lithotypes of the Bowry Member

Megascopically, the **amphibolites** are mostly fine grained (0.1-0.5mm) dark green-grey mafic rocks and consist of a fine aggregate of amphibole, plagioclase, commonly with some epidote, possibly chlorite and ubiquitous magnetite. Most specimens have a massive to weakly linear or foliar nematoblastic fabric. Some of the better exposures suggest a crude grainsize banding which is parallel to the regional trend of foliation and strongly suggests relict bedding; the banding, however, is not megascopically discernable on sawn faces of selected specimens. Some of the amphibolites have a paler pinkish greenish grey colour which may be partly attributable to albitization or weak K-feldspar alteration. Magnetite is ubiquitous as fine, usually octahedral, disseminated grains constituting around 1-5% of volume; all the rocks mapped as amphibolite are distinctly magnetic.

Petrographic descriptions of five typical amphibolites from the grid; (specimen numbers: A104569, A104591..94; Ref: Appendix II) indicate that they are albite-hornblende-quartz-epidote-magnetite schists variably sheared and retrograded with chlorite largely replacing hornblende. Most contain considerable accessory sphene or rutile and a trace of tourmaline; some contain minor K-feldspar. The petrographer has interpreted these as regionally metamorphosed calc-silicate rocks of argillaceous/calcareous origin and has recognized relict sedimentary layering in some.

However, the high sphene/rutile contents, reflected in analytical results of 1-1.9% T1, (Appendix III; A104569 and others) strongly suggests a mafic igneous origin, probably as basaltic extrusives or associated intrusive sills. I suspect that the reported faint "bedding" is a largely cataclastic/metamorphic effect but concede that some may represent relict layering of metamorphosed mafic volcanoclastics.

Closely associated with the amphibolites are some subordinate? **mafic schists**; usually regrettably strongly weathered but apparently largely composed of chlorite, albite and quartz. These are usually of fine to medium grainsize (0.2-0.8mm), dark greenish (to brown when weathered) colour and distinct micaceous foliation. Some have a "gritty" fabric with porphyroblastic? or relict porphyritic albite +/- quartz? grains. These chloritic schists are usually only weakly magnetic and contain <1% megascopically distinguishable magnetite, if any. Some specimens contain a few percent pyrite as disseminations or associated with thin lenses and pods of grey quartz. The petrographic description of a typical representative, A104590, (Appendix II) indicates that the gritty fabric is due to relict, partly sheared and brecciated, plagioclase phenocrysts (which are also partly replaced by tourmaline) and infers that the precursor was a silicified? porphyritic andesite or dacite.

It is considered that these possibly represent metamorphosed mafic to intermediate porphyritic extrusives, volcanoclastic

wackes or more intensely sheared and retrograded equivalents of the amphibolites. A number of analyses of this rock type (A104559, '564, '565; Appendix III) show Ti contents greater than 0.77% suggesting a mafic igneous relationship with the precursors of the amphibolites. They generally do not form prominent outcrops. They have not been differentiated in the interpretation shown in Fig. 3 but are grouped together with amphibolites for overall clarity. Nevertheless, the mafic schists seem more prominent near the south eastern boundary of the Bowry Member here.

Associated with these mafic rocks are some rather siliceous schists which may be best described as **micaceous quartzites**. These consist dominantly of fine to medium grained (0.1-1.0mm) granular quartz with subordinate (2-20%) chlorite and/or sericite and (occasionally) minor relict plagioclase phenocrysts. In a couple of exposures this type of micaceous quartzite is interlayered on a 2-20cm scale with more chloritic mafic schist; the layering is parallel to foliation and probably represents relict bedding. These micaceous quartzites are interpreted to be meta-volcaniclastic sediments, perhaps representing thinly interbedded quartzwackes and mafic to felsic volcaniclastics.

In the western part of the grid there are a few small outcrops of apparently **felsic schist**. These typically are composed of scattered (5%) porphyroblasts or relict phenocrysts of translucent grey to pinkish grey quartz or plagioclase of upto about 1mm diameter contained in a fine sheared/schistose base of buff coloured feldspar?, quartz, sericite, minor chlorite and accessory magnetite. Texturally similar but extremely weathered exposures exist along the Heemskirk Road about 800m NW of Reece Dam. They megascopically resemble a sheared quartz/feldspar phyrlic felsic volcanic and it is considered likely that the precursors were such. Alternatively, these felsic schists could represent more intensely sheared versions of the sodic leucogranites observed elsewhere (within the Bowry Member) on the grid, in Doctor's Creek and in the Whyte River.

Dolomite-magnesite marble has been observed in only one location (at Round Creek near 12600N) where it appears to lie close to the northwestern boundary of the Bowry Member. The marble (represented as analysis No: A104567, Appendix III) here is massive, with fine grained compact granular texture and uniform pale buff colour and appears to lack any alteration. However, there are several exposures and patches of float over the length of the grid (most notably at Horseleg Creek and on lines 11800N and 13200N) of sintery-cavernous, sometimes brecciated, quartz which are confidently interpreted to represent silicified carbonate and may represent a single horizon as shown in Fig.3.

This rock type has been petrographically described as A104589 (Appendix II), analysed in A104556 (Appendix III) and depicted in Photo No. 1.

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At Horseleg Creek, the silicified carbonate unit is no more than about 5m in thickness and shows distinct relict bedding ? lamination dipping at 60 degrees to the south east, parallel to the regional foliation. The origin of the silicification is not known but a surficial/supergene process seems likely.



Photo 1. Southeast dipping, 5m thick unit of vuggy silicified carbonate; north bank of Horseleg Creek near OM grid 11870N/9700E

In Trackcutter Creek this ? carbonate unit seems to be in contact with sodic leucogranite and is locally altered to a quartz + tremolite/actinolite skarn which has formed a 10m high waterfall in the creek here. The skarn is described (Appendix II; Nos. A104587, '588) as having originated by contact metasomatic/metamorphic alteration of an impure quartz-carbonate sediment. The petrographer seems to imply that contact metasomatism/metamorphism preceded shearing (and regional deformation/metamorphism ?).

Analysis A104572 of a rather pyritic/semi gossanous sample of this skarn (in float at the foot of the falls) is distinctly anomalous in yttrium and lanthanum.

The sodic leucogranite has been observed only in a few outcrops between Trackcutters Creek and line 12600N, in a patch of very weathered float near 12850N/9950E and in outcrops at Doctor's Creek.

The petrographic report (A104566, Appendix II) indicates that the rock is dominantly composed of oligoclase and quartz with minor zircon and iron oxides after biotite; there is evidence of cataclastic metamorphism with syndeformational growth of granophyric quartz-plagioclase and the rock is termed trondjemite.

A suite of three felsic rocks from the Bowry Member at the Whyte River, (A104596..598, Appendix II) seem to have more or less similar compositions with additional upto 10% ferromagnesians (hornblende, epidote, chlorite) and are termed meta tonalites. The sodic leucogranite in Doctor's Creek (megascopically) appears to have similar composition and contains minor veins of tourmaline.

The textural indications are that these leucogranites were emplaced prior to metamorphism. The field relationships are rather obscure but they could be present as narrow semi conformable bands (dykes or transposed lenses ?) and in a number of places there is a spatial relationship to metasomatic ? assemblages including tremolite/actinolite and tourmaline.

The calcsilicate-quartz skarn at the contact between carbonate and leucogranite in Trackcutter's Creek has already been mentioned; a similar skarn like lithology occurs adjacent to the northern contact of the leucogranite in Doctor's Creek, perhaps in an analogous setting although a carbonate formation has not been observed here.

Near 12800N/9900E there are occurrences of an unusual tremolite/actinolite + tourmaline + magnetite +/- pyrite "schorl" which appears to have formed by pre metamorphic alteration of a mafic igneous rock, probably of similar type to the (high T1) precursors of the amphibolites. (A104574, '575; Appendices II & III) Similar rocks occur at the margin of a massive martitized magnetite ironstone in Doctor's Creek 50m downstream from the leucogranite.

A specimen from the former locality was examined and microprobed by G.J. Davidson, 1987, (in: Mathison and Ferguson, 1987) who concluded that the tourmaline was a hybrid type (Fe/Fe+Mg ratios around 0.5) derived from reaction between a metasomatic fluid of granitic origin with a magnesium rich basaltic rock and suggested that the immediate area was prospective for Sn-W-Cu mineralization of Cleveland type. Davidson reported that the actinolite showed no preferred orientation and was partly replaced (postdated) by tourmaline. Mathison and Ferguson (1987) concluded that metasomatism in the Bowry Member was "associated with very much younger granophyric intrusives." Petrographer Curtis (Appendix II), however, interprets that metamorphism and shearing postdated the tourmalinization. Given the spatial association between schorls and leucogranites and the strain effects described in both it seems more likely that they have a genetic association and were emplaced prior to metamorphism; ie: are not associated with younger (Devonian) granitoids, and this seems to be supported by the low Sn,W,Mo analytical values.

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Ironstones of several compositional/textural varieties have been observed on the grid and in Doctor's Creek:

Banded ironstones occur at 11600N/9825E, 12200N/9880E, and at the Bowry - Oonah contact in Doctor's Creek. Most of these exposures are regrettably strongly oxidised but appear to have consisted of thin bands (1-10mm thick) of granular magnetite + pyrite alternating with bands of magnetite + chlorite? + quartz. They are variably siliceous containing from about 10-90% quartz. The more siliceous type, eg: A104585, floater from 12600N/9880E, resembles cherty jaspilite. Magnetite content varies from about 10-60% and pyrite is usually subordinate but ranges upto perhaps 30%.

Curtis (in Appendix II) petrographically described two ironstones of this type from the Rocky River Ironstone near the junction of Whyte and Rocky Rivers, (A104581 with 5% Py and 104586 without Py) as quartz + iron oxide +/- carbonate sediments which have been subjected to cataclastic metamorphism. The pyrite in A104581 is reported to occur as replacement of magnetite and martitized magnetite.

The banded ironstone at Doctor's Creek occurs as a 10cm thick unit of delicately layered quartz + magnetite ~30% + pyrite ~5% + minor chlorite and possibly albite lying apparently conformably at the contact between amphibolitic mafic schist and the overlying pyritic quartzite. The mafic schists, within about 5m of the contact, contain numerous discontinuous thin bands, <20mm, and lenses of similar quartz + magnetite +/- pyrite which may represent transposed remnants of thin beds. The textures and modes of occurrence strongly suggest a stratiform, probably sedimentary origin but given the degree of deformation and strong shearing, a selective replacement may be possible.

Analyses of the banded ironstones indicate that they contain :
upto 65% Fe
low Mg, usually <1%
variable Ti upto about 0.5%
very low Ca, Na, K
very low Pb, Bi, As, Sn, W, Mo and Sb
variable Ba, upto 1500ppm at Rocky River.
Most of the samples are also low in Cu, Zn (<200ppm) and Au.
However, the Doctor's Creek samples are exceptions in that they contain upto 0.5% Cu and 0.3g/t Au.

Massive Ironstones occur on the grid at 12000N/9975E, in float at the junction of Trackcutter's and Round Creek, 13200N/9990E and in Doctor's Creek at the western margin ? of the Bowry Member. A few similar occurrences at Rocky River and Main Creek have been cursorily examined and sampled.

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These ironstones essentially consist of massive compact magnetite, sometimes with a little sintery quartz and scattered blebs of pyrite, variably martitized, oxidized, limonitic and gossanous (if pyritic) in outcrop.

Analyses of these rocks (Appendix III) show iron contents in the range 60-75% with other element abundances more or less similar to the banded ironstones except that none of the massive types are significantly anomalous in copper or gold, (max: 220 ppm Cu)

The origin of these massive ironstone bodies, which probably are locally of considerable size (eg: Rocky River; estimated at ~4 million tonnes) and their relationship with the banded types is uncertain.

Other minor occurrences of magnetite have been observed as thin discontinuous, foliation parallel lenses of, usually gossany, magnetite + pyrite in amphibolite, such as those at 11790N/9560E (A104576, '577). These are possibly less siliceous analogues of the banded qtz + mt + py bands and lenses in mafic schists at Doctor's Creek and, like those are sometimes weakly anomalous in copper and gold (upto 800ppm and 0.06g/t respectively).

6.2 Geochemistry

Rock Chip Geochemical samples collected during mapping were analysed by ANALABS of Burnie as follows:

Cu,Pb,Zn,Fe,Mg,Ca,Na,K	by AAS methods 101, 104 or 140 (as appropriate)
Mo,W,Ba,Zr,Y,La,Ti	by XRF methods 401 or 403 (as appropriate)
Au	by Fusion/AAS method 309

Some of the (first batch) samples were also analysed for:

B1 (101) and As,Sb,Sn (401)

The analytical results are recorded in Appendix III.

Some of the geochemical features have been briefly discussed above but overall it may be concluded that the rocks sampled, including the mineralogically exotic ironstones, are relatively barren of the likely metals.

The most significant anomalies are associated with:

- * Banded siliceous ironstone and associated ? lenses in amphibolite at Doctor's Creek. These contain upto 0.5% Cu and 0.3g/t Au (in selectively high graded samples). The overlying ~4m thick unit of pyritic quartzite (A104608) also

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contains anomalous Cu,Au (0.4%, 0.08g/t) but no magnetite which might imply that Cu-Au mineralization is associated with pyrite rather than magnetite. This would have important implications for geophysical exploration. Textural relationships elsewhere (Rocky River and Alpine) suggest that pyrite may have formed by replacement of magnetite.

- * Thin lenses or pods of gossany, sometimes siliceous sintery material after pyrite + magnetite + quartz, usually within amphibolite (eg: at 11790N/9560E, 13200N/9985E) or as occasional floaters (eg: A104553, '554 at 11250N/9300E). These contain upto 800ppm Cu and 0.06g/t Au.
- * The small gossan associated with the tremolite/actinolite + tourmaline + magnetite schorl near 12800N/9900E (A104575) contains 0.13% Cu. The tremolite/actinolite + quartz + pyrite skarn from the falls at Trackcutter's Creek contains 480ppm Cu (and anomalous Y,La), (A104572) Both of these occurrences may be metasomatically related to nearby sodic leucogranite.

Otherwise, Cu and Zn rarely exceed 300ppm and Pb is mostly at less than 10ppm, peaking in an isolated gossany-pyritic sample at 170ppm.

The elements Ti,Zr,Y and La were analysed for the purpose of comparison with the geochemical data summarized by Davidson (1990)

I have calculated the means and standard deviations of these elements for the ironstones as follows:

	Banded (n=9)		Massive (n=9)		All Ironstones (n=18)	
	x	SD	x	SD	x	SD
TiO2	0.26	0.32	0.48	0.67	0.37	0.52
Zr	14	11	9	5	11	9
Y	10	7	10	7	10	6
La	21	8	36	13	27	15

Comparison of these values with those of Davidson's Table 6 (1990) from Starra ironstones suggests that the Owen Meredith etc. ironstones have:

- TiO2 values similar to Starra cherty BIF but higher variability,
- Zr values similar to Starra mineralized ironstones,
- Y values lower but approximating to distal massive ironstones and cherty BIF.
- La values most like cherty BIF.

These results are equivocal at best but do not appear to support an analogy with the Starra mineralization model.

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Soil Geochemistry :

A total of 409 soil geochemical samples were collected from the locations as shown on Figure 4 to provide a nearly complete coverage of the Bowry Member within the extent of the grid. Samples were collected from the B/C horizon by hand auger at depths ranging from 0.3 to 1.0m. These were mostly clayey soils interpreted to be of residual formation although a minor downslope transport may have occurred on some of the steeper slopes.

-80# fractions of soils were analysed by ANALABS, of Burnie, as follows:

Cu,Pb,Zn	AAS method 101
Au	Fusion/AAS method 309

The analytical results are listed in Appendix IV and plotted together on Figure 5.

Lead and gold results are almost featureless apart from three "spot" anomalies in gold on line 12000N ranging from 0.19 to 0.37g/t Au. These are not immediately explicable and do not appear to correlate with other anomalies or magnetic trends.

Copper values range upto 700ppm and zinc peaks at 515ppm but there are relatively few values of greater than 200ppm in either. In general, the results are spotty, barely contourable and (with only two exceptions) show little correlation between copper and zinc anomalies.

The copper anomalies, as contoured, show a weak coincidence with some of the magnetic trends.

With a few minor exceptions (like the peak copper value at 13200N/9725E and the peak lead value at 11000N/9925E) nearly all of the "anomalies" (>200ppm) fall within the interpreted limit of the Bowry Member but this is very possibly an artefact of the extent of sampling.

In general, it may be concluded that the soil geochemical data, at this sample spacing, has not provided a focus for more detailed investigations. Close spaced sampling, at 5m intervals or less, over the main magnetic peaks as suggested by C.Anderson (Appendix I) may be worth a try but, in consideration of the generally low Cu-Au values in rock chip samples of the various ironstones on the grid, cannot confidently be expected to provide any startling anomalies.

6.3 Magnetism

The Owen Meredith grid has been covered by a detailed ground magnetic survey as described by C.Anderson in Appendix I. Total magnetic intensity profiles, contours and a preliminary interpretation are presented in Figures: 6,7,8.

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The preliminary interpretation indicates a broad magnetic zone, exactly coincident with the extent of the Bowry Member, within which are a number of narrow intense anomalies which, in the southern part of the grid, correspond with observed ironstone outcrops or float. The principal anomaly extends between 12400N and 13200N at about 9925E. Ironstone exposures are not prominent in this zone but the anomaly may be associated with the tremolite/actinolite + tourmaline + magnetite schorl near 12880N/9800E and may extend northwards, via a northwesterly offset at 13400N, to connect with the massive development of ironstone at the western contact of the Bowry Member in Doctor's Creek, (Figure 3). The anomaly can also be tentatively inferred to extend southwards to connect observed occurrences of ironstone on lines 12200N and 11600N.

C. Anderson (App. I) interprets that the ironstone sources are likely to occur as multiple narrow bands rather than individual (massive) bodies and to lie at shallow depths, of less than 20m.

7. DISCUSSION

The results of the mapping and exploration programme to date, indicate that a number of banded to massive magnetite +/- quartz +/- pyrite ironstone bodies occur within a narrow belt of rocks comprising an assemblage of amphibolites, mafic to felsic schists, impure quartzites, dolomite-magnesite marble and sodic leucogranite (the Bowry Member) sandwiched between semi pelitic schists (to the northwest) and psammo-pelitic metasilstones and phyllites (to the southeast).

The Bowry Member in the southern part of EL 14/89 ranges from about 200 to 400m in thickness and appears to represent a group of mafic to felsic volcanics, volcanoclastics, minor clastic sediments, carbonate and possibly syngenetic iron formations which have been regionally metamorphosed to albite-epidote-amphibolite facies (transitional greenschist - amphibolite) and subsequently partly retrogressed to greenschist facies by cataclastic metamorphism related to deformation having a substantial shear component. The sodic leucogranites are interpreted to be narrow intrusive bodies; although the timing of intrusion with respect to metamorphism is uncertain the leucogranites do appear to have undergone significant cataclasis and therefore probably predate the retrograde phase of deformation/metamorphism.

Minor occurrences of tremolite/actinolite + quartz skarn and tremolite/actinolite + tourmaline + magnetite schorl appear to be spatially related to leucogranite and are probably derived from contact metasomatic/metamorphic alteration of impure carbonate sediments and basaltic volcanics respectively. The timing relationship of this metasomatism with respect to prograde regional metamorphism remains uncertain but perhaps could be resolved by more detailed petrographic investigation.

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Textural relationships in the schorl (from near 12800N/9800E, A104574) appear to indicate that some of the magnetite was co-genetic with tourmaline which may suggest that some of the massive ironstones were of metasomatic origin. On the other hand, fine scale lamination in the banded quartz + magnetite +/- pyrite +/- chlorite ironstones strongly suggests that these are of sedimentary origin. The spatial relationships between banded and massive ironstones are, at this stage, obscure but apparently close. Magnetic interpretation indicates that the ironstones occur as narrow, possibly multiple and probably discontinuous bands and lenses. They appear to be coplanar with gross lithological layering and regional foliation in the host rocks and could well be stratiform although this form could be due to strong transposition.

Limited rock chip geochemical sampling of the ironstones suggests that most are not significantly anomalous in gold or base metals and none are anomalous in "granitophile" metals (Sn,W,Mo,Bi). The only observed occurrence with significantly anomalous gold and copper lies outside EL 14/89, in Doctor's Creek at the eastern contact of the Bowry Member, and in this instance the anomalism may be associated with pyrite rather than magnetite.

Comparison of "immobile" element (Ti,Zr,Y) levels of the ironstones with limited published data for Starra ironstones (in Davidson, 1990) has been inconclusive but does not appear to support an analogy with Starra type mineralization.

The age and tectonic setting / history of the Bowry Member remains quite uncertain and does not suggest that comparisons with other ore hosting, mafic volcanic dominant, terrains can be confidently made.

Further exploration for ironstone related mineralization in this area could include:

- * close spaced soil geochemical sampling over the main magnetic anomalies to identify lateral variations in Cu-Au content, if any.
- * more detailed prospecting and mapping along the identified magnetic anomalies in attempt to obtain more detailed geochemical coverage, identify lateral relationships ? between banded and massive ironstones and perhaps structural relationships with the host rocks.
- * detailed petrographic, possibly micro-analytical, investigation of ironstones, especially from the anomalous occurrence in Doctor's Creek and the (fresh) drill core intersections of presumably related ironstones from the Alpine prospect, in order to obtain better understanding of the style of mineralization, and mineralogical association and paragenesis of gold, copper and zinc, where present.

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- * extension of the Owen Meredith grid and geochemical, magnetic surveys to cover the (weaker) southwestward extension of the aeromagnetic anomaly associated with the Bowry Member approximately 1km west of Reece Dam. (Figure 9)

8. LOCATION AND ACCESS

EL 14/89 lies over the southern part of the Arthur Metamorphic Complex between Lake Pieman and Brown Plains.

The northern boundary lies within 1km of the Corinna Road and 4wd access to the far northeastern corner of the EL can be obtained via the road between the former and a river gauging station on the Whyte River about 1km upstream from its' junction with the Rocky River. There are additionally a number of old logging tracks leading southwards from Brown Plains towards the Whyte but these are mostly overgrown and impassable for vehicles.

Access to the southern end of the licence is afforded by the sealed Pieman-Heemskirk Road which crosses the Pieman River at Reece Dam. Foot access to the Owen Meredith grid can be obtained from Reece Dam by fording Stringer's Creek (when water level allows) a few hundred metres upstream from the power station. Alternatively, Dennis' Track, which departs the Pieman Road about 10km (by road) east of Reece Dam, provides 4wd vehicle access to the southern part of the grid and is the easiest route to the northeastern parts of the grid.

Otherwise there is no vehicular access to the, major, central part of the licence.

EZ Co. used the Pieman River for access by boat, presumably from Corinna, for the western parts of the licence and helicopter ? to a tent camp near Paradise Creek for the eastern parts.

EZ Co. established a reconnaissance grid with 1km spaced east-west cut lines over the entire licence. Although only about three years old these are now thickly overgrown and essentially useless for foot access. (Photo No. 2)

The terrain is mostly undulating to steep derived from fairly intense stream dissection of a former, probably Tertiary, peneplain; local relief is of the order of only about 150m but hillside slopes are commonly of the order of 30 deg. and occasionally upto 60 deg.

The country was formerly mostly covered by temperate rainforest which was destroyed by a 1982 wildfire which originated at Savage River and burnt out some 650 sq km of land to the south and south east including much of the Meredith Range. The post fire regrowth is now of the order of 5m tall and includes a dense tangle of ti-tree, Acacia, Eucalypt, Bauera, Banksia, cutting grass and locally bracken growing through a multitude of partly burnt downed logs. This vegetation is nearly impenetrable away from cut tracks and a reasonable rate of pedestrian progress would be measured in hours per kilometre. The track cutting contractors reported that cutting progress was about 350m/day/2 man team.

Minor remnants of rainforest vegetation exist in some of the gullies and valleys and the streams are generally overgrown with a typical mixture of horizontal and leatherwood scrub; a reasonable scrambling rate along stream courses is about 1km/hr.

Photographs 2 to 8 depict the nature of the terrain and vegetation



Photo 2. View west along EZ Co. (1986-87) grid line 390N from logging track at 347900E

Photo 3. View northwest from Dennis' Track at 349000E, commencement of walking track to OM grid 12200N, Track cutters setting out.





Photo 4.
View southwest along OM
grid baseline toward
Reece Dam.

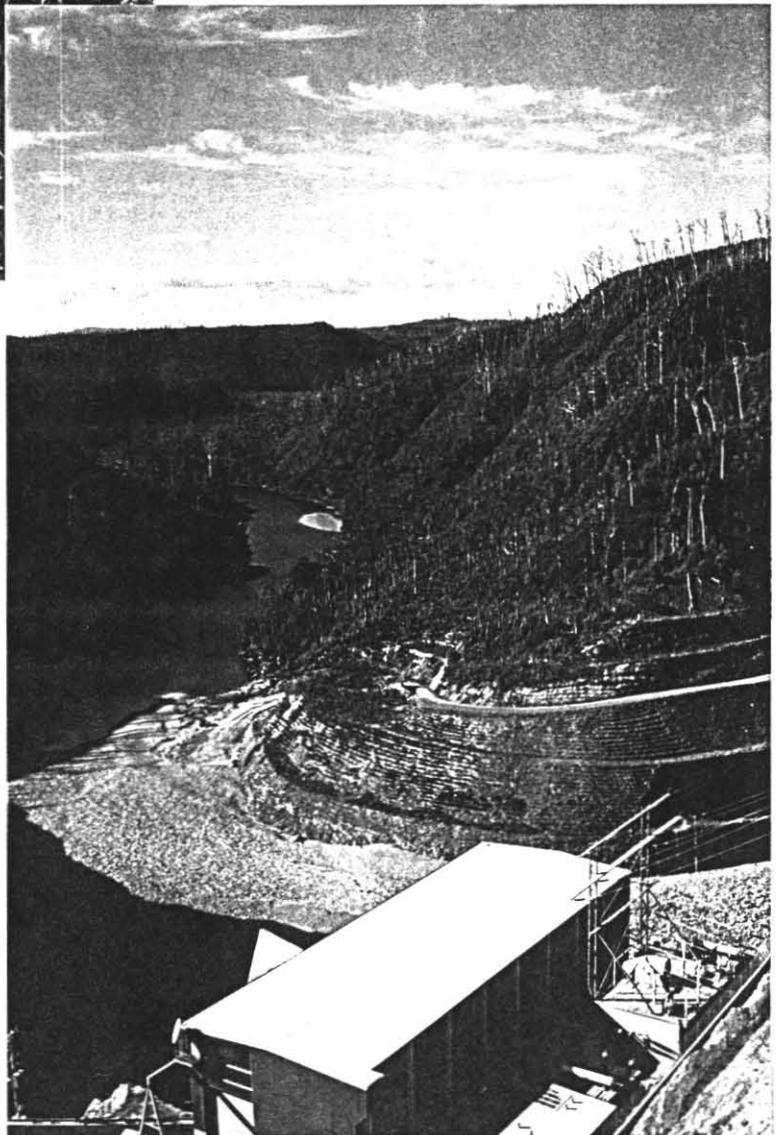


Photo 5.

Pieman River below Reece
Dam; power station in
foreground.



Photo 6.

View east south east
from logging track at
AMG 348000E, 5390300N
across Whyte River
toward Meredith Range;
Rocky River ironstone is
located on spur at right
of frame.

Photo 7.

View west southwest from
OM grid 13400N/9100E
down valley of Owen
Meredith River.





Photo 8.

Typical post fire
regrowth scrub; view
southeast along OM grid
line 11880N from
baseline.

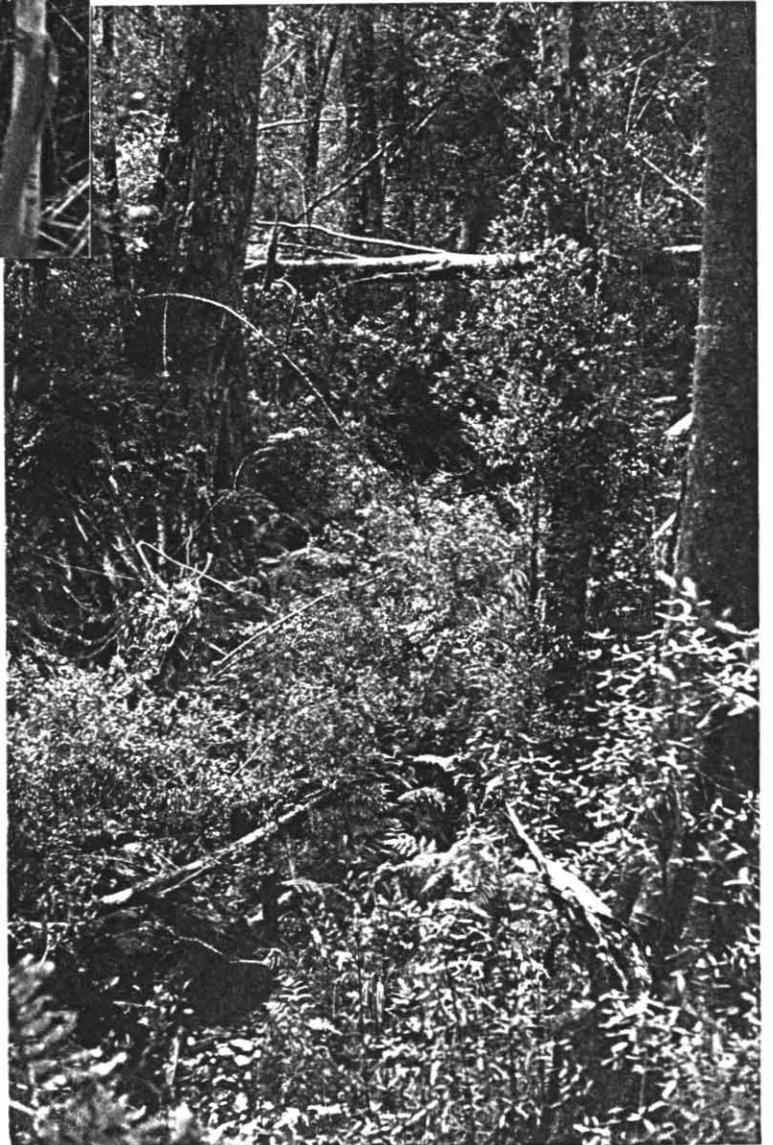


Photo 9.

Remnant rainforest, (myrtle
beech, sassafrass, leather-
wood and horizontalis)
Doctor's Creek near OM grid
13400N.

9. REFERENCES

- Davidson, G. 1990 Major and trace element geochemistry of the Starra ores and host rocks. CODES - University of Tasmania, Proterozoic Au-Cu Project, Workshop Manual No. 4
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0037

Appendix I Ground Magnetic Survey - Summary of results.

370037

OUTOKUMPU EXPLORATION AUSTRALIA PTY LIMITED

0036

Report No: R72.3
File No: 2.72.9
Filename: 272CA007.RT1

CORINNA PROSPECT
EL 14/89 - TASMANIA
Summary of Results and Data Listings
Ground Magnetic Survey - June 1990

For: Outokumpu Exploration Australia Pty Limited
77 Pacific Highway, NORTH SYDNEY NSW 2060

By: C. Anderson & Associates, CRAFERS SA 5152

Date: July 1990

DISTRIBUTION:

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2. W. Herrmann.
3. Dept Mines

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2. Preliminary Interpretation
3. Contours of Total Magnetic Intensity

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1. SURVEY DETAILS

The extent of the Corrina grid has been covered with detailed ground magnetics with total field measurements at 5 metre intervals on all lines from 10600N to 13400N. The survey was conducted in two parts, with initial coverage on lines generally at 400 metre intervals and subsequent in-fills to 200 metres. All data were recorded by independent contractors, using digitally recording proton precision magnetometers (Geometrics 856) for both field readings and base station diurnal. Data were subsequently corrected for diurnal drift and levelled to produce a merged digital data set.

1.1 Presentation

All data acquired during both surveys are shown as stacked profiles of total magnetic intensity (TMI) in Figure 1 and listings of corrected values are included in Table 1. Because of the intense level of relief and relatively coarse line spacing, the data do not produce a coherent contour presentation, without applying excessive smoothing.

2. DISCUSSION OF RESULTS

All profiles (with the exception of Line 10600N) indicate a zone of moderate to strong magnetic relief, centred between 9600E to 10000E and from 200 to 500 metres in width. A preliminary interpretation plan (Figure 2) attempts to outline the boundary of this zone and major individual magnetic trends within it. It should be noted however that the apparent width of most magnetic sources is significantly less than the survey line spacing and the lateral correlations of sources shown in Figure 2 is relatively tentative.

2.1 Ironstone Targets

The broad magnetic zone is inferred to represent a meta-sedimentary/volcanic sequence, within which a number of narrow, intense magnetic anomalies are considered to reflect possible (quartz-magnetite) ironstone 'lodes' comparable to known prospects within the Arthur Metamorphic Complex. The main ironstone 'lode' occurs between 12400N(?) and 13200N, and single line sources are indicated on Line 13400N and Line 11600N. In all three areas, the magnetic data indicate that the ironstone development is likely to be as multiple narrow bands - the distribution as shown in Figure 2 attempts to define the limit of ironstone rather than individual sources.

Several minor developments of ironstone are also indicated in Figure 2, to explain locally intense 'spikes' in the magnetic data. These are generally very minor sources and not considered to be significant targets at present.

2.2 Recommendations

The magnetic data indicate generally shallow depths (less than 20 metres?) for the inferred ironstone positions, and geochemical sampling of interpreted ironstone targets using a hand auger ('C' Horizon soil) is recommended as the next evaluation stage.

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Profile positions for the three main ironstone features, plus an additional line (Line 12200N) to test a structurally complex 'secondary' magnetic lithology, are indicated in Figure 2. These profiles are suggested as a minimum test of the magnetic positions, and a more systematic appraisal of the interpreted targets would be warranted if initial sampling establishes the presence of (geochemically anomalous?) ironstone.

Appendix II Petrographic Report No. 20/90, Minpet Services.

370043

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MINPET SERVICES

62 Banksia Avenue
ANDERGROVE, MACKAY 4740

REPORT NO. 20/90

PETROGRAPHIC ANALYSIS OF
SPECIMENS FROM E.L. 14/89 PROSPECT
CORRINA, TASMANIA

[prepared for Mr. W. Hermann,
Consulting Geologist for
Outokumpu Exploration Aust P.L.]

April 1990

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APPENDIX

- I LETTER AND QUESTIONNAIRE FROM MR. W. HERMANN REGARDING SPECIAL REQUIREMENTS FOR PETROGRAPHY.

1. INTRODUCTION

Seventeen rock specimens from Mr. W. Hermann are from E.L. 14/89, Corinna, and are from the Bowry Formation of the Arthur Metamorphic Complex of northwestern Tasmania. Petrographic descriptions and answers to a listed questionnaire were required.

2. SUMMARY

- A104566 *Leucogranite (or Trondhjemite - see Wells) shows cataclasis with limited shear. Shock metamorphism.*
- A104574 *An altered basic igneous rock, shows tourmalinisation of phenocryst forms and earlier tremolite:actinolite replacement of fine groundmass. Could be a porphyritic basalt? From the tremolite groundmass, texture is probably contact metamorphosed*
- A104581 *A banded quartz:magnetite rock that shows bedding units of relic graded bedding with a weak cross bedding. Magnetite grains occupy the base of each unit. Quartz beds show shear, and strong cataclasis affects bedding units, but this does not interfere with grading pattern. There was metamorphic recrystallisation. Iron oxides appear to be sedimentary in origin. There is no textural or compositional relationship with either Specimen A104574 or A104581.*
- A104586 *As for A104581 compositionally, but rock is strongly sheered and much of the magnetite has been martised. Sedimentary units are identifiable.*
- A104587 *An actinolite skarn (after Joplin) of quartz and tremolite:actinolite. Thinly veined by quartz:pyrite and quartz:albite:pyrite:chlorite. Iron metasomatism and contact metamorphism were contemporary.*
- A104588 *An actinolite skarn (after Joplin). Derived from a fine iron rich calcareous banded sediment. Contact metamorphism was associated with contemporary iron metasomatism.*
- A104589 *Carbonate-rich sediment, leached, silicified and weakly sheared. Palimpsest carbonate crystal shapes are present. Quartz shows low temperature metamorphic crystallisation.*

- A104590 *A silicified blastoporphyritic andesite or dacite. Sheared and altered to chlorite:quartz:albite schist. Deformed plagioclase phenocrysts are present that retain basic crystal forms, but with an altered groundmass.*
- A104591 *An albite:chlorite:quartz schist with minor biotite, hornblende, magnetite, rutile and pyrite. A 'chlorite grade' argillaceous sediment (after Harker). Quite different in composition from Specimens A104519 to A104594, A104591 being more chlorite-rich and with less hornblende.*
- A104569 *Albite:chlorite:magnetite schist with relict hornblende and biotite. An argillaceous sediment (refer to Harker). Sedimentary grain sized bedding is discernible.*
- A104592 *Albite:hornblende:chlorite schist. An altered amphibolite. More stressed than for Specimen A104569, but a metasediment, argillaceous and calcareous in origin. Banding of rhythmic grain size variations is present.*
- A104593 *Albite:hornblende:sphene:chlorite:epidote schist. A fine grained calc-silicate metasediment. Weakly foliated. Weak sedimentary banding is shown as variations in mineral composition. An altered amphibolite.*
- A104594 *Albite:hornblende:epidote:quartz schist with sphene. Strongly sheared. Veined by tourmaline, quartz and earlier K feldspar. An altered amphibolite, derived from the metamorphism of a calc-silicate sediment. Shows sedimentary banding as variations in grain size and weak current bedding, although the latter could be partly metamorphic.*

Comparative Composition

	A104569	A104592	A104593	A104594
Quartz	5	14	10	5
Plagioclase	41	33	29	37
Hornblende	3	24	24	33-75
Chlorite	39	15	4	4-20

Variations in composition of the above specimens are less obvious if one assumes that chlorite is largely replaced hornblende.

From Whyte River:-

A104595 Hornblende:plagioclase:quartz:epidote:sphene schist. Strongly foliated. Veined by K feldspar stringers. Originated from silicified metapyroxenite or other ultramafic igneous rock. Pyrite has partly replaced magnetite but also accreted onto magnetite crystals.

A104596 Granulitic plagioclase:quartz:chlorite gneiss. A possible metagranodiorite or meta-tonalite. Shows differential brecciation and shear along bands.

A104597 Granulitic plagioclase:quartz:chlorite gneiss; or fine grained metagranodiorite or silicified metamorphosed diorite or tonalite; less brecciated than for A104596. No phenocrysts are noted but plagioclase was likely porphyroblastic before shear.

A104598 Granulitic plagioclase:quartz:chlorite gneiss, a metagranodiorite or metatonalite. Shows alteration of magnetite to hematite (martisation).

Specimens A104596 to A104598 are granulitised, silicified tonalites or granodiorites, but are not amphibolite.

Compositional Variation

	A104596	A104597	A104598
Quartz	15	17	15
Plagioclase (andesine)	51	68	65
K feldspar	-	-	3
Chlorite	5	8	9
Hornblende	3	-	-

Carbonate alteration has reduced the plagioclase of Specimen A104596.

Compositions of major minerals are similar in the three rocks (Specimens A104596 to A104598).

3. PETROGRAPHIC DESCRIPTIONS

Specimen No: A104566/MPS 5888

Field Description: Leuco granite.

Petrographic Summary: ^{Tonalite} Leucogranite (or Trondhjenite - Hatch, Wells & Wells) of plagioclase and quartz (also with biotite - now destroyed). Shows intense brecciation, some rotation of quartz fragments and shear along narrow parallel planes.

<u>Mineralogy:</u>	<u>Vol.%</u>
Primary Recognisable	
Quartz	22
Plagioclase (An32)	77
Zircon	1
Tourmaline	<1
Alteration	
Iron oxides	3

Texture: A strongly brecciated leucogranite of oligoclase plagioclase and quartz with more than the normal amount of fine zircon.

Plagioclase is present as clear recrystallised breccia. Prior to brecciation the randomly set laths would have had a maximum grain size of 3 x 0.6 mm. The brecciation has produced a strain-slip fracture effect demonstrated by displaced albite twinning. Plagioclase surrounding more brecciated and healed plagioclase shows intense fragmentation and partial silicification with quartz replacement and fill of breccia spaces within the feldspar. Brecciated plagioclase is intermingled with finely brecciated and healed quartz, although several areas (0.8, 1.2 mm diameter) of quartz:plagioclase granophyre appear to have extended into brecciated quartz and plagioclase.

complectite type
micrographic intergrowth

Largely preserved quartz grains (to maximum size 3.2 x 1.2 mm) show intense strain with fine microfractures, grain margins are milled and grains are somewhat rounded (1 x 1 mm) which suggests grain rotation. Areas of milling indicate healed fine quartz:plagioclase breccia that occupies spaces between the non-cataclased quartz and feldspar grains. So that narrow and broad networks (0.04 to 1 mm) of fine quartz:feldspar mosaics separate the remnant nuclei of preserved grains.

Continuous microfaulting along parallel crush zones (0.2 to 0.8 mm wide) show shear of quartz:feldspar along a broader zone.

Networks of limonite lenticles (0.08 to 0.2 mm) as fragments occupy brecciation zones.

Zircons of coarse size (\approx 0.2 mm) are fractured and with iron oxides occupy zones of strong brecciation with iron oxides suggesting this is all that remains of brecciated and sheared biotite subjected also to leaching. Coarser zircon is recrystallised fine material.

Alteration: Destruction of biotite during metamorphism was followed by oxidation of exsolved iron.

Metamorphism: Cataclasis with limited shear. Shock metamorphism with brecciation and deformation.

N.B.: The growth of granophyre type (symplectite structures) during stress is noted.

Specimen No: A104574/MPS 5889

Field Description: An unusual amphibole:tourmaline(?) rock.

Petrographic Summary: Rock was tourmalinised, contact metamorphosed and sheared along narrow fractures; an altered intermediate or basic igneous rock. Some phenocryst shapes are pseudomorphed by composites of coarse tourmaline.

<u>Mineralogy:</u>	<u>Vol.%</u>
Tremolite:actinolite	38
Tourmaline	45
Sphene	10
Magnetite	5
Hematite	2

Phenocrysts occupy approximately 15% of microscope field.

Texture: A strongly hornfelsed tourmalinised porphyritic volcanic rock where the feldspar was largely tourmalinised prior to contact metamorphism.

Tremolite-actinolite growths as sheafs of very pale green pleochroic amphibole vary greatly in grain size from <0.1 to 2×0.16 mm, as tapered prisms of very pale green colour with a $2V$ of 80 degrees and $c\wedge z$ of ~ 15 degrees, and negative. Coarse tremolite occurs along originally open channelways that appeared in the rock after tourmalinisation. Tremolite grains arrange themselves as radiating sheafs of similar grain size, although where fine grained (0.2×0.06 mm) the grains may be randomly distributed as intergrowths around isolated subrounded to rectangular masses (0.5×0.4 to 2×1.5 mm) after plagioclase, replaced by pale olive green to pink pleochroic tourmaline. Tremolite has replaced a fine mafic groundmass. The tourmaline has become massive where welding of original fine prisms(?) took place, and the shapes of some masses suggest replacement of feldspar (2.4×1.4 mm) or simple twinned clinopyroxene grains (3×1.5 mm). More massive tourmaline ($4.4 \times$ length of

section) is a mosaic of welded tourmaline grains separated by vein-like growths of tremolite (1 to 2 mm wide) containing variably sized (0.08 to 1 x 0.8 mm) euhedral magnetite as lenticular intergrowths within the tourmaline. Some magnetite along a narrow (0.5 mm wide) zone of sheared tourmaline was altered to hematite or where leached was filled in by colloform structured hematite.

Otherwise magnetite (0.2 to 1.0 mm) occurs intergrown with similar size tourmaline masses or is scattered separately through fine tremolite intergrowths. Trails of granular sphene surround magnetite in lenticles and flank or pass through tourmaline masses.

Some of the coarser subhedral prismatic 'sphene' shows a uniaxial positive interference figure* and is therefore coarse rutile (or recrystallised leucoxene).

Alteration: Tourmalinisation, followed by metamorphism.

Metamorphism: Contact to epidote:amphibolite grade followed by localised shear along well deformed fracture planes which included both tourmaline and narrow channels of tremolite.

* Chemical test for cassiterite was made and found to be negative.

Specimen No: A104581/MPS 5890

Field Description: A banded quartz:magnetite:pyrite rock.

Petrographic Summary: A sandstone of repeated sedimentation units of varying iron oxide richness and grain size of magnetite and quartz grains. Units vary from fine to coarse sand size and form weak planar cross bedding.

Metamorphism with some mylonitisation of quartz clasts show growth mosaic substructures around quartz clasts. No relationship exists between Specimens A104574 and A104581. With regard to pressure metamorphism there are sheared quartz layers in finer quartz-rich bands.

<u>Mineralogy:</u>	<u>Vol. %</u>
Quartz	66
Magnetite	4
Martite	25
Pyrite	5
Muscovite	<1

Texture: Repeated sedimentary units of varying magnetite concentration are present and show varying mineral grain sizes. Sedimentation units vary from 0.5 to 5 mm depth. One can assume that dense magnetite as coarse grains (to 0.5 mm) is at the base of each unit, the magnetite becoming finer and less dense towards the top, followed upwards by quartz with almost no magnetite with the width of each unit being quite variable. Also there is a weak cross bedding in places and each sedimentary unit shows tabular, planar sets.

Quartz between the planar sets shows cataclasis and elongation of grains (0.4 x 0.2 mm to 1.2 x 0.4 mm) but no graded bedding is noted only quartz grains (0.2 to 0.7 mm) in mosaics of finer quartz:magnetite beds. However, mortar texture as fine recrystallised quartz flour breccia occurs between relict sedimentary quartz and brecciation has not disturbed the angle of rest of many tabular quartz clasts. In reflected light, matched rock slab surfaces

indicate strong martitisation of magnetite and replacement of martite, magnetite with martite overgrowths by euhedral pyrite grains.

Alteration: Magnetite -> martite -> pyrite.

Metamorphism: Partly mylonitised and recrystallised iron-rich sand of fine to coarse sand size grains.

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Specimen No: A104586/MPS 5891

Field Description: As for Specimen 104581

Petrographic Summary: Thinly bedded quartz, iron oxide and quartz rich sediments, occur rhythmically in successive alternate sedimentary layers. Silicified, brecciated and sheared to a quartz:magnetite gneiss. Related to Specimen A104581 but not to A104574.

<u>Mineralogy:</u>	<u>Vol.%</u>
Quartz	85
Martite	3
Limonite	5
Magnetite	7

Texture: Similar to Specimen 104581 but strongly sheared and separate sedimentary units are more easily identifiable. There also occur magnetite (or martite) rich quartz bands. Original clast shapes of quartz have not survived. One quartz:limonite band indicates layers of strongly sheared quartz lenticles (~0.15 mm wide) that contain rhomb shapes (0.15 to 0.4 mm) thinly encapsulated by iron oxides or now filled with colloform limonite and this was most likely a quartz:carbonate bed. Distribution of the colloform limonite is irregular as aggregates squeezed between sheared quartz lenticles.

Above the coarse quartz horizon described above, is a quartz gneiss layer containing milled recrystallised magnetite dust as layers (0.01 to 0.3 mm depth) of cement between quartz laminae but there is a tendency for the magnetite to consistently occupy layers (0.03 to 0.2 mm wide) and bedding as such disappeared with pressure and shear. Additional quartz-rich beds with limonite have replaced leached carbonate forms which occur twice again above sheared quartz:magnetite layers, suggesting quartz:carbonate beds that alternate with quartz: iron-rich sediments.

Some magnetite layers have suffered post-metamorphic martitisation.

Alteration: Magnetite -> martite and silicification.

Metamorphism: Cataclasis and shear.

Specimen No: A104587/MPS 5892

Field Description: -

Petrographic Summary: Actinolite skarn (reference, Joplin). A quartz: carbonate sediment that was contact metamorphosed, shows contemporary contact metasomatism with iron replacement, a pre-existing, fine grained, calc-silicate sediment.

<u>Mineralogy</u> (vol.%)	(a)*	(b)*
Plagioclase	-	-
Quartz	60	30
Tremolite:actinolite	31	63
Chlorite	-	-
Sphene	4	2
Pyrite	5	5

* (a) Fine; (b) Medium grained.

Veins: (1) Quartz:pyrite; (2) Quartz:albite:pyrite; albite:biotite:chlorite.

Texture: Discounting metamorphosed veins, the section shows two lithologies described as beds; including (a) of very fine grain size and actinolite rich, with less quartzose altered sediment. Grain sizes vary 0.002 to 0.08 x 0.02 mm, median 0.024 mm, of quartz as polyhedral mosaics of slightly sutured grains in contact with embedded squat, prismatic, pale green to colourless tremolite:actinolite, 0.01 to 0.07 x 0.03 mm, median size 0.017 x 0.007 mm of porphyroblastic forms. This is a hornfelsed sediment, although much of the quartz was introduced prior to contact metamorphism as veins that now merge with the groundmass. Granular aggregates (0.15 mm) and single grains of rubbly sphene (0.01 to 0.08 mm) are scattered through the section, as are euhedral and subhedral pyrite grains (0.01 to 0.1 mm) although the latter is dispersed, derived from quartz:pyrite vein.

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Bed (b) is separated from (a) by coarse veins of quartz:albite and albite:biotite:chlorite.

The bed (b) shows grain variations 0.04 to 0.08 mm, median 0.05 mm, of quartz and 0.04 to 0.4 x 0.15 mm, median 0.08 x 0.04 mm, as actinolite. Texture includes polyhedral mosaics of quartz and porphyroblastic actinolite, as for (a). The larger actinolite porphyroblasts contain numerous poikiloblastic inclusions of quartz. Sphene (~0.03 mm) is mainly in granular aggregates (0.15 mm). Also pyrite (0.08 to 0.2 mm) is dispersed from quartz:pyrite veins that transect the hornfels.

Broad sinuous veins (1 to 5 mm across) of chlorite:quartz:albite vein are margined by porphyroblastic actinolite in places. Chlorite occurs as pale green pleochroic radiate prism structures (0.3 to 0.6 mm radius) or as squat random interlocking intergrowths with interstitial squat albite (0.5, 0.7 mm) and quartz; also present are pyrite (0.6 x 0.4 mm) as random growths that coarsen in the absence of much chlorite to a vein 10 mm wide that cut narrow quartz stringers. Biotite in chlorite is residual.

Alteration:

Synmetamorphic (contact) originally a calc silicate sediment.

Silicified and pyritised by vein (1).)

) See Mineralogy Section

Intruded by vein (2).)

Metamorphism: Strong contact but to Green Schist grade only.

Specimen No: A104588/MPS 5893

Field Description: -

Petrographic Summary: Actinolite skarn (after Joplin). Derived from a fine colourless banded sediment. Subjected to silicification coupled with a dispersal of pyrite, followed by contact metamorphism, weak fracture and moderate shear that resulted in a preferred lineation orientation. Alteration was metasomatic, pre- and synmetamorphic. Originally calcareous as a carbonate sediment.

<u>Mineralogy:</u>	<u>Vol. %</u>
Plagioclase	5
Quartz	varies 87-65
Tremolite/actinolite	3-25
Pyrite	3
Sphene	2
Limonite	<1

Veins: (1) Quartz:pyrite:chlorite:albite; (2) Chlorite.

Texture: Similar to Specimen A104587 but finer, fairly even grained and locally sheared includes shearing of some fine veins, shows limonite staining along and adjoining vein systems. A thin (0.03 mm wide) vein network follows fractures that developed as veins of quartz, chlorite, pyrite and albite and cut across the later more coarse chlorite vein system.

The metasomatized, contact metamorphosed sediment contains variable quartz and tremolite:actinolite rich beds. The quartz grains (0.02 to 0.1 mm) show not so much equant polyhedral structures as porphyroblastic (also crystalloblastic) growths but include more euhedral squat twinned albite as clear grains. Rubbly and lobate sphene shapes and crystal intergrowths (0.01 to 0.08 mm) are scattered throughout, particularly in the actinolite rich bands.

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Quartz varies, 0.01 to 0.08 mm outside the incorporated, truncated vein systems and grains are around 0.25 mm in the veins where margins grade into sediments.

Actinolite varies 0.015 to 0.1 mm x 0.02 mm, as short fine prisms that in growth cut across quartz grain boundaries and as small grains are poikiloblastic within quartz. Truncated, coarse actinolite, margins vein systems; grains are parallel where veins are broad (2 mm wide) following a later developing lineation. Pyrite is variably subhedral (0.02 to 0.7 mm, mainly 0.4 mm) and distributed as intergrowths with albite and quartz (0.1 to 0.2 mm) but mostly is attached to deformed chlorite plates in veins where the quartz shows evidence of mutual grain boundaries and strain and show healed brecciation. Both pyrite and albite have dispersed into host groundmass and the latter shows limited silicification adjoining the veins.

Other lenticles parallel with the coarse vein system show porphyroblastic growth of actinolite (to 0.6 x 0.4 mm), to decussate arranged groups (to 1.6 mm) that appear to be in zones of silicification.

Alteration: Silicification with pyrite dispersal.

Metamorphism: Contact followed by fracture and veining with weak shear along some foliae gives the rock a well defined lineation. Finer fractures (now with albite, sphene and actinolite) were foci for migration after brecciation.

Specimen No: A104589/MPS 5894

Field Description: A very siliceous silicified carbonate.

Petrographic Summary: Leaching and silicification of a carbonate rich sediment. Silicification, recrystallisation and weak shear to a preferred orientation of coarse quartz grains (ex-quartz vein) and alternate fine bands.

<u>Mineralogy:</u>	<u>Vol. %</u>
Quartz	95
Muscovite	2
Iron oxides	3

Veins: Quartz.

Texture: A weakly banded rock of silicified and leached carbonate structures. The latter as rhomb shapes and irregular forms are defined and delineated by limonite staining and vary from 0.02 to 0.5 mm, replaced by stressed quartz in mosaics. Carbonate forms cross the quartz grain structure and recrystallised quartz grains are of variable grain size (0.02 to 0.19 mm) and show fine sutured boundaries between the grains caused by stress. Several leached wholly vacant vughs remain between areas of quartz replacement. Residual sericite occurs with limonite and cherty quartz, patchily in places, suggesting the carbonate may have been admixed with clays and black manganese oxides which substituted for limonite (residual from carbonates containing Mn) in some 'bands'. Between the bands is coarser quartz (0.05 to 0.3 mm) of vein material. Again the quartz is complexly sutured due to stress, could be 1.5 to 3 mm wide but tend to merge with silicified host. Quartz tends to weld into elongate shear laminae to follow a preferred lineation. In places muscovite (1 x 0.2, 1 x 0.3 mm) occurs distributed en-echelon within the bedding adjoining carbonate replaced forms and would reinforce the theory that the limestone contained pelite-rich areas.

Alteration: Oxidation, leaching and silicification (cherty with limonite and quartz replacement).

Metamorphism: Shows shear and low temperature (not contact) recrystallisation of quartz.

Specimen No: A104590/MPS 5895

Field Description: A mafic schist with a gritty texture.

Petrographic Summary: A silicified blastoporphyritic andesite or dacite, sheared and altered to quartz:chlorite:albite schist. Shows deformed plagioclase phenocrysts, which often retain prism and clinopinacoid faces as primary crystal forms, but no groundmass microlite plagioclase, or vitric textures remain. Tourmaline-replaced plagioclase phenocrysts are present.

<u>Mineralogy:</u>	<u>Vol.%</u>
Tourmaline	2
Quartz	23
Albite	8
Chlorite	60
Muscovite	3
Iron oxides	4

Texture: A chlorite:quartz:albite schist with fibrous iron-rich foliated chlorite which enveloped rounded and euhedral plagioclase phenocryst shapes (0.2 to 0.6 mm) showing simple twinning and also enveloped zoned blue-green tourmaline shapes (0.24 x 0.15, 0.3 x 0.3 mm) which totally to partly replaced plagioclase crystals. Quartz present occurs as coarse foliae (1.3 x 0.5 mm maximum size) as mosaics of quartz (0.3 x 0.15 mm and 0.15 mm) with mutual and sharply angular sutured boundaries. Quartz foliae includes also deformed albite grains of similar size range to quartz as cemented, fractured leucocratic minerals (0.5 to 2 mm at maximum width) but undulating and of variable thickness alternate with aggregates of fine fibrous chlorite of similar variation in thickness along the plane of preferred orientation. Iron oxides occur as scattered fine specks (0.01 to 0.2 mm) or as squat prism forms.

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Limonite-stained lenticles (0.01 to 0.3 mm) follow or cross the foliation at angles varying from 5 to 40 degrees, several are leached and vacant, and microfaulted chlorite foliae are present showing a displacement of up to 2 mm along the fault plane. Magnetite occurs as euhedral forms and deformed crystals (~ 0.01 mm), also laths ($\sim 0.18 \times 0.05$ mm), and alteration to hematite is noted.

Alteration:

More calcic to albite plagioclase. *albite*

Vitric(?) matrix to chlorite.

Quartz veins - brecciated and foliated with moderate tourmalinisation of feldspars.

Metamorphism: Strong shear and brecciation of plagioclase phenocrysts.

Cross-fracture and faulting.

Specimen No: A104591/MPS 5896

Field Description: Pale pinkish grey leuco-amphibolite.

Petrographic Summary: A plagioclase:chlorite:amphibole intergrowth of mildly K feldspathised mafic igneous rock. Broad fractures contain coarse, sheared plagioclase intruded before K feldspathisation. The plagioclase is albitic and later than the host oligoclase.

<u>Mineralogy:</u>	<u>Vol.%</u>
Chlorite	30
Hornblende	5
Plagioclase (oligoclase)	50
Leucoxene	4
Magnetite	9
Tourmaline	2

Veins (1) Plagioclase (albite):magnetite. (2) K feldspar.

Texture: A granular uneven mosaic of anhedral and subhedral plagioclase (0.05 to 0.4 x 0.24 mm) and where subhedral, present as squat prisms is apparently random decussate and grain contacts are mildly sutured. Also joining the mosaic of feldspar are subrounded green tourmaline grains (0.04 x 0.03 mm and 0.02 x 0.02 mm); also between the plagioclase laths are similarly random intergrowths of pale green fibrous chlorite.

Intergrowths of chlorite vary from 0.05 x 0.03 to 0.8 x 0.6 mm and where coarse intergrowths occur, these accompany partly altered hornblende clusters and are commonly surrounded by magnetite as euhedral grains (0.01 to 0.16 x 0.13 mm) or aggregates of magnetite of variable grain sizes (1 x 0.5 mm) immersed in pale brown leucoxene as lenticular masses to maximum 1.1 x 0.5 mm. Lenticular intergrowths of chlorite:magnetite and leucoxene:magnetite may

extend to 1.6 x 0.3 mm if chloritic or otherwise are somewhat smaller as several elongate masses that form a plane of schistosity.

Weathering is indicated as thin networks of limonite-stained chlorite that are common in parts of the section.

Blue-green hornblende laths (0.24 x 0.072, and 0.06 x 0.01 mm) occur locally and green hornblende as squat laths (0.04 x 0.01 mm, 0.2 x 0.3 mm) intermesh with chlorite in places mainly in the absence of iron oxides or otherwise contain iron oxides as specks and show marginal alteration to chlorite.

K feldspar advancing along thin veins (0.15 mm) has resulted in pools (2, 5 mm diam.) of localised K feldspathisation. Other veins (3.2 to 1.6 mm wide) are made up of coarse (2 x 0.8 mm) tabular shaped plagioclase that alternate with similarly sheared magnetite. The veins are microfaulted locally and are transected by thin K feldspar veins. Plagioclase in vein marginally merges with the host plagioclase (much finer) and locally in ladder-type plagioclase vein, the mineral is ruptured and partly rotated.

Alteration:

Biotite -> chlorite.

Hornblende -> actinolitic hornblende -> chlorite.

K feldspar locally caused feldspathisation.

Metamorphism: Regional metamorphism with shear (includes chlorite and leucoxene) with intergrowths of preferred orientation and sheared plagioclase in vein.

Specimen No: A104569/MPS 5897

Field Description: Amphibolite.

Petrographic Summary: An albite:chlorite:magnetite schist that contains relict blue-green hornblende and biotite. Albite porphyroblasts contain relict rutile from marginally altered biotite. Pyrite shows replacement of magnetite. Albite:chlorite schist after an argillaceous sediment (see Harker, p.213). Preferred orientation and sedimentary banding of grains are recognisable.

<u>Mineralogy:</u>	<u>Vol.%</u>
Quartz	5
K feldspar	2
Albite	41
Biotite	2
Chlorite	39
Hornblende	3
Magnetite	4
Rutile	1
Pyrite	3

Vein: Quartz:K feldspar.

Texture: Contains subrounded porphyroblasts of albite, (size variation, 0.04 to 0.4 x 0.3 mm); grains are formed along beds in a sediment showing a mostly parallel orientation of elongate grains along slide axis; few grain orientations are oblique to axis. Many grains show Carlsbad twinning, few show albite twinning and then very faintly. Grains are poikiloblastic with more than one grain of rutile as stumpy prisms and needles which in places show two cleavage directions parallel to prism and basal pinacoid. Many albite grains were rolled and have marginal intergrowths of chlorite. Grains also show microfaulting-displacement along cleavages and twin planes.

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Between the albite grains is an abundance of pale green chlorite that envelopes the feldspar crystals to give a foliation pattern. Where chlorite is particularly abundant, fine fragments (0.006 to 0.01 mm) of feldspar in the chlorite show an orientation parallel to the main foliation of albite and chlorite.

Chlorite contains relict brown biotite (0.01 mm) along foliae, parallel with the main foliation. Also prisms of hornblende (to maximum size 0.4 x 0.15 mm) are intergrown with chlorite and are oriented with schistosity. Quartz with orthoclase occurs as augen shapes (2 x 0.4 mm) internally fractured and healed and occur as part of a quartz vein (0.4 to 0.2 mm wide) parallel to the schistosity.

Magnetite as octahedra and subhedral grains are abundant, intergrown with chlorite and are partly engulfed by albite porphyroblasts. Partial pyrite replacement of magnetite is noted. Tourmaline traces (0.06 x 0.02, 0.05 mm) also occur within albite.

Alteration:

Biotite -> chlorite - almost total -> albite.

Magnetite -> pyrite - moderate.

Metamorphism: Strong brecciation, some shear with porphyroblastic growth of albite.

Specimen No: A104592/MPS 5898

Field Description: Amphibolite.

Petrographic Summary: An albite:hornblende:chlorite schist, as an altered amphibolite schist. More stressed than for Specimen 104569 and shows a well defined foliation. Most likely a metasediment of both argillaceous and calcareous origin. A preferred orientation of minerals with discernible sedimentary banding shows a grain size with variation along banding.

<u>Mineralogy:</u>	<u>Vol.%</u>
Quartz	14
Albite:oligoclase	33
Chlorite	15
Hornblende	24
Epidote	4
Magnetite	4
Sphene	6

Texture: Similar to Specimen A104569 but in this specimen there is an abundance of granular sphene distributed along the schistosity plane, a presence of epidote and absence of pyrite and show rather more green hornblende intergrowths with chlorite.

Plagioclase porphyroblasts (vary 0.08 to 0.4 x 0.2 mm) and somewhat smaller quartz grains occur as periodically arranged foliae (0.8 to 3.5 mm) where thin chlorite cements the quartz and feldspar grains. The intervals between the foliae of mostly plagioclase and less quartz are bands of en-echelon disposed, mostly plagioclase of a finer grain size than present in the coarse feldspar foliae (~0.1 mm+). Fine chlorite foliae occur as an abundant cement for other minerals. All quartz and feldspar grains are sheared and elongate within direction of foliation. Chlorite is finely fibrous replacing hornblende laths. Associated with the chlorite are granules of epidote (0.04

to 0.6 mm) that are fractured and deformed, and magnetite (0.08 to 1 x 0.6 mm) of euhedral shapes, porphyroblastic, and poikiloblastic with small grains of quartz and feldspar.

Albite is poikiloblastic with epidote and less chlorite. Granular sphene rarely up to 0.2 mm is embedded in chlorite, but most often occurs as trails of breccia (0.004 to 0.02 mm) often thickly clustered (0.08 to 0.2 mm wide) as foliated intergrowths within chlorite and occasionally intergrown with brecciated magnetite. These foliae vary from 0.2 to 3 mm apart.

Blue-green hornblende forms a nucleus to green hornblende (to maximum 0.6 x 0.2 mm) and occurs interfoliated with chlorite.

Alteration:

Hornblende > biotite -> chlorite + sphene.

Calcareous minerals -> epidote.

Metamorphism: Stress with :-

- i) Brecciation along some (more chlorite rich) planes.
- ii) Porphyroblastic growth of albite along alternate schistosity planes.

Specimen No: A104593/MPS 5899

Field Description: Amphibolite.

Petrographic Summary: Altered amphibolite. An albite:hornblende:sphene: epidote:chlorite fine grained metasediment, weakly foliated. A metamorphosed calc silicate rock. The preferred orientation of minerals is weak.

Sedimentary banding if present is weak.

<u>Mineralogy:</u>	<u>Vol.%</u>
Quartz	10
K feldspar	5
Albite	29
Chlorite	4
Epidote	8
Hornblende	24
Sphene	15
Pyrite	<1
Magnetite	5
Limonite	<1

Veins: (1) K feldspar; (2) Epidote:chlorite.

Texture: Finer grained and more quartzose than for Specimens A104569 and A104593; also less chloritic but with more sphene. Magnetite is partly replaced by similarly sized, although mainly coarse pyrite.

The clear anhedral transparent mineral present looks like quartz, shows no cleavage, but is largely albite or locally by optical tests, K feldspar.

Quartzo feldspathic grains vary from 0.015 to 0.15 x 0.12 mm, several contain rhombic or squat rectangular crystal forms but mostly grains are anhedral and weakly sheared and are seen to be brecciated but with healed fractures. Grain margins show encroachment on adjoining epidote, hornblende and chlorite, and

grains are poikiloblastic with fine (0.001 to 0.002 mm) epidote. Quartz occurs throughout as disseminated grains. K feldspar is present in fine cross-cutting veinlets.

Chlorite as laminae of fibres (0.2 x 0.05 mm) is mostly oriented to a weak lamination in the section and engulfs epidote granules.

Epidote is seen as granules and granular aggregates (0.03 to 0.15 mm) with porphyroblastic grains including fine feldspar. The aggregates with subhedral blue-green hornblende (0.04 to 0.02 mm) form networks around irregular sizes and shapes of quartz and feldspars. Sphene is abundant as subrounded but otherwise anhedral granules (0.004 to 0.02 mm) throughout, with epidote, chlorite and hornblende.

Magnetite (0.04 to 0.3 mm) is most commonly euhedral, is present as intergrowths with other minerals and is poikiloblastic with fine epidote, quartz and plagioclase. There is evidence of brecciation and recrystallisation of many grains and fracture and displacement of laminae (0.9 x 0.1 mm) of epidote. A coarse epidote:chlorite (0.2 to 0.4 mm) vein of epidote with tributary veins of chlorite transects the section. Other veins are presently leached, flanked by colloform limonite.

A weak preferred orientation of minerals is noted, and also porphyroblastic growth. Sedimentary banding is weak as variations in proportions of albite, hornblende, quartz.

Alteration:

Biotite -> chlorite + sphene.

Hornblende -> chlorite + epidote.

Quartz present may be a partly fractured vein.

Metamorphism: Weakly foliated, associated with porphyroblastic growth of quartz and feldspar.

Specimen No: A104594/MPS 5900

Field Description: Amphibolite.

Petrographic Summary: An altered albite:hornblende rock or amphibolite which includes some quartz, epidote, chlorite, and sphene. This is a fine grained metasediment showing a moderate lineation of minerals. A calc silicate rock regionally metamorphosed, and strongly sheared forming a strong lineation. Vein fractures contain fine sutured K feldspar that is cut by tourmaline and quartz and also by partly leached pyrite. Shows 'sedimentary' banding and weak current bedding.

<u>Mineralogy</u> (vol.%)	(a)	(b)
Quartz	5	-
Albite	37	-
K feldspar	2	-
Chlorite	4	20
Epidote	7	5
Hornblende	33	75
Sphene	7	-
Magnetite	5	-

Veins (1) K feldspar; (2) Tourmaline:pyrite.

Texture: Fine grained as in Specimen A104593 but less quartzose and more plagioclase rich. In this section there is a greater differentiation of minerals in what appear to be sedimentary layers (~ 20, 5 mm wide) of greater and less silt size plagioclase and quartz or with less and also more hornblende.

Green hornblende is present as small acicular random or subparallel growths (0.03 x 0.012 to 0.015 x 0.004 mm) associated with fine scattered granular sphene (0.008 to 0.03 x 0.024 mm) and uniformly dispersed irregular sized

epidote granules (0.008 to 0.16 x 0.08 mm). The minerals show mutual intergrowths and are also intergrown with acicular hornblende. Spaces between the described coloured minerals are filled mostly with plagioclase, less quartz and minor K feldspar.

Chlorite is patchy or confined to bands (~ 0.5 mm wide) at the expense of hornblende and is seen to have partially replaced the latter. K feldspar as mosaics of irregular sutured grains is confined to cross-cutting veins (~ 0.2 mm wide) including those oriented approximately 50 degrees to the 'bedding' that are displaced by tourmaline veins. Magnetite is mostly euhedral (0.03 to 0.15 mm) intergrown with hornblende and chlorite. Sinuous veins (0.08 to 0.5 mm wide) of coarse tourmaline crystals with quartz and leached pyrite transect the section but the vein minerals show only minor dispersion into host associated with chloritisation of hornblende. At the base of the thin section is a shear zone of fine parallel actinolite fibres, enclosing augen of blue-green hornblende (0.03 x 0.012 mm) and attached to laminae of fibrous chlorite with enclosed epidote. This is a broad strongly sheared zone (+9 mm depth) and goes beyond the thin section limits.

Alteration: Hornblende \rightarrow chlorite + sphene(?) \pm epidote.

Metamorphism: Shear, particularly at base of section.

0070

Specimen No: ⁵⁹⁵ A104554/MPS 5901

Field Description: More mafic than Specimens A104569, A104592, A104593 and A104594.

Petrographic Summary: Hornblende:plagioclase:quartz:epidote schist with a strong foliation. Veined by thin K feldspar stringers that cut across the foliation. Formed from a metamorphosed silicified pyroxenite or other ultramafic rock. ? More likely a meta. mafic possibly dolomite. (Note)

<u>Mineralogy:</u>	<u>Vol. %</u>
Hornblende	66
Quartz	9
Epidote	5
Plagioclase	12
Magnetite	3
Sphene	4
Pyrite	1

Vein: K feldspar.

Texture: A strongly foliated mainly hornblende rock. Hornblende is massive and blue-green as clusters (1 to 0.5 mm wide) of prisms (0.05 to 1 x 0.4 mm). Prisms are subparallel or are present as oblique growths. Pleochroism is blue green to pale yellow, and sandwiched between the hornblende laths are anhedral clear plagioclase laths (0.05 to 0.08 mm) with sutured anhedral grain margins laths and often show minor well spaced plagioclase twinning.

Foliae (to 2 mm) between the mainly hornblende lenticles are mosaics of anhedral plagioclase, epidote and hornblende, between 0.012 and 0.13 mm in grain size but mostly around 0.1 x 0.07 mm as brecciated and recrystallised grains. Where abundant plagioclase is present, grains show mutual grain boundaries.

Sphene as aggregates of fine squat laths occasionally lozenge shaped are seen as deformed lenticles (1.6 x 0.3 mm) and form sinuous irregular shaped lenticles between hornblende crystal aggregates which alternate en-echelon with similar size and shapes of plagioclase:epidote:hornblende lenticles as described above.

Magnetite (0.04 to 0.4 x 0.16 mm) is embedded at centres of sphene aggregates or as euhedra and aggregates of the latter embedded in hornblende intergrowths. Rare cross sections of tourmaline grains (0.16 mm) are noted in the epidote:feldspar mosaics. Pyrite shows accretion on to and partial replacement of the magnetite. Veins show no dissemination of K feldspar into host.

Alteration: Metamorphic after a mafic or ultramafic rock (e.g. pyroxenite). KF vein is rare.

Metamorphism: A strongly foliated metamorphosed mafic rock.

Metaschistose
Amphibolite with less (or no) retrograde
alteration (chlorite absent).

Specimen No: A104596/MPS 5902

Field Description: Metamorphosed felsic volcanics?

no biotite : hornblende? or albite?

Petrographic Summary: A granite of plagioclase:quartz composition that contains residual hornblende, altered to chlorite and epidote, and then carbonated. Could be a metamorphosed granodiorite or silicified diorite. ^(Relict fabric) Palimpsest forms were mostly obliterated during metamorphism. Large plagioclase grains do not appear to be porphyroblasts.

Mineralogy:

	<u>Vol. %</u>
Plagioclase (oligoclase)	51
Quartz	15
Chlorite	5
Epidote	1
Hornblende	3
Carbonate	20
Sphene	<1
Magnetite	4
Pyrite	1

*Granite
family 20*

Texture: Grains of most abundance are those of large and finer plagioclase and quartz where preferred orientation of finer deformed grains that are drawn out and ovoid are seen and show the grain margins of recrystallised fine breccia. Finer plagioclase if present shows only 'ghost' albite twinning. In larger grains, twinning is more distinct. Quartz tends to be present as strongly brecciated lenticles forming mosaics (1 x 0.5 mm) of strongly sutured grains. Grain size variation of quartz and plagioclase (determined as oligoclase:andesine by mineral staining) varies 0.015 to 2.4 x 1.0 mm. Parallel to the foliation are aligned a number of large (~ 2 x 1.5 mm) twinned grains, varying as marginally to grossly milled plagioclase which form dislocated foliae that alternate with finer

0976

brecciated plagioclase and quartz lenticles. The latter show few inclusions and may be brecciated coarse plagioclase, but not granulitised as in the remainder of section. Throughout the section are large (0.12 to 0.4 mm) clear epidote grains that show brecciation, and also localised fine blue-green hornblende (0.08 x 0.01 mm) in clusters which are partly altered to fibrous brown-green chlorite.

Sphene is present as large rhomb shaped grains (0.1 mm) associated with chlorite and epidote:chlorite intergrowths are abundant. Carbonate as calcite is common as anhedral mosaics (to 0.24 mm) and intergrowths and as fine grains down to 0.015 mm that fill spaces between feldspar and fractures in plagioclase to form almost continuous networks of feldspar replacement.

Magnetite (varies 0.02 to 0.3 mm) as mostly euhedral forms and is idiomorphic to surrounding feldspars. Many clustered intergrowths (0.6 mm) of magnetite are noted as porphyroblasts. One large grains of pyrite (3 x 1.2 mm) is embedded in chlorite and epidote.

Alteration:

Hornblende -> chlorite + epidote and actinolite - metamorphic?

Silicification is possible.

Plagioclase -> less calcic plagioclase + calcite. ✓ OR but 20% CO₂?

Metamorphism: Porphyroblastic growth of large feldspars. Brecciation with moderate shear.

Specimen No: A104597/MPS 5903

Field Description: Felsic volcanic.

Petrographic Summary: Brecciated (granulated) medium grained granodiorite or silicified diorite. Less brecciated than for Specimen A104596. Not a volcanic rock.

<u>Mineralogy:</u>	<u>Vol.%</u>
Plagioclase (An27)	68
Quartz	17
Chlorite	8
Muscovite	<1
Magnetite	4
Zircon	<1
Apatite	<1
Tourmaline	<1
Carbonate	3

Texture: Similar to Specimen A104596, but less brecciated and sheared.

Relict large plagioclase grains along foliae indicate from lamellar twinning and areas of remaining random intergrowth to have an original granitic or dioritic texture. This rock is therefore not a volcanic but could be a strongly brecciated granodiorite (or silicified diorite). Larger plagioclase laths vary 1 x 0.6 mm to 2 x 1.6 mm. Many of the latter show healed fractures shown by dislocated displaced albite twinning; others are fractured and brecciated with fine brecciation present, lateral to grain fractures. Other grains show extensive brecciation that grades into the interstices of quartz:plagioclase granulation. Quartz inclusions (0.03, 0.05 mm) are present only along healed fractures and large feldspars are rarely poikiloblastic with other minerals.

Much of the 'groundmass' shows as sheared quartz:plagioclase intergrowths (0.015 to 0.4 x 0.2 mm), often evenly lenticular and with strongly sutured grain boundaries of healed brecciation.

Other minerals present in the interstices of large plagioclase grains are chlorite as blebs (0.1 x 0.05 mm) and laths (0.2 x 0.05 mm) and lenticles (to 2.4 x 0.3 mm) squeezed between plagioclase laths. Carbonate (calcite) occurs as specks (0.08 mm) and veinlets (0.1 x 0.015, 0.4 x 0.15 mm) along fractures in the feldspar. Zircon varies to 0.24 x 0.24 mm or occurs as short perfectly formed prisms (0.24 x 0.12 mm) that are present associated with chlorite or are emplaced in quartz:feldspar breccia.

Magnetite (0.1 to 0.4 mm) grains are euhedral or deformed crystals attached to chlorite. One large (brown to black) squat ovoid tourmaline grain is partly embedded in plagioclase but attached to chlorite and magnetite.

Pyrite (3 x 1.5, 1.0 x 1.0 mm etc) shows marginal attrition of larger grains. There is no evidence of replacement of magnetite by pyrite.

Alteration:

Plagioclase -> carbonate - weak.

Biotite(?) -> chlorite.

Metamorphism: Brecciation (granulation) and shear.

Specimen No: A104598/MPS 5904

Field Description: Felsic volcanic, amphibolite?

Petrographic Summary: Granodiorite (or tonalite), or silicified diorite. Granulated, but leaving along alternate foliae, coarse plagioclase intergrowths of granitic texture. Biotite is altered to chlorite and leucoxene; magnetite (secondary?) is altered to hematite.

<u>Mineralogy:</u>	<u>Vol.%</u>
Plagioclase	65
<u>K feldspar</u>	3
Quartz	15
Chlorite	9
Muscovite	-
Carbonate	<1
Magnetite	-
Zircon	1
Tourmaline	<1
Leucoxene	2
Hematite	5

Texture: Similar to Specimen A104597 but in this section granulation is slightly stronger and resulted in stronger foliation.

Coarse plagioclase is more ovoid in shape. Intergrowths of large plagioclase (0.6 x 1.0 mm) show random orientation of grains that were fused into augen shapes (3.2 x 1.2 mm) and the larger grains were orientated into foliae showing preferred orientation. Grain sizes of coarser feldspars range 0.5 to 4 x 2 mm, and finer grains (range 0.01 to 0.2 mm) of anhedral grains, and lenticles; grains were strongly sutured as similarly was quartz in lenticles. Plagioclase grains however small, show faint twinning. Orthoclase (to 0.3 x 0.24 mm) has rounded forms, low birefringence and

complex thin cross-hatched twinning. Chlorite in this specimen is present only as fine (0.01 to 0.08 mm wide) stringers between feldspars (and quartz) and is associated with fine rubbly leucoxene and secondary magnetite and zircon as squat prisms (0.08 mm) that are strongly resistant to brecciation. Fractured tourmaline as fragments (0.15 x 0.03, 0.015 mm) is embedded in healed feldspar breccia.

Clear red hematite (0.1 x 0.05, 0.05 x 0.05, 0.1 x 0.03 mm) has pseudomorphed magnetite grains and has possibly replaced rutile. Hematite occurs (as original magnetite) along foliae as trails of grains with leucoxene and zircon.

Alteration:

K feldspar was spread along foliation (most likely secondary).

Biotite -> chlorite and leucoxene.

Magnetite -> hematite.

Metamorphism: Strong granulation of plagioclase and quartz to incipient foliation.

4. REFERENCES

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Background Notes for Petrographer

on

Suite of 17 Rock Specimens from EL 14/89 - Corinna

by : W.Herrmann, RSD 1066 Devonport 7310
(on behalf of Outokumpu Exploration Aust P/L)

The enclosed 17 rock specimens are from the Bowry Fmn. of the Arthur Metamorphic Complex of northwestern Tasmania. The formation reportedly consists mainly of amphibolites, chlorite-albite schists and quartz-mica schists and includes a number of large and small magnetite and magnesite deposits.

The principal objectives of obtaining petrographic descriptions of these specimens are to:

- * determine the precursors of the metamorphic rock types
- * elucidate the nature of the iron mineralization and its relative age with respect to deformation.

Specific points of interest, listed specimen by specimen, are as follows :

- | | |
|----------|---|
| A 104566 | This seems to be a leuco-granite; are there any signs of deformation or metamorphism? |
| A 104574 | An unusual amphibole-tourmaline? rock, any signs of deformation or metamorphism here? What precursor? |
| A 104581 | A banded quartz-magnetite-pyrite rock; is the lamination sedimentary?, does the fabric suggest (pressure) metamorphic re/crystallization?, is there any compositional or textural relationship with 104574? |
| A 104586 | Questions as for 104581 |
| A 104587 | Please elucidate the nature of alteration, pre syn or post metamorphic?, what was/is the original rock type? (Note the fine lamination? cross cut by veinlets? at one end of the proposed section.) |
| A 104588 | Questions as for 104587; is this an altered metasediment? perhaps carbonate? |
| A 104589 | What was the precursor for this very siliceous rock? A coarse vughy character in outcrop is somewhat suggestive of silicified carbonate. Does the fabric indicate metamorphic crystallization of quartz? |

- A 104590 A mafic schist, sorry about the weathering but it is hard to find fresh outcrops of this lithology. It seems to have a rather "gritty" texture, is this porphyroblastic or representative of a relict porphyritic or sedimentary texture? Any ideas on a likely precursor?
- A 104591 A pale pinkish grey "leuco-amphibolite". Is this rock of distinctly different composition to the four that follow or is the colouration related only to alteration or weathering?
- See below ✓*
- A 104569
A 104592
A 104593
A 104594 Collectively : I have called these rocks amphibolite in the field, is there much compositional variation? Specimens 104593 and 104594 seem to have faint textural/grainsize banding which is very apparent on outcrops and suggestive of relict sedimentary layering. Is this discernable microscopically? What are the likely precursors to these (meta) amphibolites?
- A 104595-598 A sub group of amphibolites and felsic gneisses from the Whyte River; all seem to be coarser grained than the preceding group of amphibolites, does this imply a different metamorphic grade or a precursor type?
- Specifically:
A 104595 This seems to be more mafic than the preceding group, any distinct compositional contrasts? It is also less magnetic; any particular textural relationships between magnetite and pyrite?
- A 104596
A 104597
A 104598 These three are considerably more felsic, some of the feldspar seems to be porphyroblastic or relict porphyritic, likewise the quartz in 104598.
Can they be classified as amphibolites?
How much quartz is present? Are these rocks metamorphosed felsic volcanics?

Appendix III Rock Chip Geochemical Sample Listing and
Analytical Results

ROCK SAMPLE DATA FIELD SHEET

PROJECT NAME EL W/89 CORINNA
PROJECT No. _____

PROSPECT NAME OWEN MEREDITH GRAB (etc.)
PROSPECT I.D. _____
GRID I.D. _____

Sample Number	Field / Station Number	FIELD-GRID CO-ORDINATES			Samp Type	Samp Meth	Samp Length (m)	Est True Width (m)	Lithology	OXD		Sul Vol %	A I	VEINING			Fract No	A CAPTURE	B CAPTURE	COMMENTS / ANALYSES (ppm)
		E	N	R.L.						E x I	Vol % Lim			Type	Vol %	No				
111041511	OWEN MEREDITH GRAB	10000	10650		HF	GR													Talc-tremolite-carb schist?	
1111512		9625	11000		BR	"													Weathered greenschist	
1111513		9300	11250		SF	"					50% Py								Compact granular massive Py + Qtz	
1111514		9300	11250		SF	"													Spongy limonitic gossan	
1111515		9300	11270		HF	"													Silty arg + limonite + musc.	
1111516		9695	11800		BR	CP													Silty silicified carbonate.	
1111517		9605	11800		BR	"													Amphibolite	
1111518	Dennis Trade		10600		BR	"													White Quartz in ferric veins	
1111519		9985	12200		"	"													Weathered gritty mafic schist	
11115110		9880	12200		SC	"													Mt + chl? (wd) Banded Ironstone	
11115111		"	"		"	"													Mt + chl? + Py? (wd) gossan B. Ironstone	
11115112		"	"		"	"													Wd. chl. schist = lenses limonitic gossan?	
11115113		9695	12200		HF	GR					5%								Wd. chl - talc? schist 5% lim on py?	
11115114		10000	12525		BR	CP					2-3% Py								Chl. mafic schist = 3% Py.	
11115115		9930	12000		"	"													Gritty mafic schist	
11115116		9810	12600		SC	CP													Sodic Lenses granite	
11115117		9740	12580		BR	CP													Buff colored dolomite-magnetite-marble.	
11115118		10000	12770		HF	CP													Qtz + tourmaline veins in mafic schist	
11115119		9940	13000		BR	CP													Amphibolite	
11115120		9980	11985		BR	CP													Massive Mt + chl? (wd) Ironstone	
11115121		11850	9590		BR	CP													Amphibolite	
11115122		9680	12330		SF	CP					10% Py								Tremolite/Actinolite + Qtz "skarn" 10% Py	
11115123		9640	12460		SF	CP													Mt + Py. Massive Ironstone	
11115124	E7.	346900	381 N		BR?	CP													Tremolite/Actinolite - Tourmaline schist.	
11115125	E7.	346890	V		"	"													Gossan ore schist?	
11115126		9555	11800		HF	CP													Spongy limonitic gossan	
11115127		9560	11790		BR	CP													50 mm bands gossan in Amphibolite etc Mt + Py // fibration.	

ROCK SAMPLE DATA FIELD SHEET

PROJECT NAME EL 14/89 CORINNA
PROJECT No. _____

PROSPECT NAME OWEN MEREDITH c.f.d and etc.
PROSPECT I.D. _____
GRID I.D. _____

Sample Number	Field / Station Number	FIELD-GRID CO-ORDINATES			Samp Type	Samp Meth	Samp Length (m)	Est True Width (m)	Lithology	OXD		Sul Vol %	A I	VEINING			Fract No	ASSAY	P.P.T.M.P.	COMMENTS / ANALYSES (ppm)
		E	N	R.L.						E %	Vol % Lim			Type	Vol %	No				
A110145178	Rocky River Ironstone				BR														Weathered amphibolite?	
1115179	"				BR														Dehydrated hematitic massive Ironstone	
1115180	"				"														"	
1115181	"				HF	CP													Qtz + Mt + Py Banded Ironstone	
1115182	"				"	"													Qtz + Mt Banded Ironstone	
1115183	"				"	"													Pyritic mafic schist, 25% Py	
1115184	Main Ck. Ironstone				BR														Dehydrated hematitic Ironstone 70% Fe	
1115185	Owen Mer. Cwid: 9990	12605			HF	CP													Qtz + Mt + Hem Banded Ironstone	
11151816	Rocky River Ironstone				"														Qtz + Mt + Py Banded Ironstone	
11151817	O.M. Cwid	9910	12330		BR	CP													Qtz + tremolite / Actinolite skarn	
11151818	"				"	"													"	
11151819	"	9700	11880		"	"													Silicified Carbonate	
11151910	"	9960	12600		"	"													Metaporphitic meta volcanic / clastic	
11151911	"	9860	13000		"	"													Amphibolite	
11151912	"	9620	11960		"	"													Amphibolite	
11151913	"	"	"		"	"													"	
11151914	"	"	"		"	"													"	
11151915	White River	upstream from Cragging Station																	"	
11151916	"																		Sodic leucogranite / Meta tonalite	
11151917	"																		"	
A110145198	"																		"	
111111																				
111111																				
111111																				
111111																				
111111																				
111111																				

25% Mt 5% Py
70% Mt

ROCK SAMPLE DATA FIELD SHEET

PROJECT NAME EL 1A/8A CORINNA
PROJECT No. _____

PROSPECT NAME OWEN MERRITT West and etc.
PROSPECT I.D. _____
GRID I.D. _____

Sample Number	Field / Station Number	FIELD-GRID CO-ORDINATES			Samp Type	Samp Meth	Samp Length (m)	Est True Width (m)	Lithology	OXD		Sul Vol %	A I	VEINING			Fract No	A S S A Y	COMMENTS / ANALYSES (ppm.)
		E	N	R.L.						E x t	Vol % Lim			Type	Vol %	No			
A11046011	O.M. Grid	9985	12200		BR	CP												Common rusty limonitic Ironstone	
1116012	"	9910	12100		"	"												Tremolite/Actinolite - Tremolite schist.	
1116103	"	9908	12800		HF	"												Tremolite/Actinolite schist, ex amphibolite	
1116104	"	9930	12100		"	"												Tremolite/Actinolite - tremolite schist	
1116105	"	9975	12000		BR	"												Oxidized massive Ironstone.	
1116106	"	9835	11600		HF	"												Qtz + Mt (+ Py) Banded Ironstone.	
1116107	"	9535	11200		BR													Wd. massive compact granular Pyrite	
1116108	Doctor's Creek				BR	CP												Pyritic Quartzite 5% Py.	
1116109	"				"	"												Qtz + Mt + Py Banded Ironstone	
1116110	"				BR	SE												Mt + Py lenses in mafic schist	
1116111	"				"	"												"	
1116112	Heardville Road				BR	SE												Pyritic Nodules in Tantalum sand	
1116113	"				BR	"												50 mm pyritic lenses in mafic schist	
1116114	"				"	CP					4% Py							Black dolomitic metasiltstone	
1116115	Doctor's Creek				BR	CP												Massive Magnetite Ironstone	
1116116	"				HF?	CP												"	
1116117	"				BR	CP												Tremolite / Actinolite schist	
1116118	"				"	"												"	
1116119	"				"	"												Tremolite/Act/Talc + Py + Mt	
1116120	"				"	"												Amphibolite ?	
1116121	"				"	"												Massive Magnetite Ironstone	
1116122																			
1116123																			
1116124																			
1116125																			
1116126																			
1116127																			
1116128																			
1116129																			
1116130																			

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FAX: 084 31 8890

Telex AA92560

ANALYTICAL REPORT No. 599. 66. 08. 06927

THIS REPORT MUST BE READ IN CONJUNCTION WITH THE ACCOMPANYING ANALYTICAL DATA

0991

Subokumpu Exploration Aust
Suite 2, Level 6
77 Pacific Highway
Sydney NSW 2060

ORDER No. 20228	PROJECT EL 14789
DATE RECEIVED 13/03/90	RESULTS REQUIRED ASAP

No. OF PAGES OF RESULTS 4	DATE REPORTED 02/04/90	No. OF COPIES 1	TOTAL No. OF SAMPLES 35
------------------------------	---------------------------	--------------------	----------------------------

SAMPLE NUMBERS	PRE-TREATMENT							ANALYSIS		
	DRY	CRUSH	SPLIT	PUL-VERISE	SIEVE	OTHER SEE REMARKS	NONE	REFER TO ANALYSIS SECTION	PREPARATION	METHOD
A1045, 51785	RO	Prep	00	009	01	016			Co, Pb, Zn, Bi / 101	
A1045, 51785	RO								As, Au, Hk / 309	
A1045, 51785	RO								As, Sb, Sn, W / 401	

RESULTS TO M. Herrmann
MSD 1066
Bayswater Tasmania 7310

RESULTS TO Subokumpu Exploration Aust
Suite 2, Level 6
77 Pacific Highway
Sydney NSW 2060

REMARKS

STATE OF SAMPLES	ANALYSIS — PREPARATION				ANALYSIS — METHOD	
core WC	perchloric acid	A1	cold acid	CA	atomic absorption	AAS
core SC	hydrochloric acid	A2	specific sulphide	SS	x-ray fluorescence	XRF
ng CU	nitric acid	A3	other mixed acids	Ma	spectrophotometry	SPEC
Ro	aqua regia	A4	alkaline attack	AA	colorimetry	COL
SO	nitric-perchloric	A5	volatilization	VD	chromatography	CHR
PU	HF mixture	A6	ignition	IG	titration	TTN
r WA	HF under pressure	A7	pressed powder (XRF)	PP	other chemical means	CHEM
e TI	fusion	A8	glass fusion (XRF)	GF	miscellaneous	MISC
m sediment SS					fluorescence	FLUOR
y mineral HM					inductively coupled plasma	ICP

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ANALYTICAL DATA

SAMPLE PREFIX REPORT NUMBER REPORT DATE CLIENT ORDER No. PAGE

999.66.00.06927 02/04/90 20228 1 OF 4

TUBE No.	SAMPLE No.	Au	AuChk	Cu	Pb	Zn	Bi	As	Sb	Sn
1	A104551	0.014	-	160	10	100	<10	6	<3	<3
2	A104552	0.015	-	215	60	350	<10	7	4	<3
3	A104553	0.010	-	250	55	265	<10	15	<3	3
4	A104554	0.046	0.043	480	30	205	<10	100	<3	<3
5	A104555	0.013	-	305	<5	45	<10	100	<3	7
6	A104556	0.010	-	10	<5	10	<10	<2	<3	<3
7	A104557	0.011	-	30	<5	55	<10	<2	<3	<3
8	A104558	<0.008	-	10	<5	10	<10	<2	<3	<3
9	A104559	<0.008	-	65	<5	205	<10	<2	4	<3
10	A104560	<0.008	-	105	<5	130	<10	<2	<3	<3
11	A104561	<0.008	-	190	<5	110	<10	<2	7	<3
12	A104562	<0.008	-	155	<5	155	<10	2	6	<3
13	A104563	0.010	-	470	<5	20	<10	4	<3	<3
14	A104564	0.009	-	50	<5	115	<10	3	3	<3
15	A104565	<0.008	-	80	<5	205	<10	<2	<3	<3
	A104566	0.010	-	10	5	20	<10	<2	<3	<3
17	A104567	<0.008	-	10	<5	35	<10	<2	<3	<3
18	A104568	<0.008	-	15	5	60	<10	<2	<3	<3
19	A104569	<0.008	-	120	<5	115	<10	<2	3	<3
20	A104570	<0.008	<0.008	70	<5	265	<10	25	7	4
21	A104571	<0.008	-	15	<5	65	<10	3	3	<3
22	A104572	<0.008	-	450	<5	70	<10	15	5	4
23	A104573	<0.008	<0.008	80	<5	75	<10	5	5	<3
24	A104574	<0.008	-	40	<5	15	<10	<2	4	<3
25	A104575	0.012	-	1250	<5	30	70	25	<3	4

Results in ppm unless otherwise specified
 T = element present, but concentration too low to measure
 X = element concentration is below detection limit
 - = element not determined

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A Division of Incharge Inspection and Testing Services Australia Pty Ltd.

ANALYTICAL DATA

SAMPLE PREFIX REPORT NUMBER REPORT DATE CLIENT ORDER No. PAGE

999.66.00.06927 02/04/90 20228 3 OF 4

TUBE No.	SAMPLE No.	W								
1	A104551	<20								
2	A104552	<20								
3	A104553	<20								
4	A104554	<20								
5	A104555	<20								
6	A104556	<20								
7	A104557	<20								
8	A104558	<20								
9	A104559	<20								
10	A104560	<20								
11	A104561	<20								
12	A104562	<20								
13	A104563	<20								
14	A104564	<20								
15	A104565	<20								
	A104566	<20								
17	A104567	<20								
18	A104568	<20								
19	A104569	<20								
20	A104570	<20								
21	A104571	<20								
22	A104572	<20								
23	A104573	35								
24	A104574	<20								
25	A104575	<20								

Results in ppm unless otherwise specified
 T = element present, but concentration too low to measure
 X = element concentration is below detection limit
 - = element not determined

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ANALYTICAL DATA

SAMPLE PREFIX REPORT NUMBER REPORT DATE CLIENT ORDER No. PAGE

999.56.08.06927 02/04/90 20228 2 OF 4

TUBE No.	SAMPLE No	Au	AuCl ₃	Cu	Pb	Zn	Bi	As	Sb	Sn
1	A104576	0.045	-	275	30	75	<10	10	<3	<3
2	A104577	0.062	-	510	15	65	<10	7	<3	<3
3	A104578	<0.008	-	145	5	60	<10	<2	<3	<3
4	A104579	0.010	-	205	<5	170	<10	<2	<3	5
5	A104580	0.069	-	220	<5	150	<10	<2	<3	<3
6	A104581	<0.008	-	30	<5	25	10	10	<3	<3
7	A104582	<0.008	-	20	<5	35	<10	<2	8	<3
8	A104583	0.026	-	55	20	115	10	5	3	<3
9	A104584	<0.008	-	200	<5	80	<10	<2	5	3
10	A104585	<0.008	-	35	<5	20	<10	<2	<3	<3
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23	DETECTION	0.008	0.008	5	5	5	10	2	3	3
24	UNIT	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
25	UNIT	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm

Results in ppm unless otherwise specified
 T = element present; but concentration too low to measure
 X = element concentration is below detection limit
 - = element not determined

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A Division of Incharge Inspection and Testing Services Australia Pty Ltd.

ANALYTICAL DATA

SAMPLE PREFIX REPORT NUMBER REPORT DATE CLIENT ORDER No. PAGE

999.56.08.06927 02/04/90 20228 4 OF 4

TUBE No.	SAMPLE No	W								
1	A104576	<20								
2	A104577	<20								
3	A104578	<20								
4	A104579	<20								
5	A104580	<20								
6	A104581	<20								
7	A104582	<20								
8	A104583	<20								
9	A104584	<20								
10	A104585	<20								
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23	DETECTION	20								
24	UNIT	ppm								
25	UNIT	ppm								

Results in ppm unless otherwise specified
 T = element present; but concentration too low to measure
 X = element concentration is below detection limit
 - = element not determined

AUTHORISED OFFICER *[Signature]*

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A division of MacDonald Hamilton & Co. Pty. Ltd.

Phone (09) 458 7999

52 Murray Road, Welshpool, W.A. 6106

Telex AA92560

FAX: 004 31 8890

ANALYTICAL REPORT No. 999-66-08-07175

THIS REPORT MUST BE READ IN CONJUNCTION WITH THE ACCOMPANYING ANALYTICAL DATA

ORDER No. PROJECT

Outokumpu Exploration Aust Suite 2, Level 6 77 Pacific Highway Sydney NSW 2060	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; padding: 2px;">2022B</td> <td style="width: 50%; padding: 2px;">EL 14/89</td> </tr> <tr> <td style="padding: 2px;">DATE RECEIVED</td> <td style="padding: 2px;">RESULTS REQUIRED</td> </tr> <tr> <td style="padding: 2px;">18/06/90</td> <td style="padding: 2px;">ASAP</td> </tr> </table>	2022B	EL 14/89	DATE RECEIVED	RESULTS REQUIRED	18/06/90	ASAP
2022B	EL 14/89						
DATE RECEIVED	RESULTS REQUIRED						
18/06/90	ASAP						

No. OF PAGES OF RESULTS	DATE REPORTED	No. OF COPIES	TOTAL No. OF SAMPLES
4	11/07/90	1	35

PRE-TREATMENT								ANALYSIS		
SAMPLE NUMBERS	DRY	CRUSH	SPLIT	PULV. VERSE	SIEVE	OTHER SEE REMARKS	NONE	REFER TO ANALYSIS SECTION	PREPARATION	METHOD
CA1045, 51/85	PU							Ca, Na, K, Mg, Fe/104		
CA1045, 51/85	PU							Mo, Ba, Zr, Y, La, Ti/401		
CA1045, 51/85	PU							Ti/403		

RESULTS TO Outokumpu Exploration Aust
Suite 2, Level 6
77 Pacific Highway
Sydney NSW 2060

RESULTS TO W. Herrmann
RSD 1066
Devonport
Tasmania 7310

REMARKS
EL 14/89
DUMPEREARTH CALD
ROCK CHIPS.

STATE OF SAMPLES	ANALYSIS — PREPARATION				ANALYSIS — METHOD			
core ore g WC SC CU Rg SO PU WA TI m sediment y mineral SS HM	perchloric acid hydrochloric acid nitric acid aqua regia nitric-perchloric HF mixture HF under pressure fusion	A1 A2 A3 A4 A5 A6 A7 A8	cold acid specific sulphide other mixed acids alkaline attack volatilization ignition pressed powder (XRF) glass fusion (XRF)	CA SS Ma AA VO IG PP GF	atomic absorption x-ray fluorescence spectrophotometry colorimetry chromatography titration other chemical means miscellaneous fluorescence inductively coupled plasma	AAS XRF SPEC COL CHR TTN CHEM MISC FLUOR ICP		

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A Division of Inchcape Inspection and Testing Services Australia Pty Ltd.

ANALYTICAL DATA

SAMPLE PREFIX REPORT NUMBER REPORT DATE CLIENT ORDER No. PAGE

999.66.08.07175 11/07/90 20228 2 OF 4

TUBE No.	SAMPLE No.	Ca	Na	K	Mg	Fe	Mo	Ba	Zr	Y
1	A104576	0.04	0.04	<0.01	0.16	64.00	5	10	50	15
2	A104577	1.61	1.48	0.19	2.13	33.50	<3	45	40	10
3	A104578	0.03	0.38	0.28	0.52	9.69	<3	100	440	25
4	A104579	0.02	<0.01	<0.01	0.03	70.10	<3	20	20	<5
5	A104580	<0.01	0.06	0.03	<0.01	73.70	4	25	5	5
6	A104581	<0.01	<0.01	0.04	<0.01	25.00	5	1500	<5	<5
	A104582	<0.01	0.05	0.08	<0.01	42.60	<3	80	<5	10
8	A104583	<0.01	0.76	0.13	2.03	20.30	8	860	110	25
9	A104584	<0.01	0.03	<0.01	0.62	67.50	<3	50	10	<5
10	A104585	<0.01	0.08	<0.01	<0.01	5.87	<3	430	7	10
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23	DETECTION	0.01	0.01	0.01	0.01	0.05	3	10	5	5
24	UNITS	%	%	%	%	%	ppm	ppm	ppm	ppm
25	METHOD	104	104	104	104	104	401	401	401	401

Results in ppm unless otherwise specified
 T = element present, but concentration too low to measure
 X = element concentration is below detection limit
 - = element not determined

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ANALYTICAL DATA

SAMPLE PREFIX REPORT NUMBER REPORT DATE CLIENT ORDER No. PAGE

999.66.08.07175 11/07/90 20228 4 OF 4

TUBE No.	SAMPLE No.	La	Ti	Ti
1	A104576	30	1050	-
2	A104577	35	6800	-
3	A104578	15	10000	-
4	A104579	30	360	-
5	A104580	35	620	-
6	A104581	15	140	-
	A104582	30	170	-
8	A104583	25	7200	-
9	A104584	35	10000	1.11
10	A104585	<10	470	-
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23	DETECTION	10	50	0.01
24	UNITS	ppm	ppm	%
25	METHOD	401	401	403

Results in ppm unless otherwise specified
 T = element present, but concentration too low to measure
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 - = element not determined

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0115

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ANALYTICAL DATA

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ANALYTICAL DATA

0220

SAMPLE PREFIX REPORT NUMBER REPORT DATE CLIENT ORDER No. PAGE

SAMPLE PREFIX REPORT NUMBER REPORT DATE CLIENT ORDER No. PAGE

UBE No.	SAMPLE No.	Ca	Na	K	Mg	Fe	Pb	Ba	Zr	Y
	999.66.08.07175									1 OF 4
1	A104551	6.78	0.98	0.67	5.03	8.38	<3	540	75	35
2	A104552	0.10	0.25	0.25	0.29	15.30	<3	1200	110	40
3	A104553	0.10	0.03	0.02	0.15	32.10	15	140	10	15
4	A104554	0.10	0.27	1.17	0.38	27.70	20	400	120	15
5	A104555	0.04	0.03	0.37	0.10	15.10	15	240	40	<5
6	A104556	0.04	<0.01	<0.01	0.07	1.75	5	50	<5	<5
	A104557	1.93	3.34	0.24	4.04	10.40	<3	100	110	25
8	A104558	0.06	0.08	0.14	0.15	0.71	3	50	35	<5
9	A104559	0.05	0.49	0.04	1.52	13.60	<3	80	320	55
0	A104560	0.02	<0.01	0.04	0.66	65.10	<3	50	10	<5
1	A104561	<0.01	<0.01	<0.01	0.55	65.40	6	15	10	<5
2	A104562	0.03	0.13	<0.01	3.73	15.00	3	70	100	50
3	A104563	<0.01	<0.01	<0.01	10.10	20.50	<3	20	60	9
4	A104564	0.80	1.38	<0.01	4.18	7.21	7	60	110	35
5	A104565	1.53	3.08	0.55	4.53	11.30	<3	130	100	30
	A104566	0.05	5.63	0.10	0.47	1.42	6	45	480	70
7	A104567	3.30	0.13	<0.01	24.40	1.93	<3	15	5	<5
8	A104568	0.05	0.70	<0.01	0.74	3.94	<3	35	100	20
9	A104569	0.21	2.93	0.14	3.72	14.70	7	85	150	60
20	A104570	<0.01	0.07	<0.01	<0.01	64.40	8	20	15	20
21	A104571	3.08	3.84	0.30	4.28	13.00	<3	65	100	40
22	A104572	7.91	0.11	0.04	3.18	28.20	3	10	25	320
23	A104573	0.02	<0.01	0.06	<0.01	69.90	5	30	8	15
24	A104574	4.57	0.54	0.04	6.17	11.00	<3	75	130	15
25	A104575	0.03	0.04	<0.01	4.64	50.00	<3	35	65	8

TUBE No.	SAMPLE No.	La	Ti	Ti						
	999.66.08.07175									3 OF 4
1	A104551	30	5400	-						
2	A104552	35	>10000	1.02						
3	A104553	25	330	-						
4	A104554	45	3550	-						
5	A104555	<10	680	-						
6	A104556	10	100	-						
	A104557	20	>10000	1.04						
8	A104558	<10	460	-						
9	A104559	30	>10000	1.89						
10	A104560	30	3800	-						
11	A104561	25	1350	-						
12	A104562	35	8850	-						
13	A104563	15	2250	-						
14	A104564	35	7700	-						
15	A104565	20	9350	-						
	A104566	15	3850	-						
17	A104567	<10	100	-						
18	A104568	<10	2200	-						
19	A104569	30	>10000	1.86						
20	A104570	45	6150	-						
21	A104571	20	>10000	1.21						
22	A104572	230	3150	-						
23	A104573	30	350	-						
24	A104574	30	>10000	1.47						
25	A104575	30	>10000	1.05						

Results in ppm unless otherwise specified
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AUTHORISED OFFICER

Gentkins

Results in ppm unless otherwise specified
 T = element present, but concentration too low to measure
 X = element concentration is below detection limit
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AUTHORISED OFFICER

Gentkins

ANALABS

Phone (09) 458 7999

A Division of MacDonald Hamilton & Co. Pty. Ltd.
52 Murray Road, Welshpool, W.A. 6106
FAX: 004 31 8890

Telex AA92560

ANALYTICAL REPORT No. 999.66.08.07176

THIS REPORT MUST BE READ IN CONJUNCTION WITH THE ACCOMPANYING ANALYTICAL DATA

370098

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A Division of Incharge Inspection and Testing Services Australia Pty Ltd.

3700

ANALYTICAL DATA

ORDER No.		PROJECT	
20229			
DATE RECEIVED		RESULTS REQUIRED	
18/06/90		ASAP	
Outokumpu Exploration Aust Suite 2, Level 6 77 Pacific Highway Sydney NSW 2060			
No. OF PAGES OF RESULTS	DATE REPORTED	No. OF COPIES	TOTAL No. OF SAMPLES
2	09/07/90	1	21

SAMPLE NUMBERS	PRE-TREATMENT						OTHER SEE REMARKS	NONE	REFER TO ANALYSIS SECTION	PREPARATION	METHOD
	DRY	CRUSH	SPLIT	PUL-VERISE	SIEVE						
<A104,601/621	RC	Prep: 005,010,011,012,013,014								Cu,Pb,Zn,Fe/101	
<A104,601/621	RC									Ca,Na,K,Mg/104	
<A104,601/621	RC									Au,AuChk/309	
<A104,601/621	RC									Mo,W,Ba,Zr,Y,La,Ti/401	
<A104,601/621	RC	Prep: 005,010,011,012,013,014								Cu,Pb,Zn/140,Fe/104	

RESULTS TO	Outokumpu Exploration Aust Suite 2, Level 6 77 Pacific Highway Sydney NSW 2060	REMARKS EL 10/89 Owen HERBERTH and Peter CHODS - Danton's Creek etc.
RESULTS TO	W. Herrmann RSD 1066 Devonport Tasmania 7310	

STATE OF SAMPLES	ANALYSIS — PREPARATION				ANALYSIS — METHOD			
ale core WC ore SC ng CU k Ro SO PU er WA ue TI am sediment SS vy mineral HM	perchloric acid A1 hydrochloric acid A2 nitric acid A3 aqua regia A4 nitric-perchloric A5 HF mixture A6 HF under pressure A7 fusion A8	cold acid specific sulphide other mixed acids alkaline attack volatilization ignition pressed powder (XRF) glass fusion (XRF)	CA SS Mo AA VO IG PP GF	atomic absorption x-ray fluorescence spectrophotometry colorimetry chromatography titration other chemicals means miscellaneous fluorescence inductively coupled plasma	AAS XRF SPEC COL CHR TIN CHEM MISC FLUOR ICP			

SAMPLE PREFIX		REPORT NUMBER				REPORT DATE		CLIENT ORDER No.		PAGE	
		999.66.08.07176				09/07/90		20229		1 OF 1	
TUBE No.	SAMPLE No.	Cu	Cu	Pb	Pb	Zn	Zn	Fe	Fe	Ca	
1	A104601	600	-	<5	-	65	-	>5.00	31.90	0.05	
2	A104602	40	-	<5	-	10	-	1.69	-	1.41	
3	A104603	20	-	<5	-	80	-	>5.00	15.10	0.06	
4	A104604	35	-	<5	-	30	-	2.07	-	1.85	
5	A104605	95	-	<5	-	160	-	>5.00	16.80	0.04	
6	A104606	255	-	<5	-	60	-	>5.00	39.30	<0.01	
	A104607	395	-	170	-	145	-	>5.00	57.80	<0.01	
8	A104608	4300	-	35	-	25	-	2.55	-	<0.01	
9	A104609	5000	-	<5	-	55	-	>5.00	24.90	<0.01	
10	A104610	3200	-	<5	-	135	-	>5.00	37.40	0.06	
11	A104611	735	-	<5	-	75	-	>5.00	16.40	0.07	
12	A104612	20	-	<5	-	10	-	0.80	-	<0.01	
13	A104613	90	-	45	-	70	-	>5.00	31.80	<0.01	
14	A104614	20	-	10	-	25	-	1.17	-	0.24	
15	A104615	-	130	-	<5	-	100	>5.00	66.40	<0.01	
	A104616	-	145	-	<5	-	85	>5.00	67.60	<0.01	
17	A104617	50	-	<5	-	30	-	4.50	-	3.99	
18	A104618	115	-	<5	-	30	-	>5.00	7.90	5.10	
19	A104619	190	-	<5	-	55	-	>5.00	48.50	0.34	
20	A104620	50	-	<5	-	60	-	>5.00	6.71	3.25	
21	A104621	-	210	-	<5	-	85	>5.00	66.20	0.03	
22											
23	DETECTION	5	2	5	5	5	2	0.05	5.00	0.01	
24	UNITS	ppm	ppm	ppm	ppm	ppm	ppm	%	%	%	
25	METHOD	101	140	101	140	101	140	101	104	104	

Results in ppm unless otherwise specified
 T = element present, but concentration too low to measure
 X = element concentration is below detection limit
 - = element not determined

AUTHORISED OFFICER *Gentiana*

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A Division of Incecape Inspection and Testing Services Australia Pty Ltd.

ANALYTICAL DATA

SAMPLE PREFIX REPORT NUMBER REPORT DATE CLIENT ORDER No. PAGE

999.66.08.07176 09/07/90 20229 1 OF 2

UBE No	SAMPLE No.	Na	K	Mg	Al	AuChk	Mo	W	Ba	Zr
1	A104601	<0.01	0.09	0.07	0.053	-	<3	<20	<10	45
2	A104602	5.99	0.12	1.32	<0.008	<0.008	<3	<20	<10	480
3	A104603	0.02	<0.01	18.50	<0.008	-	<3	<20	<10	100
4	A104604	0.20	<0.01	8.00	<0.008	-	<3	<20	<10	70
5	A104605	<0.01	<0.01	0.29	<0.008	-	<3	<20	<10	<5
6	A104606	<0.01	<0.01	0.07	<0.008	<0.008	<3	<20	<10	<5
	A104607	0.09	0.04	<0.01	0.030	-	15	<20	<10	9
8	A104608	0.91	0.44	0.05	0.081	-	7	<20	150	120
9	A104609	0.32	<0.01	0.08	0.174	-	3	<20	15	15
10	A104610	1.15	0.16	1.31	0.292	-	6	<20	500	35
1	A104611	0.41	0.17	0.58	0.092	-	5	<20	520	30
2	A104612	0.03	0.03	<0.01	<0.008	-	3	<20	<10	55
3	A104613	0.04	1.51	0.42	0.012	0.020	15	<20	<10	20
4	A104614	0.05	0.08	1.66	<0.008	-	3	<20	160	100
15	A104615	0.05	<0.01	0.07	<0.008	-	<3	<20	<10	9
	A104616	<0.01	<0.01	0.08	<0.008	-	<3	<20	<10	<5
17	A104617	0.62	0.09	4.62	<0.008	-	4	<20	<10	230
8	A104618	0.33	<0.01	6.11	<0.008	-	3	<20	<10	180
9	A104619	0.05	0.04	4.47	<0.008	-	<3	<20	<10	20
20	A104620	4.54	0.37	4.24	<0.008	-	<3	<20	<10	110
21	A104621	0.05	<0.01	0.22	<0.008	<0.008	<3	20	<10	<5
22										
23	DETECTION	0.01	0.01	0.01	0.008	0.008	3	20	10	5
24	UNITS	%	%	%	ppm	ppm	ppm	ppm	ppm	ppm
25	METHOD	104	104	104	309	309	401	401	401	401

Results in ppm unless otherwise specified
 T = element present, but concentration too low to measure
 X = element concentration is below detection limit
 - = element not determined

AUTHORISED OFFICER

gentians

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ANALABS

A Division of Incecape Inspection and Testing Services Australia Pty Ltd.

ANALYTICAL DATA

SAMPLE PREFIX REPORT NUMBER REPORT DATE CLIENT ORDER No. PAGE

999.66.08.07176 09/07/90 20229 2 OF 2

TUBE No.	SAMPLE No.	Y	La	Ti	Ti					
1	A104601	7	40	-	1400					
2	A104602	45	20	-	3150					
3	A104603	<5	35	-	6500					
4	A104604	<5	20	-	8700					
5	A104605	20	10	-	230					
6	A104606	<5	20	-	220					
	A104607	40	35	-	630					
8	A104608	7	10	-	1600					
9	A104609	7	<10	-	490					
10	A104610	25	20	-	5500					
11	A104611	15	25	-	2050					
12	A104612	<5	<10	-	270					
13	A104613	6	25	-	1400					
14	A104614	15	15	-	2200					
15	A104615	5	50	-	6600					
	A104616	8	30	-	480					
17	A104617	30	60	1.32	>10000					
18	A104618	25	60	1.41	>10000					
19	A104619	10	30	-	4000					
20	A104620	40	25	-	9800					
21	A104621	5	35	-	270					
22										
23	DETECTION	5	10	0.01	50					
24	UNITS	ppm	ppm	%	ppm					
25	METHOD	401	401	103	401					

Results in ppm unless otherwise specified
 T = element present, but concentration too low to measure
 X = element concentration is below detection limit
 - = element not determined

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Appendix IV B/C Soil Samples - Analytical Results

ANALABS

A Division of Incharge Inspection and Testing Services Australia Pty Ltd

ANALYTICAL DATA

SAMPLE PREFIX: 999.66.08.07177 REPORT NUMBER: 03/07/90 CLIENT ORDER No: 20230 PAGE: 2 OF 17

TUBE No.	SAMPLE No.	Cu	Pb	Zn	Au	AuChk				
1	A104676	45	275	25	0.025	-				
2	A104677	10	10	15	0.021	-				
3	A104678	15	35	20	<0.008	-				
4	A104679	5	<5	15	<0.008	-				
5	A104680	25	<5	30	<0.008	-				
6	A104681	100	5	70	<0.008	-				
7	A104682	150	15	195	<0.008	<0.008				
8	A104683	165	20	235	<0.008	<0.008				
9	A104684	85	10	100	<0.008	-				
0	A104685	45	<5	160	<0.008	-				
1	A104686	100	<5	105	<0.008	-				
2	A104687	75	<5	130	<0.008	-				
3	A104688	140	10	235	<0.008	-				
4	A104689	105	15	295	<0.008	-				
5	A104690	80	15	175	<0.008	-				
6	A104691	85	<5	165	<0.008	-				
7	A104692	80	<5	160	<0.008	-				
8	A104693	175	<5	145	0.011	-				
9	A104694	30	5	40	<0.008	-				
20	A104695	95	<5	145	<0.008	-				
21	A104696	30	5	75	<0.008	<0.008				
22	A104697	55	5	180	<0.008	-				
23	A104698	90	50	250	<0.008	-				
24	A104699	140	45	185	0.012	-				
25	A104700	25	15	35	<0.008	-				

Results in ppm unless otherwise specified.
 T = element present, but concentration too low to measure
 X = element concentration is below detection limit
 - = element not determined

AUTHORISED OFFICER *Jenkins*

370102

ANALABS

A Division of Incharge Inspection and Testing Services Australia Pty Ltd

ANALYTICAL DATA

SAMPLE PREFIX: 999.66.08.07177 REPORT NUMBER: 03/07/90 CLIENT ORDER No: 20230 PAGE: 3 OF 17

TUBE No.	SAMPLE No.	Cu	Pb	Zn	Au	AuChk				
1	A104701	60	60	35	<0.008	-				
2	A104702	60	55	45	<0.008	-				
3	A104703	80	30	75	<0.008	-				
4	A104704	30	5	65	<0.008	-				
5	A104705	10	<5	60	<0.008	-				
6	A104706	20	65	30	<0.008	-				
7	A104707	20	30	20	<0.008	-				
8	A104708	90	10	25	<0.008	-				
9	A104709	45	<5	30	<0.008	<0.008				
10	A104710	75	50	25	<0.008	-				
11	A104711	5	<5	20	<0.008	<0.008				
12	A104712	10	10	85	<0.008	-				
13	A104713	25	5	100	<0.008	-				
14	A104714	5	5	70	<0.008	-				
15	A104715	30	<5	140	<0.008	-				
16	A104716	15	10	45	<0.008	-				
17	A104717	65	30	160	<0.008	-				
18	A104718	70	15	245	<0.008	<0.008				
19	A104719	110	15	170	<0.008	-				
20	A104720	80	<5	45	<0.008	-				
21	A104721	50	5	60	<0.008	-				
22	A104722	50	<5	155	<0.008	-				
23	A104723	20	<5	65	<0.008	<0.008				
24	A104724	100	5	195	<0.008	-				
25	A104725	90	<5	85	<0.008	-				

Results in ppm unless otherwise specified.
 T = element present, but concentration too low to measure
 X = element concentration is below detection limit
 - = element not determined

AUTHORISED OFFICER *Jenkins*

1010

ANALABS

A Division of Incharge Inspection and Testing Services Australia Pty Ltd.

ANALYTICAL DATA

SAMPLE PREFIX: 999.66.08.07177 REPORT NUMBER: 03/07/90 CLIENT ORDER No: 20230 PAGE: 4 OF 17

TUBE No.	SAMPLE No.	Cu	Pb	Zn	Au	AuChk				
1	A104726	55	10	145	<0.008	--				
2	A104727	115	<5	115	<0.008	<0.008				
3	A104728	60	<5	305	<0.008	--				
4	A104729	140	10	150	<0.008	--				
5	A104730	95	<5	105	<0.008	--				
6	A104731	60	<5	150	<0.008	--				
7	A104732	60	<5	65	<0.008	--				
8	A104733	55	<5	70	<0.008	--				
9	A104734	15	<5	20	<0.008	--				
10	A104735	75	35	30	<0.008	--				
11	A104736	10	<5	15	<0.008	--				
12	A104737	30	<5	95	<0.008	--				
13	A104738	5	20	20	<0.008	--				
14	A104739	5	<5	20	<0.008	--				
15	A104740	5	<5	15	<0.008	--				
16	A104741	<5	<5	15	<0.008	--				
17	A104742	5	<5	10	0.013	<0.008				
8	A104743	15	10	385	<0.008	--				
9	A104744	115	35	125	<0.008	--				
20	A104745	60	10	65	<0.008	--				
21	A104746	80	<5	280	<0.008	--				
22	A104747	40	5	250	<0.008	--				
23	A104748	50	<5	115	<0.008	--				
24	A104749	70	5	100	<0.008	<0.008				
25	A104750	45	5	80	<0.008	--				

Results in ppm unless otherwise specified
 T = element present, but concentration too low to measure
 X = element concentration is below detection limit
 -- = element not determined

AUTHORISED OFFICER

Gentle

370103

ANALABS

A Division of Incharge Inspection and Testing Services Australia Pty Ltd.

ANALYTICAL DATA

SAMPLE PREFIX: 999.66.08.07177 REPORT NUMBER: 03/07/90 CLIENT ORDER No: 20230 PAGE: 5 OF 17

TUBE No.	SAMPLE No.	Cu	Pb	Zn	Au	AuChk				
1	A104751	35	5	100	0.009	--				
2	A104752	75	10	70	<0.008	--				
3	A104753	60	10	155	<0.008	--				
4	A104754	110	<5	80	0.010	--				
5	A104755	50	<5	125	0.015	--				
6	A104756	100	10	90	<0.008	--				
7	A104757	35	<5	100	0.009	--				
8	A104758	25	<5	150	<0.008	<0.008				
9	A104759	75	<5	90	0.010	--				
10	A104760	100	5	165	<0.008	<0.008				
11	A104761	60	<5	80	0.010	--				
12	A104762	25	<5	35	0.014	--				
13	A104763	10	<5	30	<0.008	--				
14	A104764	50	15	20	<0.008	--				
15	A104765	60	<5	15	<0.008	--				
16	A104766	75	<5	40	<0.008	--				
17	A104767	5	<5	15	<0.008	--				
18	A104768	20	5	110	0.009	--				
19	A104769	10	45	160	<0.008	--				
20	A104770	15	40	90	<0.008	--				
21	A104771	145	10	65	<0.008	--				
22	A104772	30	5	35	<0.008	--				
23	A104773	20	<5	25	<0.008	--				
24	A104774	95	<5	60	<0.008	<0.008				
25	A104775	65	5	200	<0.008	--				

Results in ppm unless otherwise specified
 T = element present, but concentration too low to measure
 X = element concentration is below detection limit
 -- = element not determined

AUTHORISED OFFICER

Gentle

010

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A Division of Inhouse Inspection and Testing Services Australia Pty Ltd

ANALYTICAL DATA

SAMPLE PREFIX: REPORT NUMBER: 999.66.08.07177 REPORT DATE: 03/07/90 CLIENT ORDER No: 20230 PAGE: 6 OF 17

TUBE No.	SAMPLE No.	Cu	Pb	Zn	Au	AuCHK				
1	A104776	55	<5	75	<0.008	-				
2	A104777	75	<5	80	<0.008	-				
3	A104778	120	<5	65	<0.008	-				
4	A104779	10	<5	35	<0.008	-				
5	A104780	30	5	75	<0.008	-				
6	A104781	65	10	165	<0.008	-				
7	A104782	40	10	90	<0.008	-				
8	A104783	50	5	25	<0.008	-				
9	A104784	115	10	110	<0.008	-				
10	A104785	75	35	45	<0.008	-				
11	A104786	55	35	75	<0.008	<0.008				
12	A104787	65	5	30	<0.008	-				
13	A104788	35	<5	15	<0.008	-				
14	A104789	135	<5	105	<0.008	<0.008				
15	A104790	135	<5	105	<0.008	-				
16	A104791	130	<5	60	<0.008	-				
17	A104792	80	10	65	<0.008	-				
18	A104793	20	<5	15	<0.008	-				
19	A104794	45	<5	25	<0.008	<0.008				
20	A104795	10	<5	15	<0.008	-				
21	A104796	50	5	205	<0.008	-				
22	A104797	40	15	200	<0.008	-				
23	A104798	35	50	230	<0.008	-				
24	A104799	5	<5	15	<0.008	-				
25	A104800	5	5	20	<0.008	-				

Results in ppm unless otherwise specified
 T = element present but concentration too low to measure
 X = element concentration below detection limit
 - = element not determined

AUTHORISED OFFICER: *John King*

370104

ANALABS

A Division of Inhouse Inspection and Testing Services Australia Pty Ltd

ANALYTICAL DATA

SAMPLE PREFIX: REPORT NUMBER: 999.66.08.07177 REPORT DATE: 03/07/90 CLIENT ORDER No: 20230 PAGE: 7 OF 17

TUBE No.	SAMPLE No.	Cu	Pb	Zn	Au	AuCHK				
1	A105401	<5	<5	15	<0.008	-				
2	A105402	5	<5	20	0.020	-				
3	A105403	<5	<5	10	<0.008	-				
4	A105404	<5	<5	10	<0.008	<0.008				
5	A105405	5	5	10	0.192	-				
6	A105406	5	<5	20	<0.008	-				
7	A105407	<5	<5	10	<0.008	-				
8	A105408	<5	<5	10	0.195	-				
9	A105409	50	<5	60	<0.008	-				
10	A105410	130	25	290	<0.008	-				
11	A105411	40	<5	150	0.374	-				
12	A105412	290	<5	50	<0.008	-				
13	A105413	255	15	60	<0.008	-				
14	A105414	20	30	30	<0.008	-				
15	A105415	110	10	30	<0.008	-				
16	A105416	135	<5	120	<0.008	-				
17	A105417	35	5	45	<0.008	-				
18	A105418	20	5	45	<0.008	-				
19	A105419	35	10	120	<0.008	<0.008				
20	A105420	55	<5	115	<0.008	-				
21	A105421	100	<5	60	<0.008	-				
22	A105422	100	<5	40	<0.008	-				
23	A105423	210	5	120	<0.008	-				
24	A105424	65	10	60	<0.008	-				
25	A105425	105	5	95	<0.008	-				

Results in ppm unless otherwise specified
 T = element present but concentration too low to measure
 X = element concentration below detection limit
 - = element not determined

AUTHORISED OFFICER: *John King*

370104

ANALABS

A Division of Inception Inspection and Testing Services Australia Pty Ltd

ANALYTICAL DATA

SAMPLE PREFIX REPORT NUMBER REPORT DATE CLIENT ORDER No. PAGE

999-66-08-07177 03/07/90 20230 8 OF 17

TUBE No	SAMPLE No	Cu	Pb	Zn	Au	AuChk				
1	A105426	110	10	70	<0.008	-				
2	A105427	15	5	15	<0.008	-				
3	A105428	25	5	15	<0.008	-				
4	A105429	50	<5	25	<0.008	<0.008				
5	A105430	85	<5	130	<0.008	-				
6	A105431	135	10	60	<0.008	-				
7	A105432	15	5	15	<0.008	-				
8	A105433	5	5	10	<0.008	-				
9	A105434	30	<5	20	<0.008	<0.008				
0	A105435	15	5	15	0.012	0.010				
1	A105436	20	5	15	<0.008	-				
12	A105437	90	60	80	0.012	-				
3	A105438	65	15	60	<0.008	-				
4	A105439	70	15	35	<0.008	-				
5	A105440	20	15	45	<0.008	-				
6	A105441	35	25	30	<0.008	-				
7	A105442	115	65	55	<0.008	-				
8	A105443	80	20	80	<0.008	-				
9	A105444	115	20	130	<0.008	-				
20	A105445	55	5	155	<0.008	-				
21	A105446	105	35	415	<0.008	-				
22	A105447	590	5	125	<0.008	-				
23	A105448	145	10	20	<0.008	-				
24	A105449	140	10	30	<0.008	<0.008				
25	A105450	90	10	50	<0.008	-				

Results in ppm unless otherwise specified
 T = element present, but concentration too low to measure
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 - = element not determined

AUTHORISED OFFICER

Jenkins

370105

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A Division of Inception Inspection and Testing Services Australia Pty Ltd

ANALYTICAL DATA

SAMPLE PREFIX REPORT NUMBER REPORT DATE CLIENT ORDER No. PAGE

999-66-08-07177 03/07/90 20230 9 OF 17

TUBE No	SAMPLE No	Cu	Pb	Zn	Au	AuChk				
1	A105451	85	10	50	<0.008	-				
2	A105452	50	15	35	<0.008	-				
3	A105453	30	10	25	<0.008	-				
4	A105454	500	90	465	<0.008	-				
5	A105455	5	5	5	<0.008	-				
6	A105456	25	10	15	<0.008	-				
7	A105457	<5	5	5	<0.008	-				
8	A105458	5	<5	5	<0.008	-				
9	A105459	10	<5	15	<0.008	-				
10	A105460	<5	5	10	<0.008	-				
11	A105461	<5	5	10	<0.008	-				
12	A105462	<5	<5	10	<0.008	-				
13	A105463	<5	<5	10	<0.008	-				
14	A105464	<5	<5	10	<0.008	-				
15	A105465	10	<5	25	<0.008	-				
16	A105466	95	<5	70	<0.008	-				
17	A105467	115	<5	195	<0.008	-				
18	A105468	195	<5	80	0.010	0.009				
19	A105469	210	<5	35	<0.008	-				
20	A105470	90	<5	65	<0.008	-				
21	A105471	15	<5	30	<0.008	-				
22	A105472	60	<5	15	<0.008	-				
23	A105473	10	<5	10	<0.008	-				
24	A105474	30	<5	15	<0.008	<0.008				
25	A105475	70	<5	45	<0.008	-				

Results in ppm unless otherwise specified
 T = element present, but concentration too low to measure
 X = element concentration is below detection limit
 - = element not determined

AUTHORISED OFFICER

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A Division of Incharge Inspection and Testing Services, Australia Pty Ltd

ANALYTICAL DATA

SAMPLE PREFIX: 999.66.08.07177 REPORT NUMBER: 03/07/90 CLIENT ORDER No: 20230 PAGE: 10 OF 17

BE No.	SAMPLE No.	Cu	Pb	Zn	Au	AuChk				
1	A105476	100	<5	40	<0.008	-				
2	A105477	35	<5	40	<0.008	-				
3	A105478	15	<5	50	<0.008	-				
4	A105479	30	<5	20	0.020	-				
5	A105480	30	<5	45	<0.008	-				
6	A105481	40	<5	45	<0.008	<0.008				
7	A105482	20	<5	20	<0.008	-				
8	A105483	5	<5	5	<0.008	-				
9	A105484	5	<5	15	<0.008	-				
0	A105485	5	<5	10	<0.008	-				
1	A105486	15	<5	15	0.018	-				
2	A105487	60	<5	60	<0.008	-				
3	A105488	115	<5	130	<0.008	-				
4	A105489	50	<5	160	<0.008	-				
5	A105490	120	10	300	<0.008	-				
6	A105491	15	<5	10	<0.008	-				
7	A105492	5	<5	5	<0.008	-				
8	A105493	10	<5	20	<0.008	-				
9	A105494	5	<5	35	<0.008	-				
20	A105495	5	<5	15	<0.008	-				
21	A105496	5	<5	10	<0.008	<0.008				
22	A105497	5	<5	10	<0.008	-				
23	A105498	5	<5	5	<0.008	-				
24	A105499	90	<5	40	<0.008	-				
25	A105500	145	<5	30	<0.008	<0.008				

Results in ppm unless otherwise specified.
 T = element present but concentration too low to measure
 X = element concentration is below detection limit
 - = element not determined

AUTHORISED OFFICER: *Genkin*

370106

ANALABS

A Division of Incharge Inspection and Testing Services, Australia Pty Ltd

ANALYTICAL DATA

SAMPLE PREFIX: 999.66.08.07177 REPORT NUMBER: 03/07/90 CLIENT ORDER No: 20230 PAGE: 11 OF 17

TUBE No.	SAMPLE No.	Cu	Pb	Zn	Au	AuChk				
1	A105501	140	<5	70	<0.008	-				
2	A105502	175	<5	345	<0.008	-				
3	A105503	290	<5	105	<0.008	-				
4	A105504	135	<5	45	<0.008	-				
5	A105505	100	<5	105	<0.008	-				
6	A105506	85	<5	65	<0.008	-				
7	A105507	60	<5	40	<0.008	-				
8	A105508	100	<5	40	<0.008	-				
9	A105509	50	<5	35	<0.008	-				
10	A105510	45	<5	155	<0.008	-				
11	A105511	135	10	50	<0.008	-				
12	A105512	60	25	20	<0.008	<0.008				
13	A105513	25	15	15	<0.008	-				
14	A105514	20	5	10	<0.008	-				
15	A105515	15	<5	10	<0.008	-				
16	A105516	5	<5	10	<0.008	-				
17	A105517	30	<5	15	<0.008	-				
18	A105518	25	<5	15	<0.008	-				
19	A105519	20	<5	15	<0.008	-				
20	A105520	95	<5	55	<0.008	-				
21	A105521	70	<5	110	<0.008	-				
22	A105522	40	<5	320	<0.008	-				
23	A105523	45	5	270	<0.008	-				
24	A105524	10	<5	15	<0.008	-				
25	A105525	5	<5	15	<0.008	-				

Results in ppm unless otherwise specified.
 T = element present but concentration too low to measure
 X = element concentration is below detection limit
 - = element not determined

AUTHORISED OFFICER: *Genkin*

0110

ANALABS

A Division of Incharge Inspection and Testing Services Australia Pty Ltd

ANALYTICAL DATA

SAMPLE PREFIX: 999.66.08.07177 REPORT NUMBER: 03/07/90 CLIENT ORDER NO: 20230 PAGE: 12 OF 17

TUBE No.	SAMPLE No.	Cu	Pb	Zn	Au	AuChk			
1	A105526	10	<5	10	<0.008	<0.008			
2	A105527	5	<5	10	<0.008				
3	A105528	10	<5	5	<0.008	<0.008			
4	A105529	10	<5	10	<0.008				
5	A105530	10	<5	10	<0.008				
6	A105531	5	<5	10	<0.008				
7	A105532	10	<5	25	<0.008				
8	A105533	20	<5	25	<0.008				
9	A105534	20	<5	15	<0.008				
0	A105535	25	<5	20	<0.008				
1	A105536	30	<5	20	<0.008				
12	A105537	40	<5	25	<0.008				
3	A105538	195	<5	55	<0.008				
14	A105539	295	<5	60	<0.008				
5	A105540	35	<5	15	<0.008				
6	A105541	15	<5	15	<0.008	<0.008			
7	A105542	15	<5	10	<0.008				
18	A105543	15	<5	10	<0.008				
9	A105544	10	<5	15	<0.008				
20	A105545	5	<5	5	<0.008				
21	A105546	5	<5	5	<0.008				
22	A105547	20	<5	25	<0.008				
23	A105548	15	<5	15	<0.008				
24	A105549	50	<5	80	<0.008				
25	A105550	5	5	40	<0.008				

Results in ppm unless otherwise specified
 T = element present, but concentration too low to measure
 X = element concentration is below detection limit
 - = element not determined

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ANALYTICAL DATA

SAMPLE PREFIX: 999.66.08.07177 REPORT NUMBER: 03/07/90 CLIENT ORDER NO: 20230 PAGE: 13 OF 17

TUBE No.	SAMPLE No.	Cu	Pb	Zn	Au	AuChk			
1	A105551	5	<5	5	<0.008				
2	A105552	15	<5	15	<0.008				
3	A105553	20	40	40	<0.008				
4	A105554	25	<5	10	<0.008				
5	A105555	15	<5	20	0.011	<0.008			
6	A105556	15	<5	230	<0.008	<0.008			
7	A105557	10	<5	10	<0.008				
8	A105558	10	<5	5	<0.008				
9	A105559	10	<5	10	<0.008				
10	A105560	10	<5	10	<0.008				
11	A105561	5	<5	5	<0.008				
12	A105562	50	<5	10	<0.008				
13	A105563	10	<5	5	0.010				
14	A105564	10	10	5	<0.008				
15	A105565	95	<5	200	<0.008				
16	A105566	160	<5	55	<0.008				
17	A105567	185	<5	100	<0.008				
18	A105568	20	<5	70	<0.008				
19	A105569	50	<5	125	<0.008				
20	A105570	150	<5	85	<0.008				
21	A105571	20	<5	25	<0.008				
22	A105572	40	<5	25	<0.008				
23	A105573	65	<5	20	<0.008	<0.008			
24	A105574	20	<5	10	<0.008				
25	A105575	35	<5	35	<0.008				

Results in ppm unless otherwise specified
 T = element present, but concentration too low to measure
 X = element concentration is below detection limit
 - = element not determined

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ANALYTICAL DATA

SAMPLE PREFIX: 999.66.08.07177 REPORT NUMBER: 03/07/90 CLIENT ORDER No: 20230 PAGE: 14 OF 17

UBE No.	SAMPLE No.	Cu	Pb	Zn	Al	AuCHK				
	A105576	705	<5	160	<0.008	-				
2	A105577	20	<5	10	<0.008	-				
3	A105578	5	<5	<5	<0.008	-				
4	A105579	5	<5	<5	<0.008	<0.008				
5	A105580	5	<5	<5	<0.008	-				
6	A105581	40	5	25	<0.008	-				
7	A105582	15	<5	65	<0.008	-				
8	A105583	5	5	10	<0.008	-				
9	A105584	5	10	25	<0.008	-				
0	A105585	10	15	30	<0.008	-				
1	A105586	5	5	<5	<0.008	-				
2	A105587	5	<5	<5	<0.008	-				
3	A105588	5	<5	<5	<0.008	-				
4	A105589	5	<5	5	<0.008	<0.008				
5	A105590	40	25	<5	<0.008	-				
6	A105591	10	5	5	<0.008	-				
7	A105592	5	<5	<5	<0.008	-				
8	A105593	5	10	<5	<0.008	-				
9	A105594	10	<5	<5	<0.008	-				
20	A105595	5	<5	<5	<0.008	-				
21	A105596	5	5	<5	<0.008	-				
22	A105597	5	<5	5	<0.008	-				
23	A105598	5	<5	<5	<0.008	-				
24	A105599	30	<5	105	<0.008	-				
25	A105600	125	<5	185	<0.008	-				

Results in ppm unless otherwise specified
 T = element present, but concentration too low to measure
 X = element concentration is below detection limit
 - = element not determined

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ANALYTICAL DATA

SAMPLE PREFIX: 999.66.08.07177 REPORT NUMBER: 03/07/90 CLIENT ORDER No: 20230 PAGE: 15 OF 17

TUNE No.	SAMPLE No.	Cu	Pb	Zn	Al	AuCHK				
1	A105601	125	<5	90	<0.008	<0.008				
2	A105602	60	<5	35	<0.008	-				
3	A105603	95	<5	40	<0.008	-				
4	A105604	35	<5	80	<0.008	<0.008				
5	A105605	15	<5	30	<0.008	-				
6	A105606	25	<5	35	<0.008	-				
7	A105607	38	<5	15	<0.008	-				
8	A105608	15	<5	30	<0.008	-				
9	A105609	20	<5	5	<0.008	-				
10	A105610	38	<5	5	<0.008	-				
11	A105611	5	5	<5	<0.008	-				
12	A105612	5	<5	<5	<0.008	-				
13	A105613	5	5	5	<0.008	-				
14	A105614	5	<5	<5	<0.008	-				
15	A105615	5	5	<5	<0.008	-				
16	A105616	10	<5	5	<0.008	<0.008				
17	A105617	5	<5	5	<0.008	-				
18	A105618	5	5	<5	<0.008	-				
19	A105619	5	5	5	<0.008	-				
20	A105620	10	5	10	<0.008	<0.008				
21	A105621	5	<5	5	<0.008	-				
22	A105622	30	<5	10	<0.008	-				
23	A105623	5	5	<5	<0.008	-				
24	A105624	5	5	<5	<0.008	-				
25	A105625	5	<5	<5	<0.008	-				

Results in ppm unless otherwise specified
 T = element present, but concentration too low to measure
 X = element concentration is below detection limit
 - = element not determined

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ANALYTICAL DATA

SAMPLE PREFIX REPORT NUMBER REPORT DATE CLIENT ORDER No. PAGE

999.66.08.07177 03/07/90 20230 16 OF 17

BE No	SAMPLE No	Cu	Pb	Zn	Au	AuCHK			
	A105626	5	<5	10	<0.008	--			
2	A105627	35	<5	165	<0.008	--			
3	A105628	70	<5	130	<0.008	--			
4	A105629	60	5	70	<0.008	--			
5	A105630	160	<5	80	<0.008	--			
3	A105631	110	<5	90	<0.008	<0.008			
7	A105632	135	<5	45	<0.008	--			
3	A105633	40	<5	25	<0.008	--			
3	A105634	75	5	40	<0.008	--			
0	A105635	165	25	395	<0.008	--			
	A105636	170	5	105	<0.008	--			
2	A105637	190	<5	100	<0.008	--			
3	A105638	10	<5	<5	<0.008	--			
4	A105639	10	<5	<5	<0.008	--			
5	A105640	5	<5	<5	<0.008	--			
6	A105641	5	<5	5	<0.008	<0.008			
7	A105642	65	<5	15	0.027	--			
8	A105643	65	<5	<5	<0.008	--			
9	A105644	5	5	<5	<0.008	--			
0	A105645	5	5	5	<0.008	--			
1	A105646	10	<5	15	<0.008	<0.008			
2	A105647	5	<5	5	<0.008	--			
3	A105648	10	5	35	0.011	--			
4	A105649	15	10	185	<0.008	--			
5	A105650	10	5	5	<0.008	--			

Results in ppm unless otherwise specified
 T = element present, but concentration too low to measure
 X = element concentration is below detection limit
 -- = element not determined

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370109

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ANALYTICAL DATA

SAMPLE PREFIX REPORT NUMBER REPORT DATE CLIENT ORDER No. PAGE

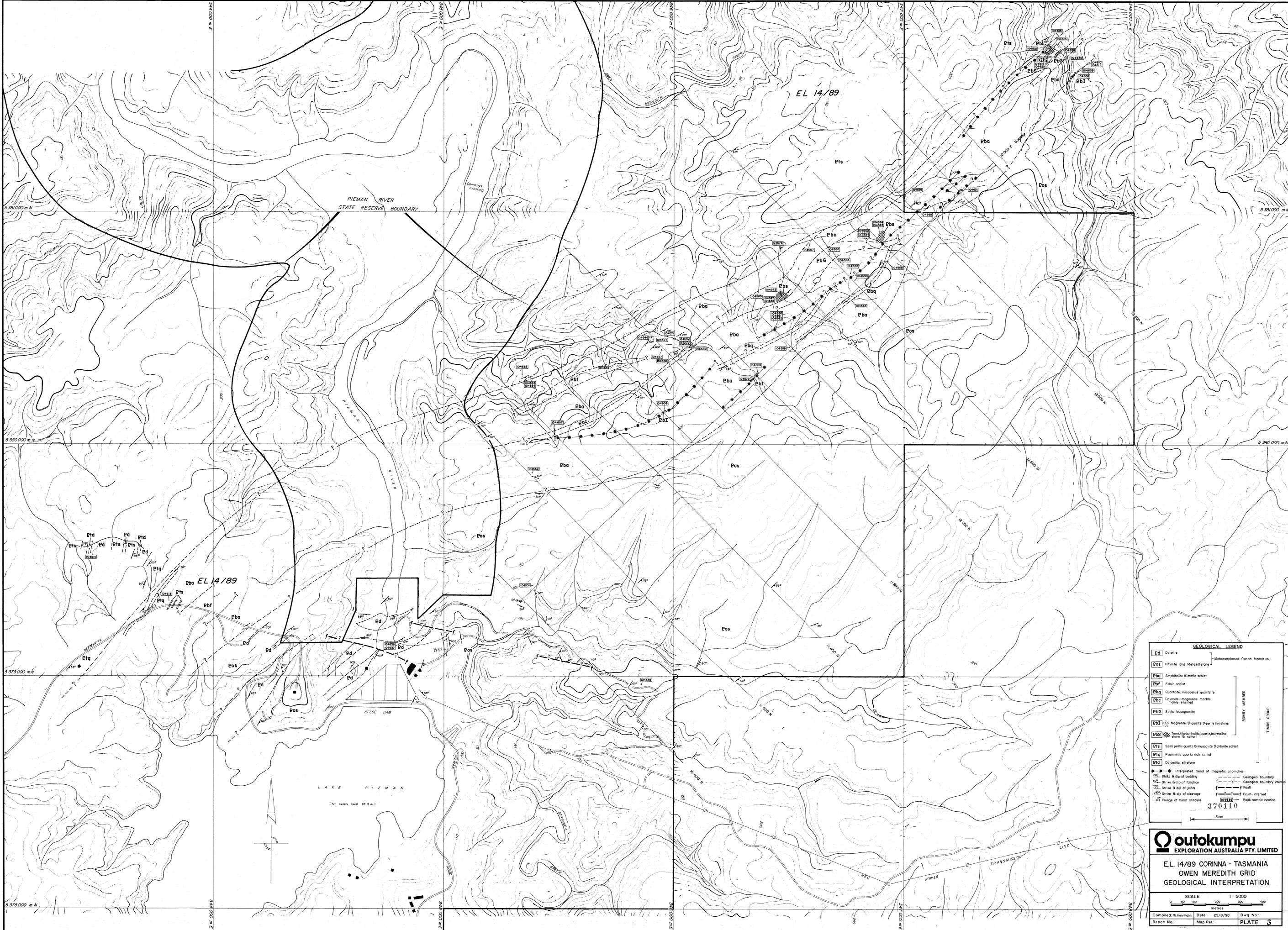
999.66.08.07177 03/07/90 20230 17 OF 17

TUBE No	SAMPLE No	Cu	Pb	Zn	Au	AuCHK			
1	A105651	5	<5	<5	<0.008	--			
2	A105652	5	<5	<5	0.015	--			
3	A105653	5	<5	<5	<0.008	--			
4	A105654	5	<5	<5	<0.008	<0.008			
5	A105655	5	<5	<5	<0.008	--			
6	A105656	5	<5	5	<0.008	--			
7	A105657	<5	5	5	<0.008	--			
8	A105658	5	<5	<5	<0.008	--			
9	A105659	50	30	10	<0.008	<0.008			
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23	DETECTION	5	5	5	0.008	0.008			
24	UNITS	ppm	ppm	ppm	ppm	ppm			
25	METHOD	101	101	101	302	302			

Results in ppm unless otherwise specified
 T = element present, but concentration too low to measure
 X = element concentration is below detection limit
 -- = element not determined

AUTHORISED OFFICER

ferkins



GEOLOGICAL LEGEND

Pd	Diorite		
Pbs	Phyllite and Metasiltstone		Metamorphosed Devonian formation
Pba	Amphibolite & mafic schist		
Pbf	Felsic schist		
Pbq	Quartzite, micaceous quartzite		
Pbc	Dolomite, magnesite marble minutely bedded		
Pbd	Sodic leucopropite		
Pbt	Magnetite V-quartz V-pyrite ironstone		
Pbs	Plunging fault/lineaments, quartz, tourmaline skarn & schist		
Pts	Semi pelitic quartz & muscovite V-schist/schist		
Ptq	Psammitic quartz rich schist		
Ptd	Dolomitic siltstone		
	Interpreted trend of magnetic anomalies		
	Strike & dip of bedding		Geological boundary
	Strike & dip of foliation		Geological boundary-inferred
	Strike & dip of joints		Fault
	Strike & dip of cleavage		Fault - inferred
	Plunge of minor anticline		Rick sample location

370110

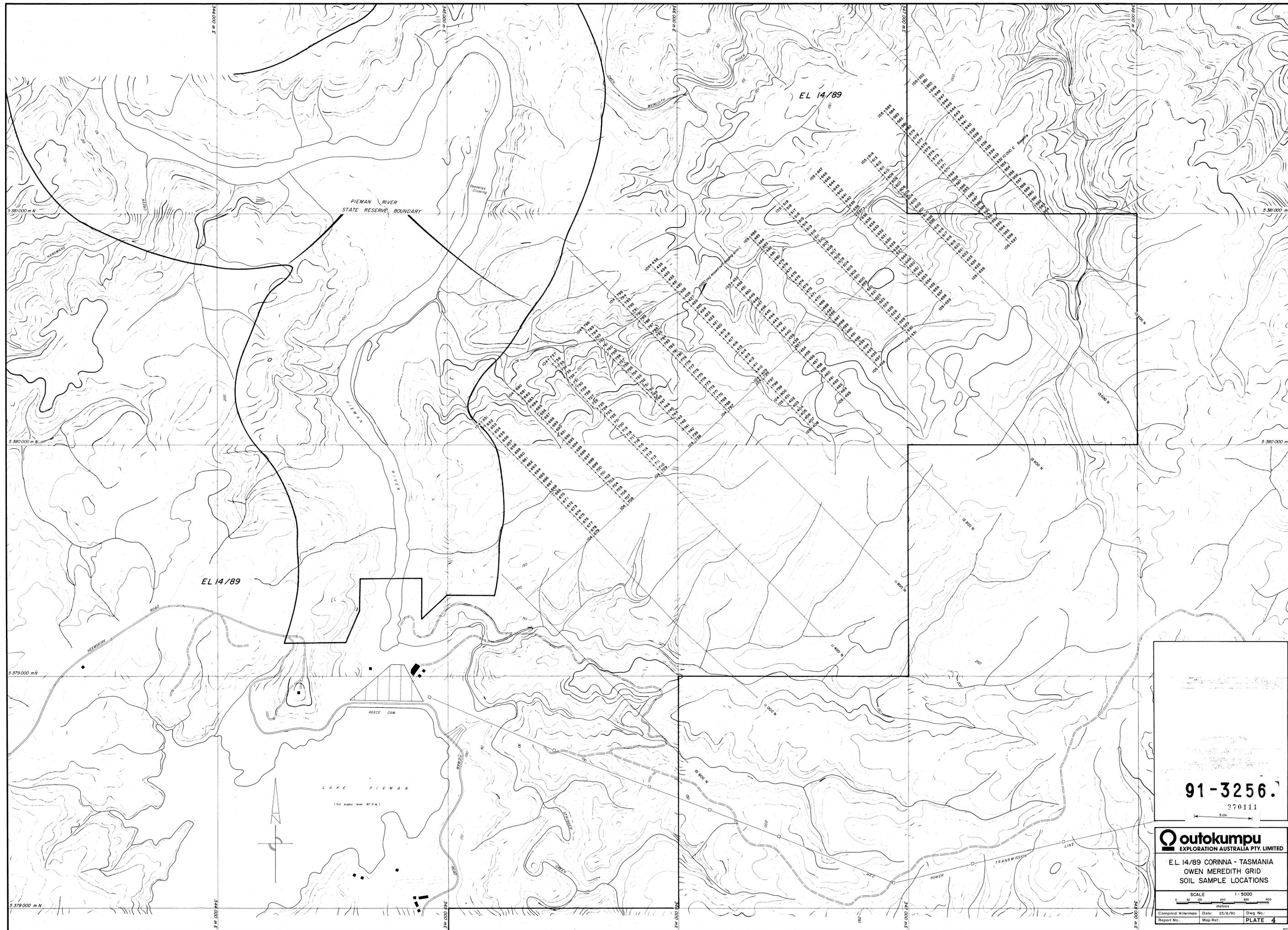
5 cm

Outokumpu
EXPLORATION AUSTRALIA PTY. LIMITED

EL 14/89 CORINNA - TASMANIA
OWEN MEREDITH GRID
GEOLOGICAL INTERPRETATION

SCALE 1:5000
0 50 100 200 300 400
metres

Compiled: N.Hermans Date: 25/8/90 Dwg No:
Report No.: Map Ref.: **PLATE 3**



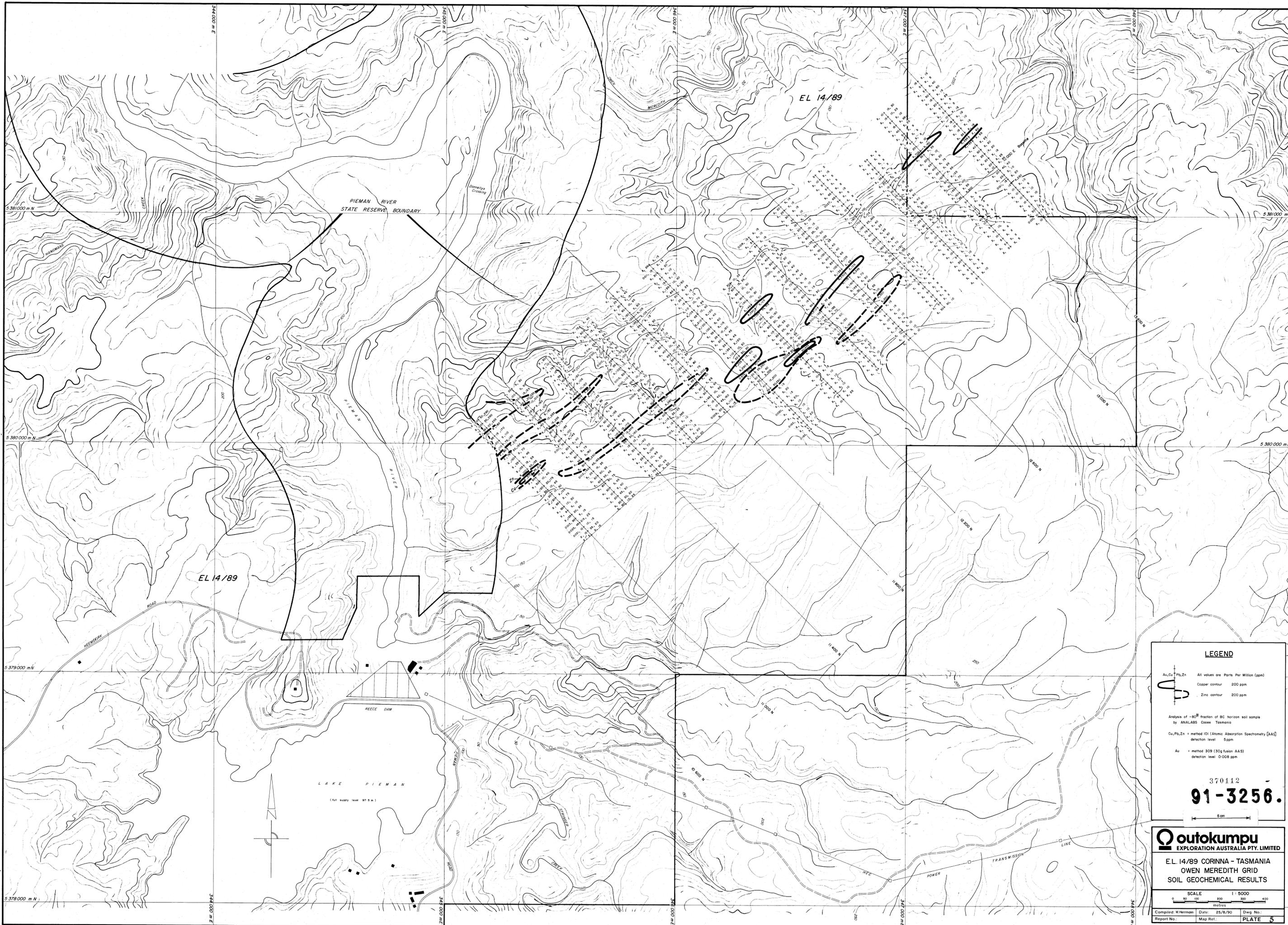
91-3256.
270111
5 cm

Outokumpu
EXPLORATION AUSTRALIA PTY. LIMITED

E.L. 14/89 CORINNA - TASMANIA
OWEN MEREDITH GRID
SOIL SAMPLE LOCATIONS

SCALE 1 : 5000
0 100 200 300 400 metres

Compiled: Wierman Date: 25/8/90 Dwg No.:
Report No.: Map Ref.: **PLATE 4**



LEGEND

Au, Cu, Pb, Zn All values are Parts Per Million (ppm)
 Copper contour 200 ppm
 Zinc contour 200 ppm

Analysis of $\frac{1}{2}$ fraction of BC horizon soil sample by ANALABS Geose Tasmania

Cu, Pb, Zn = method 101 (Atomic Absorption Spectrometry [AAS])
 detection level 5ppm

Au = method 309 (30g fusion AAS)
 detection level 0.008 ppm

370112
91-3256.

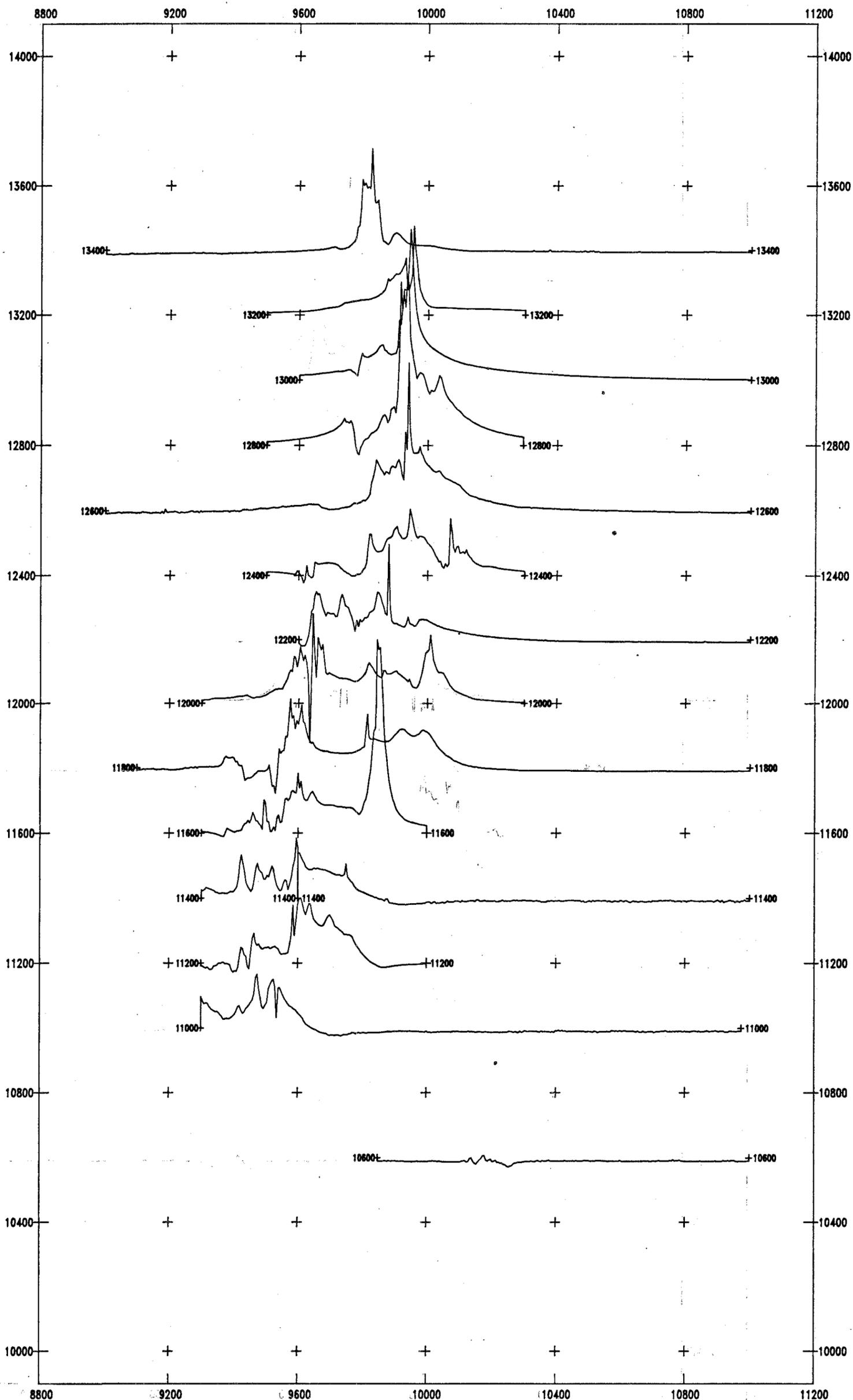
5 cm

Outokumpu
 EXPLORATION AUSTRALIA PTY. LIMITED

EL. 14/89 CORINNA - TASMANIA
 OWEN MEREDITH GRID
 SOIL GEOCHEMICAL RESULTS

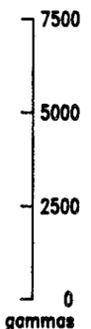
SCALE 1 : 5000
 0 50 100 200 300 400 metres

Compiled: W.Herman Date: 25/8/90 Dwg No.:
 Report No.: Map Ref: **PLATE 5**



5 cm

Z SCALE 1:1500



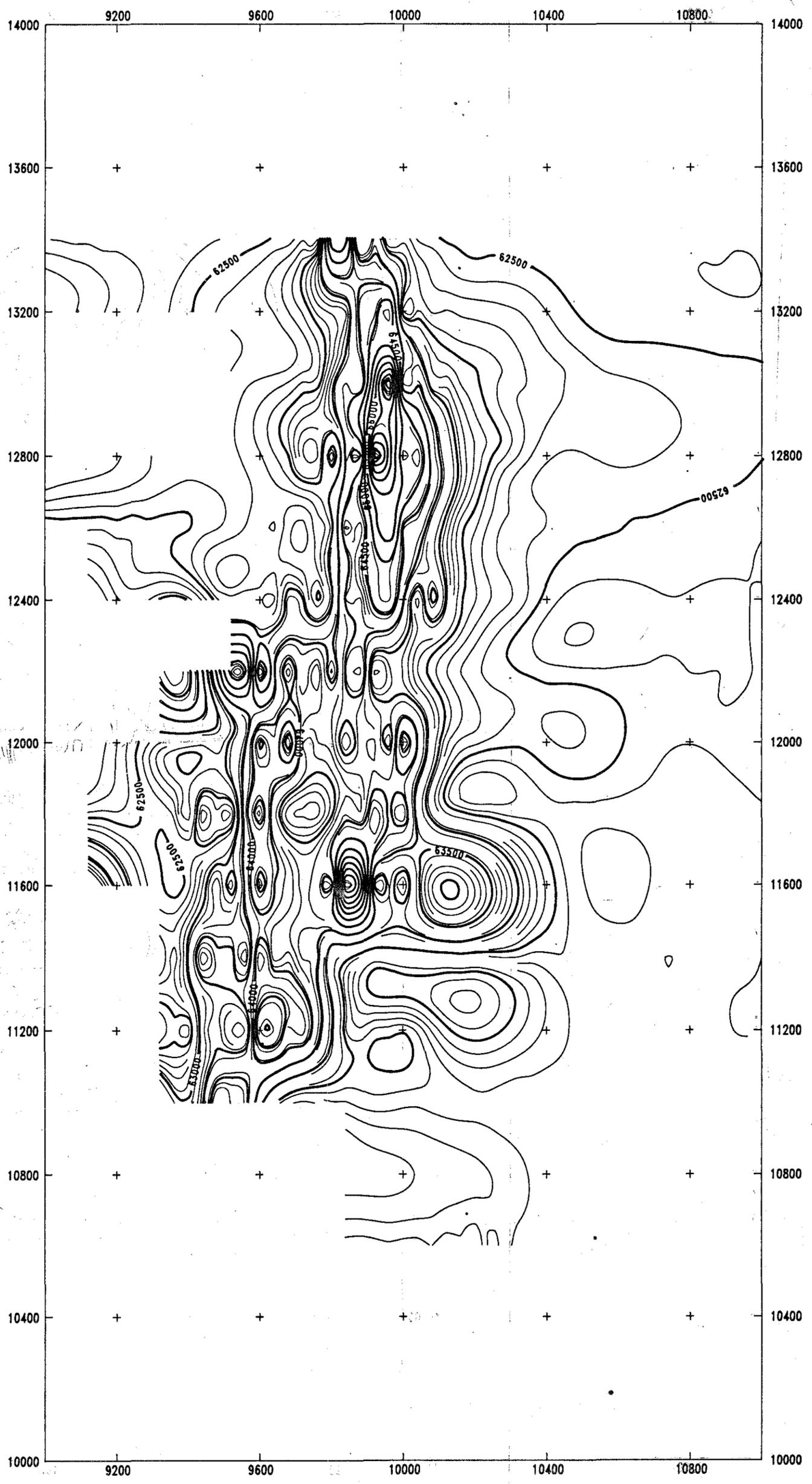
gammas

SCALE 1:10000



370113

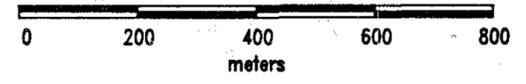
OUTOKUMPU EXPLORATION AUST. LTD.	
CORRINA PROSPECT, TASMANIA	
GROUND MAGNETIC SURVEYS	
PROFILES OF TOTAL MAGNETIC INTENSITY	
91-3256	
SCALE 1:10000	Figure 6
Z SCALE 1:1500	Z BASE LEVEL : 62500
DRAWN BY : C.G.A	DATE : 14/ 5/1990



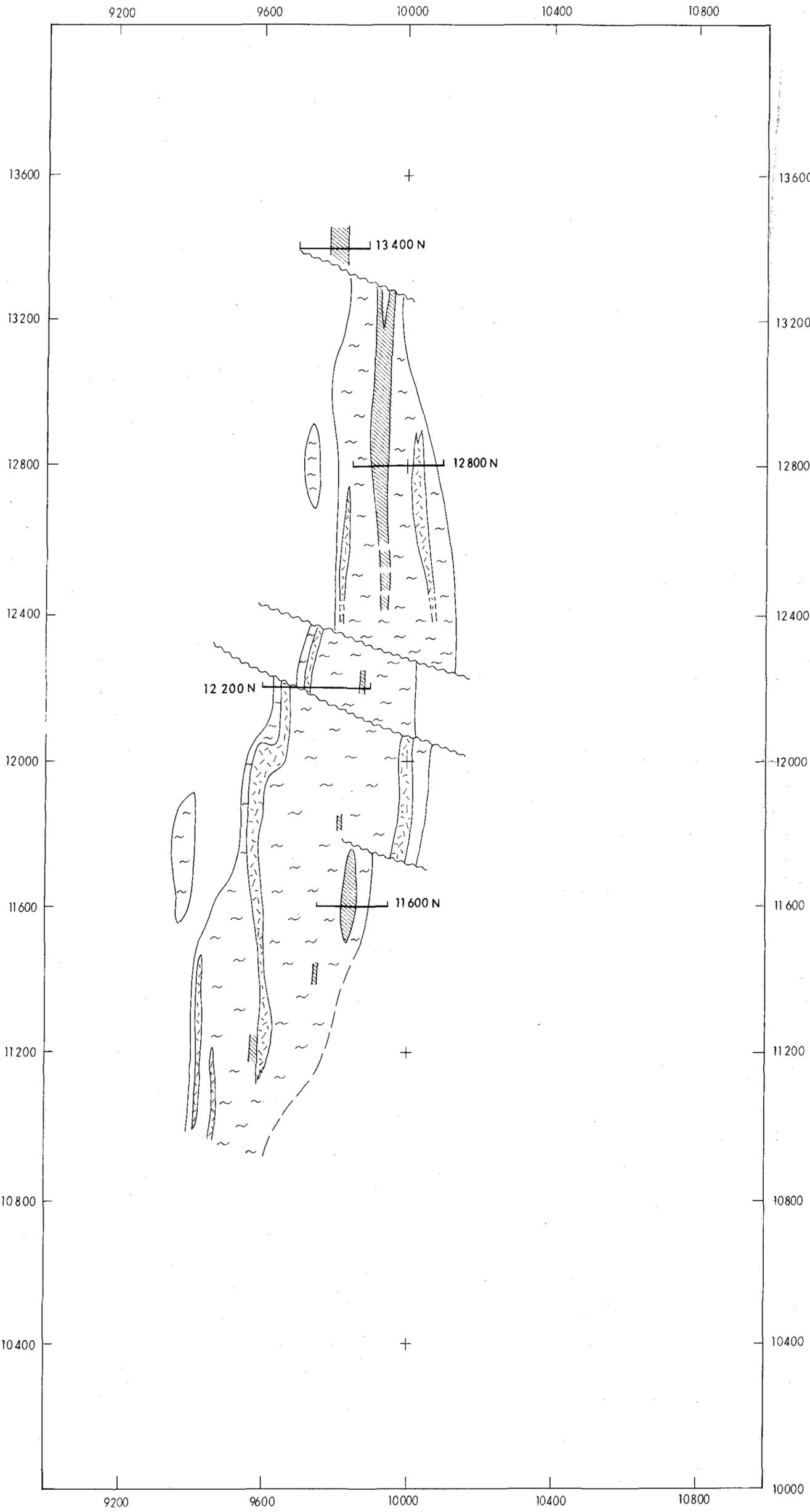
370114

5 cm

SCALE 1:10000



OUTOKUMPU EXPLORATION AUST.LTD.	
CORRINA PROSPECT, TAS.	
GROUND MAGNETIC SURVEYS	
CONTOURS OF TOTAL MAGNETIC INTENSITY	
91-3256.	
SCALE 1:10000	Figure 7
DRAWN BY : C.G.A.	DATE : 14/ 5/1990



LEGEND

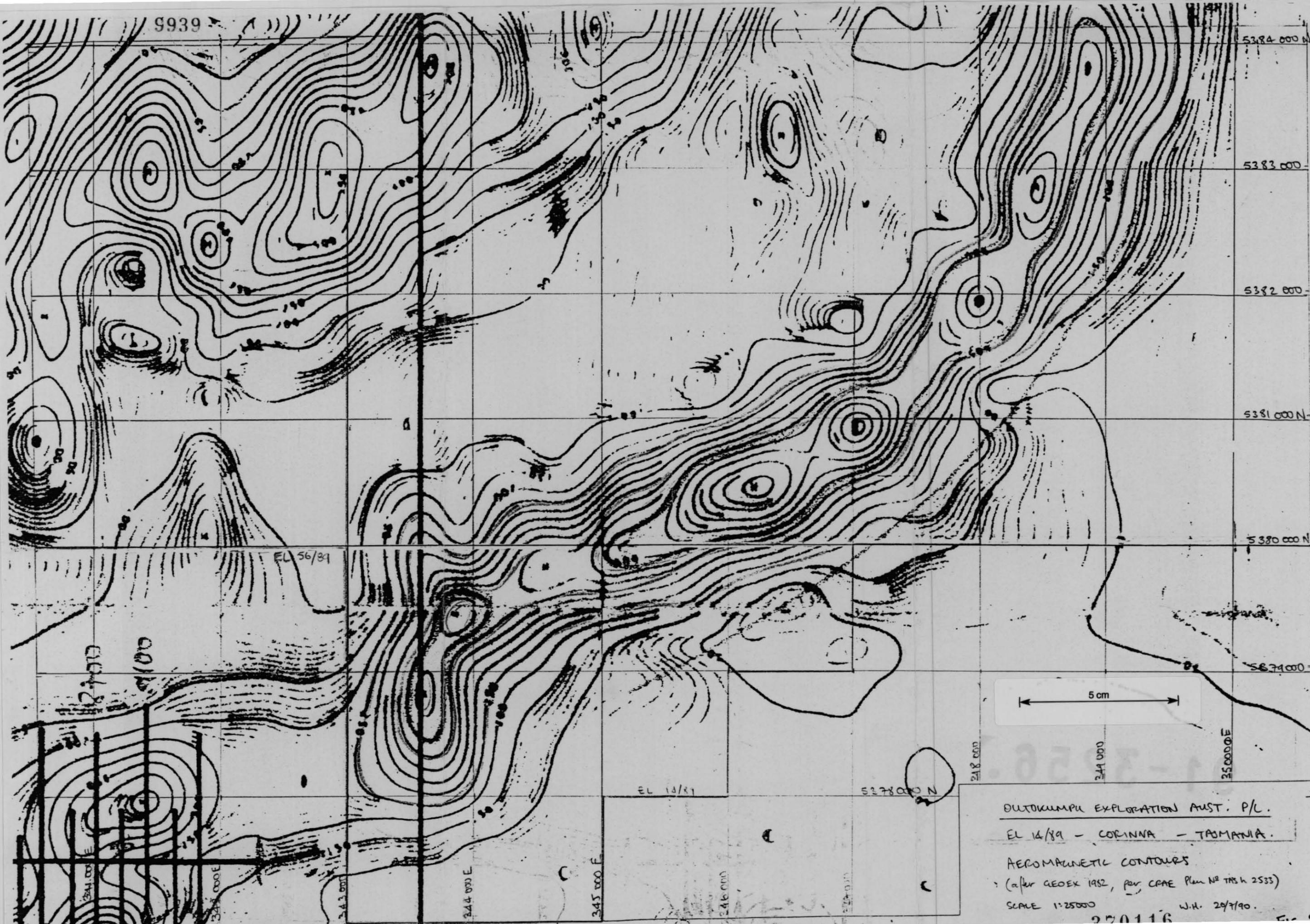
-  Major magnetic source -
qtz/mg. ironstone ?
-  Secondary magnetic source -
mafic volcanic or mg.
bearing sediment ?
-  Weakly magnetic host sequence
-  Fault (interpreted)
-  12 200 N Recommended 'C' Horizon
soil traverse

370115

5 cm

91-3256.

Outokumpu EXPLORATION AUSTRALIA PTY. LIMITED		
CORRINA PROSPECT, TAS. GROUND MAGNETIC SURVEYS		
PRELIMINARY INTERPRETATION		
Scale 1: 10,000 0 100 200 300 400 500 metres		
Compiled: G.M.	Date: Sept. 1990	Dwg No.:
Report No.:	Map Ref.:	FIGURE 8



OUTOKUMPU EXPLORATION AUSTRALIA PTY LIMITED

0109

Report No: R72.9
File No: 2.72.9
Filename: 272GM104.RT1

OPEN FILE

ANNUAL REPORT TO 26 MAY, 1991
EL 14/89 - CORINNA, TASMANIA
Volume 2 of 2

91-3256

MINES	
File	EL 14/89
29 APR 1991	
Doc. No.	
Action Officer	Initials
Refer to	
Corres dated	
22.4.91	

For: Outokumpu Exploration Australia Pty Limited
77 Pacific Highway, NORTH SYDNEY NSW 2060
By: W. Herrmann, RSD 1066, DEVONPORT TAS 7310
Date: April 1991

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(W.Herrmann 25 July 1990; 25pages, 4 appendices, 9 figures).

VOLUME 2

2. Progress Report on Exploration of the Owen Meredith Grid Extensions, EL 14/89 - Corinna.
(W. Herrmann 22 March 1991; 25 pages, 3 appendices, 7 figures).
3. Report on the petrographic examination of ironstones and associated metamorphic rocks from the Arthur Metamorphic Complex, NW Tasmania.
(J. Stoltz, 26 November 1990; 66 pages).

APPENDIX 2

Progress Report on Exploration of the
Owen Meredith Grid Extensions, EL 14/89 - Corinna.

OUTOKUMPU EXPLORATION AUSTRALIA PTY LIMITED

Report No: R72.8
File No: 2.72.9
Filename: 272WH103.RT1

PROGRESS REPORT ON EXPLORATION
OF THE OWEN MEREDITH GRID EXTENSIONS

EL 14/89 - CORINNA

For: Outokumpu Exploration Australia Pty Limited
77 Pacific Highway, NORTH SYDNEY NSW 2060

By: W. Herrmann, RSD 1066, DEVONPORT TAS 7310

Date: 22 March, 1991

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	Appendix II	Rock Chip Geochemistry
	-a	Descriptive Data
	-b	Analytical Report 111060.60.07808
	-c	Ironstone Geochemistry
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1. SUMMARY

Ground magnetic and geological mapping surveys have been carried out over the north eastern extension to the Owen Meredith Grid.

Two types of magnetic ironstones occur within the Bowry Member here and are fairly well exposed in Doctor's Creek and Owen Meredith River.

Close to the western boundary of the Bowry Member there are very large, semi-continuous stratiform lenses of massive ironstone composed essentially of compact magnetite and a little pyrite with typical grades around 70% iron but insignificant copper and gold. They occur in close spatial association with sodic leucogranite and magnesian silicate and tourmaline bearing rocks of presumably metasomatic origin.

Thin banded siliceous ironstone units of possibly sedimentary origin occur within a 15-35m wide zone of magnetite/pyrite enriched mafic to semi-felsic albite + chlorite + quartz shists at the eastern contact of the Bowry Member. These rocks contain weak copper and gold mineralisation. Selective samples of the thin (<30cm) banded ironstone layers indicate metal contents upto 0.5% Cu and 0.29g/t Au. Chip samples representative of the mineralised zone indicate lower bulk grades, eg: in Doctor's Creek 10m @ 0.12% Cu and 0.045g/t Au.

Assessment of the genetic type and economic significance of this mineralisation is hampered by the strong regional deformation and relative paucity of previous mineral exploration and geological studies. There appears to be potential for considerable strike extent but further exploration of this will be difficult due to poor access, poor exposure and sampling problems. A programme based on a combination of rock chip sampling, magnetic and IP surveys followed up by close spaced C-horizon soil/bedrock geochemistry augmented, if necessary, by shallow drilling may be worth a trial.

2. INTRODUCTION

The first phase of Outokumpu's exploration programme for EL 14/89 - Corinna involved establishment of a grid covering 2.8km of strike length of the Bowry Member of the Arthur Metamorphic Complex to the northeast of Reece Dam. Surveys carried out on the grid included geological mapping, rock chip sampling for geochemical and petrographic analysis, B-horizon soil geochemical sampling and ground magnetics.

This work, (reported by Herrmann, 1990) indicated the presence of a number of narrow, apparently stratiform bodies of magnetite ironstones within the Bowry Member. The ironstones were of two principal types:

- * Massive ironstones composed essentially of compact magnetite with a little pyrite and or quartz, with iron contents in the range 60-75% but without significant copper or gold.
- * Banded ironstones which are commonly fairly siliceous and consist of thin alternating bands of quartz, magnetite and pyrite. Some ironstones of this type, most notably occurring in Doctor's Creek off the end of the grid, were found to be anomalous in copper and gold (maxima 0.5% and 0.3g/t respectively).

The results of rock and soil geochemical sampling on the (1990) grid were not particularly encouraging and so a decision was taken to extend the grid 1.4km to the northeast to provide access for mapping, sampling and magnetic survey of the ironstones at Doctor's Creek and the reported large body at Owen Meredith River.

The grid extensions (Figure 1) were cut during January/February, and mapping, rock chip sampling and magnetic survey was carried out during late February, 1991.

This report presents the results and a preliminary discussion of the investigations carried out on the grid extensions.

3. MAGNETICS

The magnetic survey was carried out by B. Stedman on 21/2/91 and his results are included here, in profile and stacked profile form of unfortunately variable vertical scales, as Appendix I.

The profiles indicate strong magnetic anomalies on lines 13600N, 14000N, 14200N, and 14400N (the latter is actually at 14425N) which seem to be attributable to the massive magnetite lense or lenses lying near the western margin of the Bowry Member here, and observable in outcrop on 14000N and in Owen Meredith River. There is a relatively weak, twin peaked response at the corresponding position on 14600N but none on 14800N which suggests that the massive ironstone pinches out northwards. Likewise on 13800N there is no major response near the western margin of the Bowry Member. There is however, an unusually distinct anomaly associated with the Bowry eastern contact on this line which is adjacent to the zone of dismembered thin banded ironstones and disseminated magnetite/pyrite in Doctor's Creek.

Although the known exposures of the western, massive, magnetite body are restricted to some probably ex situ boulders in Doctor's Creek, line 14000N and Owen Meredith River, I have inferred from the magnetic information that the lense is probably continuous between the two streams, as shown in Fig: 2.

0116

4. GEOLOGY and ROCK CHIP GEOCHEMISTRY

The geology of the grid extension area is essentially continuous with that described for the main part of the grid (Herrmann, 1990) in that there is a narrow, 150 to 200m wide, northeast to north trending zone characterised by mafic schists, amphibolites, sodic leucogranite and ironstones (known as the Bowry Member) which is flanked to the northwest by quartz± muscovite +/- chlorite metasedimentary schists and to the southeast by psammo-pelitic metasilstones and phyllites.

Contact Relationships: The northwestern contact of the Bowry Member has not been observed to outcrop but appears to be conformable to the trend of gross lithological layering and the principal schistosity.

The southeastern Bowry contact is fairly well exposed in Doctor's Creek and Owen Meredith River and in both cases seems to be more or less conformable to the principal schistosity.



Photo 1: View northeast along schistosity parallel but fault disrupted eastern contact of Bowry Member mafic schists; Owen Meredith River about 60m upstream from baseline crossing.

Photo 1 depicts this (downstream) contact in Owen Meredith River; the contact below the hammer is aligned with the shaft of the hammer, strikes/dips at 040/76 SE only slightly oblique to the schistosity in the adjacent mafic schists (LHS) and is

marked by a 3cm thick vein of grey milky quartz incorporating schist fragments and flanked by narrow selvages of iron stained puggy clay. This is clearly a fault contact but on the footwall side adjacent to the hammer is a wedge of grey pelitic schist in which schistosity is perfectly conformable to that in the mafic schist and is truncated by the fault. On the hanging wall side the pelitic schist is rather intensely contorted and sheared with flattish shear planes aligned with the marking pen. A similar zone of contortions, about 10m wide, occurs on the hanging wall side of the same contact where it is again exposed about 150m upstream.

At Doctor's Creek the contact between mafic and pelitic schists is again concordant with the principal foliation in both and faithfully follows the open fold undulations in schistosity; the pelitic schists seem to be somewhat crushed and contorted immediately adjacent to the contact.

It seems, therefrom, that this eastern contact of the Bowry mafic schists is generally concordant with schistosity but locally disrupted by minor faults. This does not, however, prove depositional conformity or continuity; the local evidence of small scale transposition of compositional layering within the Bowry Member suggests that the gross lithological boundaries may also be substantially tectonic.

Lithotypes of the Bowry Member:

Within the Bowry Member essentially similar "sequences" of lithotypes occur in both Owen Meredith River and Doctor's Creek although the exposure is less complete in the latter stream. At this latitude the entire member is only of the order 150-200m in thickness.

The mafic schists adjacent to the eastern contact, in both streams are essentially albite + quartz + chlorite schists with subordinate epidote and minor disseminated magnetite and/or pyrite; the albite tends to be finely porphyroblastic and the chlorite typically defines a prominent foliation. In Owen Meredith River beyond about 40m from the eastern contact the mafic schists are interlayered with less schistose, fine grained amphibole bearing amphibolites and it is interpreted that the alb + Qtz + chl schists may be largely derived from the metavolcanic amphibolites by retrogression accompanying high cataclastic strain.

Downstream of the Owen Meredith River baseline crossing interlayered mafic schists and amphibolites are followed by interlayered mafic and semi felsic schists some of which are less chloritic variants of the alb + Qtz + chl schist but others closely resemble the sodic leucogranite downstream. Compositional layering is present on a 5 to 50cm scale, parallel to the principal foliation and with the layers tending to be discontinuous or lensoidal.

The proportion of felsic layers, particularly of the pinkish grey albite + quartz rich rocks resembling strained leucogranite, appears to increase downstream and in the 40m before the appearance of "massive" leucogranite there are numerous discontinuous bands and boudin like pods of deformed leucogranite?, as depicted in Photos 3 and 4.

Although the contacts, now, appear to be mainly tectonic, the prominence of mafic/felsic layering suggests that the precursors here were not massive basaltic units but more likely to have been a layered sequence of mafic to intermediate volcanics and, probably, volcanoclastics. The bands and pods resembling leucogranite may have been narrow dykes or perhaps represent tectonic slices from the main body downstream.



Photo 2: Isoclinally folded, partly transposed quartz + albite? rich layers (pale) and boudinaged pods of vein quartz (white, lumpy) in mafic schist; 1m (on footwall side) from contact with pelitic schist/phyllite, Doctor's Creek, 50m below baseline crossing. The upper edge of frame is eastwards. The isoclinal folds are coplanar with the principal foliation.



Photo 3: Folded band of albite + quartz + (chlorite) schist ex sodic leucogranite? within mafic schist; Owen Meredith River, about 60m downstream of the baseline crossing. The band of felsic rock is about 0.5m thick, increased to about 1m in the hinge area. The dashed black lines mark out the trace of foliation; the folds appear to plunge at 70 deg. to the NE; (magnetic azimuth not determinable due to proximity of the magnetite lode.)

Downstream of this "mixed" zone more or less massive sodic leucogranite outcrops in the river over a width of about 15m. It is mesoscopically similar to the granitoid in Doctor's Creek and likewise contains veins of tourmaline and has suffered some deformation. The bulk of the leucogranite shows indications of relatively minor strain with coherent tourmaline veins oblique to, and with only slight "feathering" of the vein margins along, the weakly defined foliation, (Photo 5). Close to the margins of the leucogranite it assumes a distinctly gneissic fabric with trains of tourmaline, presumably representing transposed veins, lying parallel to the foliation, (Photo 6).

The presence of this foliation and the folded bands and boudins immediately upstream strongly supports the petrographic interpretation (Stolz, 1990) that the sodic granitoids were emplaced prior to the latest phase of cataclastic deformation/metamorphism and perhaps prior to peak metamorphism which produced amphibolite grade assemblages.



Photo 4: Large pod or boudin of sodic leucogranite within mafic to semi felsic albite + quartz + chlorite schists; Owen Meredith River about 70m downstream of the baseline crossing. Note the foliation parallel mafic to semi felsic compositional banding in schists on left hand side of frame.

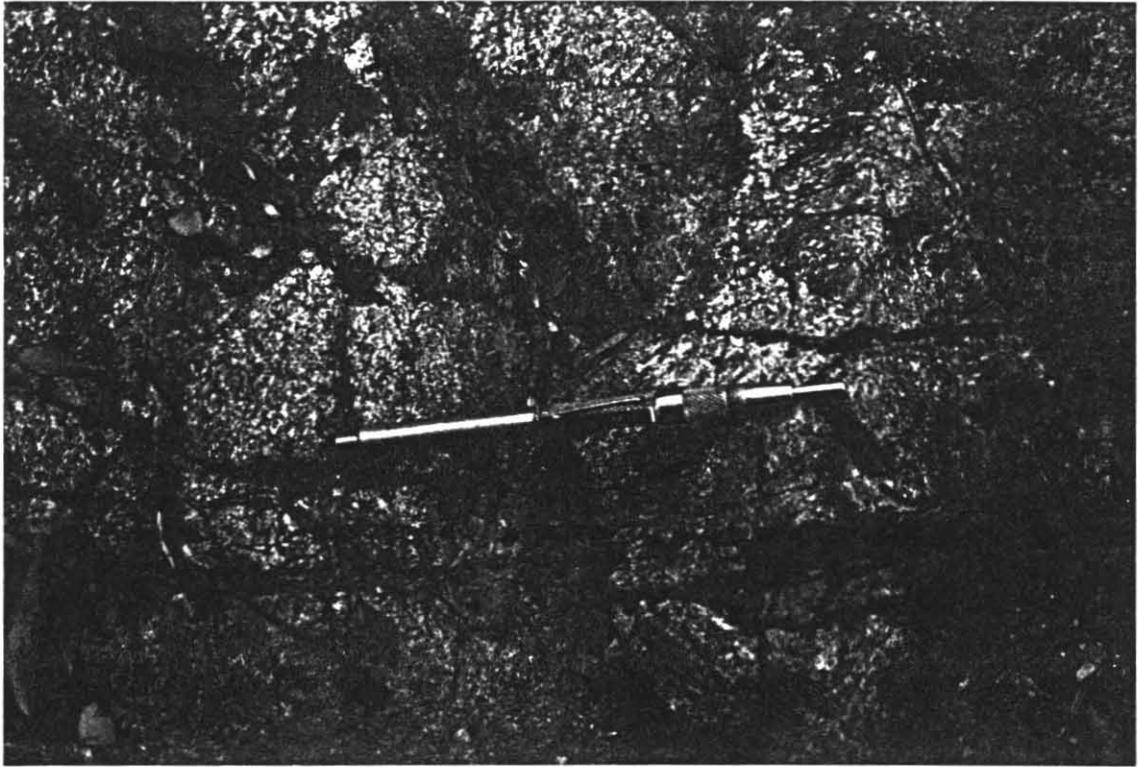
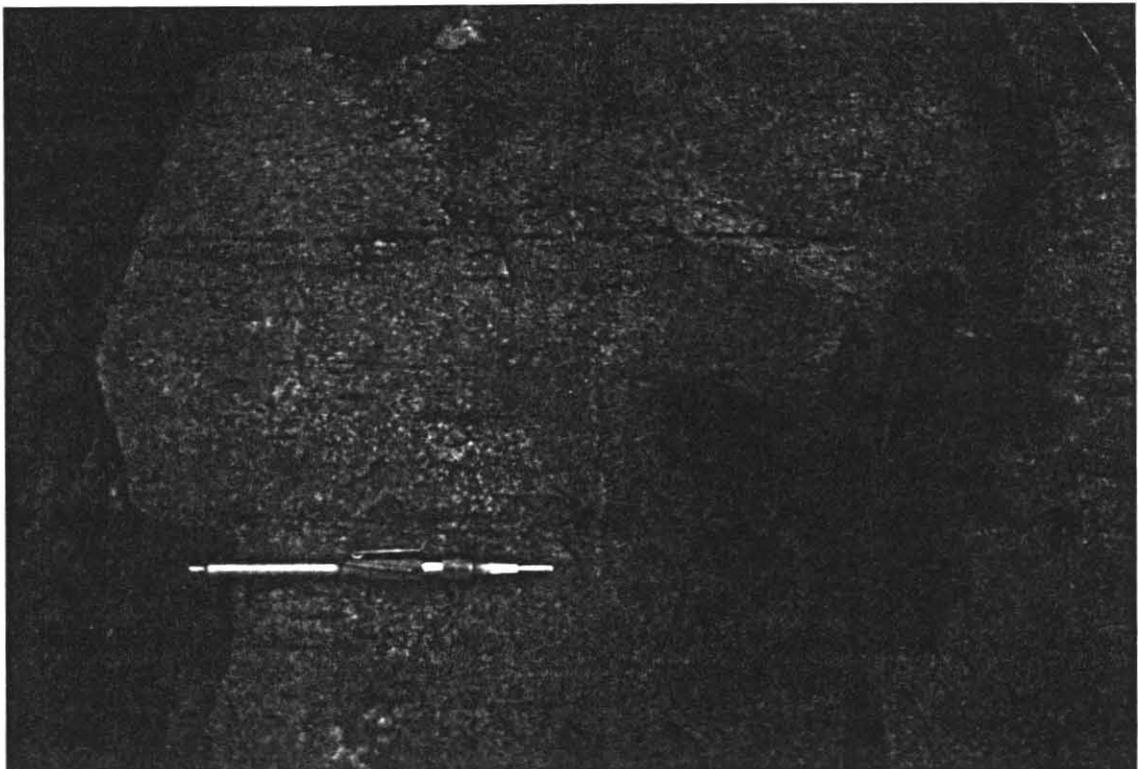


Photo 5: Relatively weakly strained sodic leucogranite with veins of dark tourmaline; Owen Meredith River, about 120m downstream of baseline crossing.

Photo 6: Deformed sodic leucogranite with dark tourmaline veins transposed parallel to gneissic foliation, at downstream margin of the granitoid in Owen Meredith River; about 2m northwest of rock depicted in Photo 5.



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Immediately downstream of the sodic granitoid is a 3 to 5m wide zone of compact amphibolite with patches of tourmaline schorl and sheared ? zones of tremolite-actinolite and talc schists which collectively appear to be characteristic of the immediate wall rocks to massive magnetite.

The precursor rock seems to be metabasaltic amphibolite which has undergone variable alteration to actinolite/tremolite + tourmaline assemblages. The tourmaline occurs in irregular veins, of which some appear to be deformed, disseminated randomly oriented acicular prisms and rosettes and as irregular massive clumps; examples of the former and latter are depicted in Photo 7. Similar tourmaline-tremolite rich rocks occur in the immediate footwall (western side) of the magnetite lode on the spur just west of the Duffer Creek confluence and in Doctor's Creek and at both of these localities the lack of preferred orientation suggests formation by contact metamorphism/ metasomatism.



Photo 7: Irregular veins and massive clumps of dark tourmaline in altered amphibolite; Owen Meredith River, immediately adjacent to the eastern contact of the massive magnetite lode. The pencil magnet is oriented parallel to principal foliation and some of the smaller veins appear to be deformed or partly controlled by the foliation; the larger masses of tourmaline seem to be relatively undeformed. The pinkish white crosscutting veinlets appear to be of feldspar?

On the north bank of the river adjacent to the magnetite lode there are zones of tremolite + talc? schist which appear to be related to small shear zones and often enclose lenses of less deformed tremolite + tourmaline +/- quartz schist and/or massive magnetite + pyrite. These talcose? schists are generally strongly foliated and contain substantial (upto 20%) disseminated, often euhedral, pyrite as well as some rather finer and apparently comminuted magnetite; they appear to represent metamorphic retrogression related to local intense shearing around the margins of the magnetite lense/s.

In places, (eg: in the river 110m downstream from Duffer Creek confluence, at 14200N/9775E and in Doctor's Creek) there are strongly foliated, rather siliceous, tremolite + quartz (+Py, Mt) schists which also seem to belong to this category and have a close spatial association with the massive magnetite lode.

In Figure 2 these variable tremolite, tourmaline and talc? bearing rocks have all been grouped together as "magnesian silicate schists and hornfelses" as they appear to be closely related and the outcrop is insufficient to differentiate them. Some samples of these rocks are weakly anomalous in copper (max: 0.1%) and they contain upto about 10% iron but are not significantly anomalous in gold.

As discussed by Stolz (1990) they are interpreted to represent metasomatically altered carbonate rich assemblages but very limited geochemical data (A104574, Tl/Zr ratio) suggests a basaltic precursor. The parent rocks may therefore have been basaltic volcanics which had undergone strong carbonate alteration prior to metasomatism and metamorphism.

Stolz, (op cit) considered that the tourmaline occurring in the tremolite hornfelses and the sodic leucogranite was formed subsequent to regional metamorphism by metasomatism from a common granitic source, probably the (Late Devonian) Meredith Granite. However, the tourmaline appears to have predated the phase of cataclastic deformation which was accompanied by significant, localised, retrograde metamorphism and hence a correlation with Devonian plutonism, which was essentially post tectonic, seems unlikely. Given the close spatial relationship between sodic leucogranite, magnesian silicate rocks and massive ironstones, a metasomatic link with the former is reasonably inferred. Furthermore, the sodic leucogranite in places contains minor prograde amphibole which implies that it and the possibly related metasomatic rocks predate regional metamorphism. The low pressure contact metamorphic/metasomatic assemblages may have survived dynamic re-metamorphism except in local areas of high strain.

The rocks in the immediate footwall of the massive magnetite lode are nowhere (known to be) well exposed and whilst there are thin units of mafic amphibolite in this position on lines 13800N and 14425N it is apparent that the magnetite lode lies very

close to the western margin of the Bowry Member. In Doctor's Creek quartz + muscovite schists outcrop 20m downstream of the last definite outcrop of magnesian silicate schist and schorl which is the place where large boulders of magnetite first appear in the stream.

Massive Ironstones:

As inferred from magnetics and sparse outcrop the main body of ironstone on the grid extension extends from about Doctor's Creek to line 14600N but appears to pinch out to the north. The magnetic data infers the presence of a smaller lense of ironstone on line 13600N which is probably continuous with the magnetic anomaly on line 13400N of the 1990 survey.

The best exposure of ironstone is in Owen Meredith River at the confluence of Duffer Creek. It forms a 5m wide bar across the river and extends as a low cliff southwestwards along the north bank, (Photo 8).

The lode in the river bed is unoxidised and consists essentially of at least 80% compact massive magnetite with about 10% pyrite as disseminations and discontinuous streaks and bands which are parallel to the regional foliation in the wall rocks. There are occasional blebs of chalcopyrite which seem to be most prominent on joint surfaces in association with pyrite and a very subordinate gangue which appears to consist of talc or chlorite, (Photo 9). The eastern margin is marked by a 20cm wide zone of sheared straw coloured carbonate? containing about 50% pyrite and thin contorted lenses of magnetite; this material is transitional to massive magnetite and appears to represent a sheared and altered margin, (Photo 10).

The outcrops above river level are generally somewhat oxidised with magnetite partly replaced by maghemite, hematite and limonite, sometimes with a little relict pyrite but commonly slightly gossanous. The outcrops on 14000N and boulders? in Doctor's Creek are of identical constitution and the lode overall appears to be of remarkably uniform composition.

Analysed rock chip samples from these exposures have indicated that the massive ironstones contain:

Iron	: 67 to 73%
Copper	: 70 to 630ppm but most samples below 250ppm
Gold	: 0.005 to 0.020g/t with most samples 0.01g/t
Manganese	: <250ppm
Lead	: <20ppm
Zinc	: <100ppm
Silver	: <1g/t

which is consistent with the geochemical results from sampling of similar massive ironstones on the 1990 grid and a few samples from Main Creek and Rocky River.



Photo 8: View southwest down the Owen Meredith River from the confluence of Duffer Creek. Massive magnetite rich ironstone forms a dip slope cliff on the north bank for about 100m downstream; a short adit has been driven northwestward into the lode at river level, the portal is just below the tree fern at right of frame.

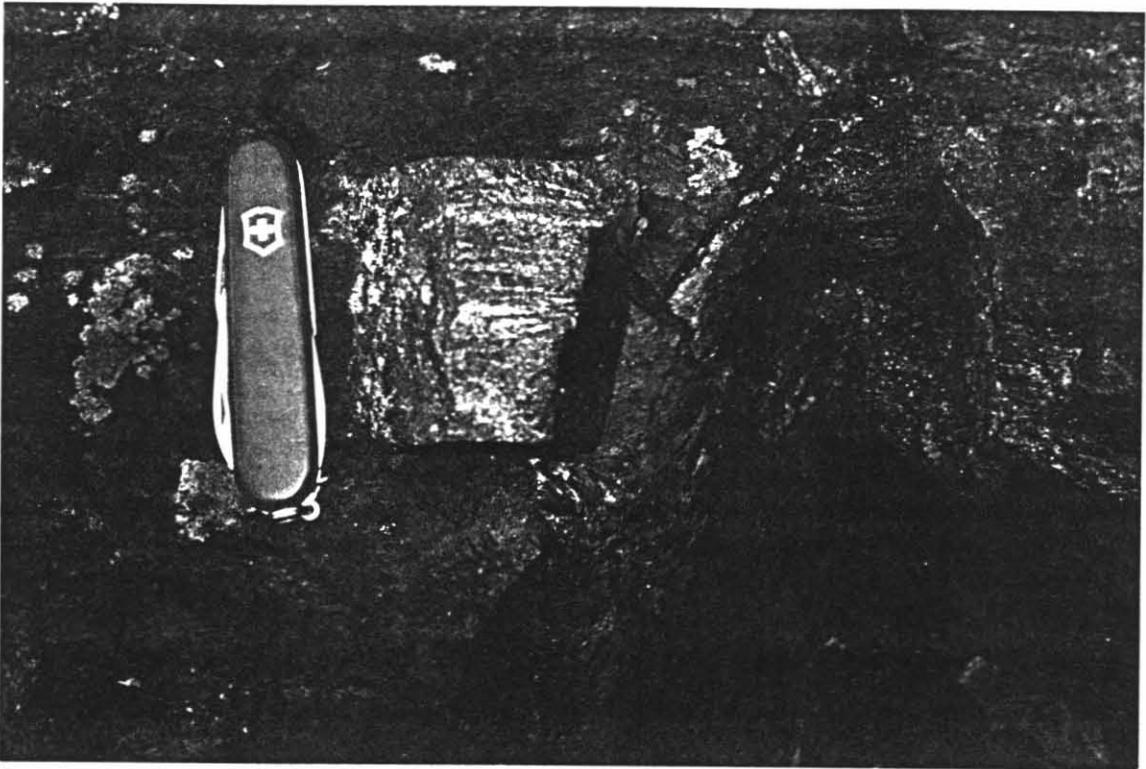


Photo 9: Close up of massive magnetite lode material outcropping in bed of Owen Meredith River; it consists dominantly of compact black magnetite with subordinate pyrite as disseminations and discontinuous streaks defining a planar fabric which parallels the regional foliation in the wall rocks.

Photo 10 Sheared eastern margin of magnetite lode in Owen Meredith River; it appears to consist of sheared carbonate with about 50% disseminated to near massive pyrite and contains thin deformed lenses of magnetite.



At Owen Meredith River the 5m wide lode in the river bed appears to be a separate lense as its extension into the northeast bank is flanked on both sides by partly sheared magnesian silicate and tourmaline bearing rocks. The main part of the lode forming the dip slope on the north bank downstream (Photo 8) appears to be about 15-20m in thickness and dips at about 75 deg. to the southeast. Magnetic compass bearings within about 50m of the lode have been found to be highly erratic so it has not been possible to measure the strike but all indications are that the lode is approximately concordant with the principal foliation and gross lithological layering.

Banded Ironstones:

Thin units of banded siliceous ironstone have been observed in Doctor's Creek and Owen Meredith River; in both localities the ironstone bands are contained within albite + chlorite + quartz schists and occur within about 10-20m structurally below the eastern contact with psammo-pelitic metasiltstone and phyllite.

In each of the three locations (Owen Meredith River crosses the contact twice) there is a single, fairly persistent, principal ironstone band of 3 to 30cm thickness and numerous thinner discontinuous lenses which appear to represent tectonically dismembered ironstone bands.

These ironstones consist essentially of quartz, magnetite, pyrite, a little chalcopryite and a trace of carbonate thinly interlayered on a submillimetric to centimetric scale. Most examples are fairly siliceous with about 60-70% quartz and magnetite dominant over pyrite in a ratio of at least two; a few contain upto about 50% Mt and 20% Py and correspondingly less quartz. Examples of the coherent banded ironstones are depicted in Photos 11 and 12; dismembered lenses of similar lithology are depicted in Photos 13 and 14.

A sample of the Doctor's Creek banded ironstone was petrographically described by J. Stolz (1990). He considered that the thicker (centimetre scale) layering could represent relict bedding whilst the thinner (<1mm) magnetite layers were probably developed by syntectonic recrystallization, that all phases had undergone dynamic metamorphism and that the rocks could have originated as sedimentary iron formations.

The schists which host these banded ironstones, in every case, contain about 10-15% magnetite and 5-10% pyrite as disseminations and foliation parallel trains and thin (<10mm) lenses. In Doctor's Creek it is evident that the less mafic schist layers are particularly enriched in pyrite with some narrow bands of near massive (~50%) pyrite; these layers also contain slightly elevated (~1%) chalcopryite. The magnetite, pyrite content and the abundance of small banded ironstone lenses diminishes rapidly down structure below the contact zone

to "normal" levels of about 3% Mt and <1% Py. The significantly "mineralised" zone adjacent to the eastern contact of the mafic schists is about 10m wide in Doctor's Creek (Fig:4), about 35m wide in the downstream exposure in Owen Meredith River and about 15m wide in the upstream river exposure (Fig:5).

A similar, partly oxidised, occurrence of magnetite/pyrite enriched mafic schist has been observed and sampled at 10000E/14630N. At 9900E/13600N there is a small outcrop of completely oxidised and leached sintery siliceous limonite stained rock (initially logged in the field as silicified carbonate?) which contains anomalous gold and copper and probably represents a weathered pyritic semi felsic/siliceous schist similar to those at the contact zone in Doctor's Creek.

It therefore seems that this zone of magnetite + pyrite enrichment, with or without coherent bands of banded ironstone, is a characteristic feature of the eastern contact of the Bowry mafic schists and may be persistent for at least one kilometre of strike length in this part of the grid.

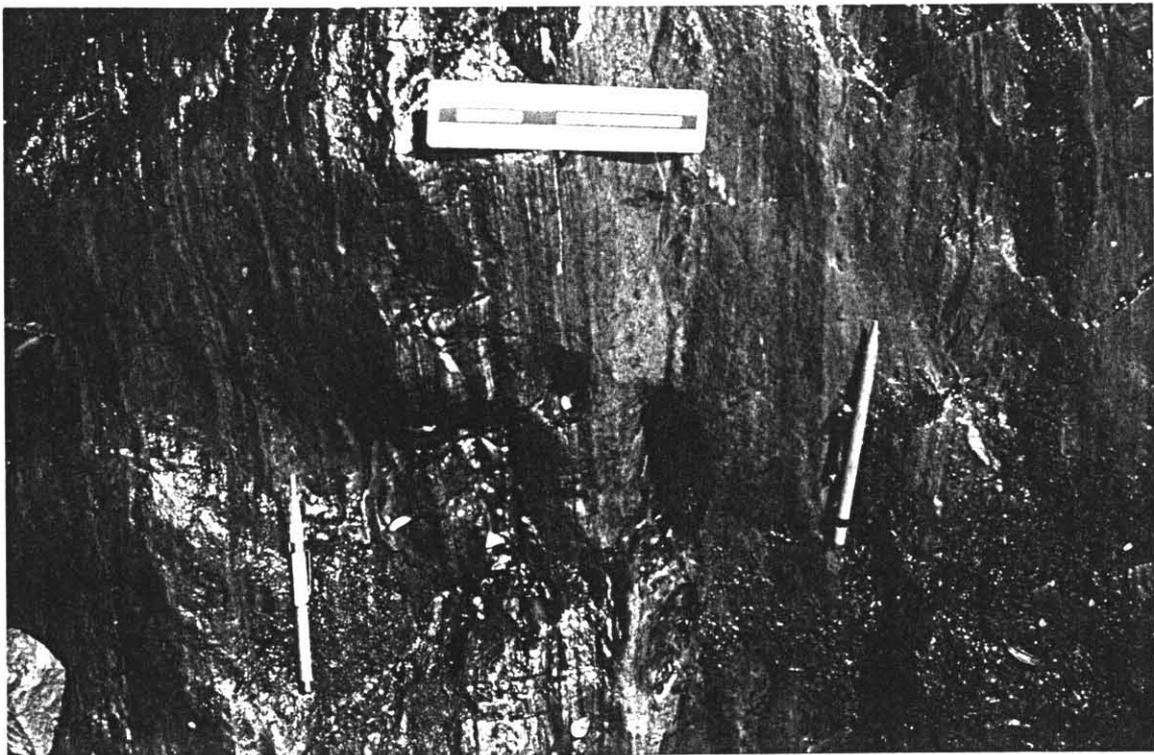


Photo 11 Banded ironstone, 15cm thick, (immediately right of magnet) within layered mafic to felsic/siliceous schists; Doctor's Creek about 50m downstream of the baseline crossing. Thin bands of near massive pyrite (pointed out by magnet and pencil) occur in the adjacent schists. This ironstone band was sampled as A104647 and is 5m to the south west along the same horizon as that sampled as A104609 in 1990. Left side of frame is to northwest (structural footwall).



Photo 12 Magnetite + pyrite rich banded ironstone, 5cm thick, in mafic schist; Owen Meredith River about 50m upstream from baseline crossing. Sampled as A114356. The lenticular fabric of the schist may represent transposed mafic/semi-felsic compositional layering. The ironstone band is persistent over the 10m of exposure in the river bed and banks, is perfectly coplanar with the foliation in the enclosing schists and faithfully follows minor undulations in the foliation. The lower edge of the frame is to the northwest (structural footwall).

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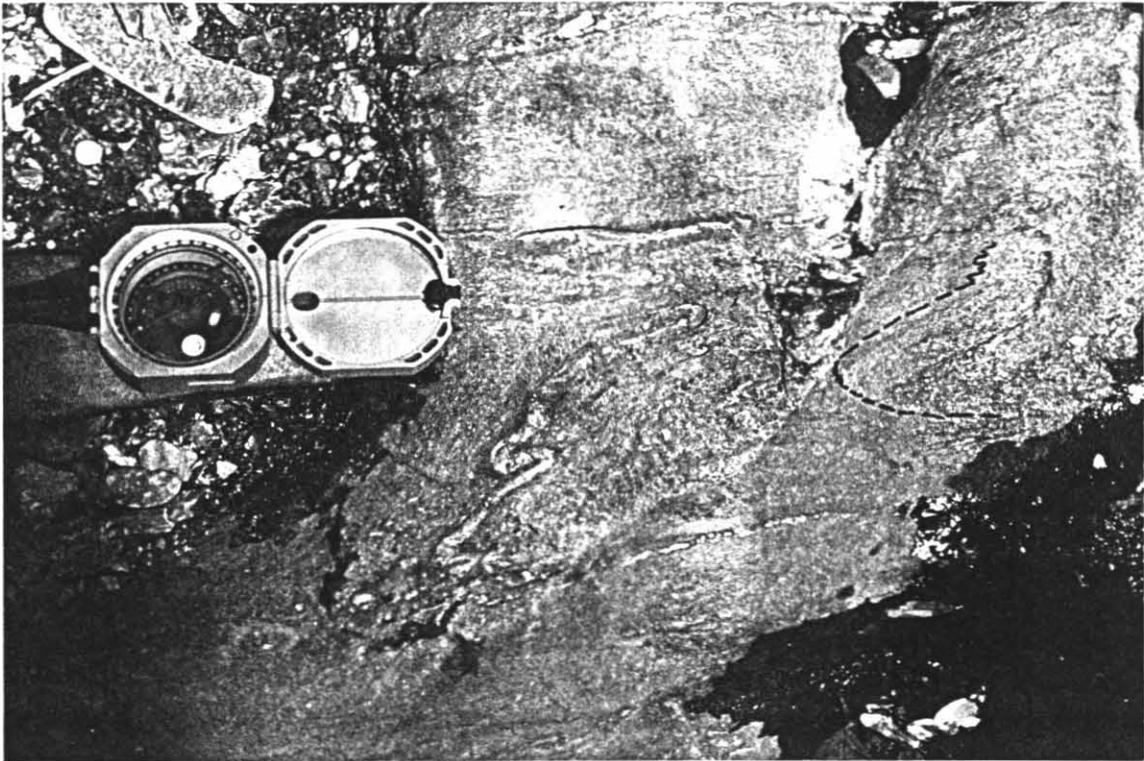


Photo 13 Folded remnant of largely transposed thin layer of banded ironstone in mafic to semi-felsic alb + chl + qtz schist; Owen Meredith River about 10m upstream of locality depicted in Photo 12. The black dashed line indicates the folded trace of faint compositional layering in the enclosing schist, the foliation is planar, not folded and appears to be axial to the folds implying that these are early structures. Right side of frame is to southwest.

Photo 14 Layered mafic/semi-felsic schists with numerous small discontinuous lenses and pods of banded ironstone (BIF), semi massive magnetite (Mt) and white ex-vein quartz (Q); Doctor's Creek 10m downstream of outcrop depicted in Photo 11. RHS of frame is to the south.



Selective rock chip samples of the banded ironstone layers and lenses at Doctor's Creek (including some from last year) and Owen Meredith indicate that these rocks are generally anomalous in copper and gold upto 0.5% and 0.29g/t respectively. The enclosing magnetite + pyrite enriched schists are also anomalous with unbiased chip samples indicating levels of upto 0.35% Cu and 0.08g/t Au. The relevant data is tabulated in Appendix II-c.

It is evident that both the selective samples of banded ironstone and the chip/channel samples of the enclosing schists from Doctor's Creek contain higher and more consistent values of copper and gold than do the corresponding samples from Owen Meredith River. The reverse situation seems to apply in respect of zinc values in the schists and, although subtle, it seems that in both sections the zinc values increase down structure away from the contact. There is a reasonably strong correlation between gold and copper and contents of both metals tend to diminish away from the contact although there appears to be a "halo" effect associated with the principal banded ironstone layer in both cases.

Apart from their higher copper and gold contents, the banded ironstones are also distinguishable from the massive ironstones by much higher manganese levels; this is not entirely attributable to possible contamination from the enclosing schists.

Sample numbers A104640 and 114358 which are interpreted now to be oxidised "mineralized" schists from the contact zone have unusually low Cu/Au ratios possibly indicating a degree of supergene gold enrichment in the weathering zone. The other samples, from outcrops in the stream beds are essentially unweathered.

Structural Geology:

As depicted in Photos 2, 12, 13 and 14 there is some evidence, at least near the eastern margin of the Bowry Member, for tight isoclinal folding and transposition of layering parallel to the plane of foliation. The remnants of folds depicted in Photos 2 and 13 have axial planes which appear to be coplanar with this penetrative regional foliation and it is tempting to assume that the two features are related to the same deformational event. Elsewhere, further into the Bowry Member and in the quartz + muscovite +/- chlorite schists to the west, compositional layering is everywhere parallel to the penetrative foliation implying that the entire "sequence" has been subjected to extreme isoclinal folding and/or large scale transposition. Nevertheless and despite the visible evidence of layer transposition, the "sequence" in general seems to maintain a remarkably persistent "stratigraphy" with banded ironstones and magnetite/pyrite enriched alb + chl + qtz schists in a narrow zone at the eastern contact and distinctive massive ironstones

in close spatial association with magnesian silicate schists, tourmaline bearing mafic hornfelses and sodic leucogranite close to the western boundary of the Bowry Member. This, incidentally, seems to closely resemble the structural situation at Rocky River, 8km along strike to the north, where there is a zone of banded ironstones and disseminated magnetite/pyrite in banded mafic schists close to the eastern contact and a large lense of massive ironstone near the western boundary; in that case, however, the sodic granitoid appears to lie to the west of the massive ironstone.

The penetrative regional schistosity generally strikes north east and dips steeply to the south east but north of the Owen Meredith River there is a marked change to a northerly trend and easterly dip. The gross lithological boundaries follow this change in trend and (although somewhat exaggerated on Figure 2 by the easterly dip and steep terrain) outline a broad open fold plunging at about 70 deg. on an azimuth of 115 deg. The axial plane of this fold appears to be near vertical and its trace runs through the confluence of Finlay creek and Owen Meredith River.

In Finlay Creek, where the outcrop is good and the metasediments frequently are thinly layered (parallel to foliation) there are several exposures of small scale folds which have a similar orientation. These easterly plunging folds, small and large, are undoubtedly of post metamorphic, probably Devonian, origin.

5. STREAM SEDIMENT GEOCHEMISTRY

I have carried out a very cursory trial stream sediment sampling survey in Doctor's Creek and Owen Meredith River and a few tributaries. A total of 15 sites were sampled for panned concentrates and -80# sediments. The sample locations are indicated in Figure 6 which also indicates the last two digits of the panned concentrate numbers (series: A114251 to 114279, odd numbers only). The -80# sample numbers are even numbers keyed to the panned concentrate numbers from the same site; eg: lowermost sample in Doctor's Creek has panned concentrate number 114257 and -80# number 114258.

Panned concentrate samples consisted of 2-3kg of -2mm sediment from best available trap sites panned down to about 10-30g and analysed without further preparation by ANALABS' method 309 (Fusion/AAS) for gold. A single duplicate sample (of A114267) was analysed by method 401 (XRF) for tin. Trap sites were generally rated good to excellent.

The -80# samples consisted of about 0.6kg of unprocessed finest available active sediment, dried in the laboratory, screened dry to provide a -80# fraction which was then analysed by ANALABS AAS method 101 for Cu, Pb, Zn, Ag, Fe, Mn.

The panned concentrate results indicate an absence of geochemically detectable gold in sediments upstream of the Bowry Member but anomalous gold appears in stream sediments immediately below the contact and, with a single exception, all sediment samples below the Bowry contact contained some gold. The P/C assays ranged from 0.3 to 413g/t Au. Several of the samples contained visible gold (Appendix III-a) which was sometimes of quite "shotty" character with small nuggets up to 3mm in diameter.

The P/C results are thus clearly influenced by the "nugget effect" and trap site variables and it is unlikely that the values can be used in a quantitative way. However, the results support the indications of limited rock chip sampling that the source of gold is local, primary and associated with banded ironstones and their enclosing magnetite/pyrite enriched schists in a zone adjacent to the eastern contact of the Bowry Member.

The -80# data shows generally low base metal values with copper, lead and zinc peaking at 80, 30 and 125ppm respectively. These results are not unexpected; the water in these streams is strongly tannin stained and presumably fairly acidic, copper particularly seems to remain mobile under these conditions and typically does not report strong anomalies in stream sediments in Western Tasmania.

Although this trial survey is far from exhaustive it does not provide encouragement for the further application of -80# stream sediment sampling as a method of identifying zones of copper enrichment along the trend of the Bowry Member.

6. DISCUSSION

The limited exploration work carried out to date on the extensions to the Owen Meredith grid has substantially contributed to an improved understanding of the geological setting of ironstone deposits in this area, largely as a result of the good exposures available in the river bed.

There are two distinct types of ironstones:

- * Banded siliceous ironstones occur in association with elevated levels of disseminated/lenticular magnetite and pyrite in mafic to semi-felsic albite + chlorite + quartz schists in a narrow zone at the eastern contact of the Bowry Member. These ironstones, and to a lesser extent the enclosing schists, contain weak chalcopyrite and gold mineralisation. Petrographic textural and outcrop observations are consistent with an interpretation that these ironstones originated as sedimentary iron formations. They are reflected in relatively weak ground magnetic anomalies.

* Massive ironstone consisting essentially of magnetite with a little pyrite occurs in close spatial association with sodic leucogranite and magnesian silicate and tourmaline bearing rocks of apparently metasomatic/metamorphic origin close to the western margin of the Bowry Member. The spatial association tempts but does not prove an interpretation that this ironstone is also of metasomatic origin. An alternative interpretation could be that the ironstone was of syngenetic/volcanogenic origin associated with a carbonate rich wall rock alteration zone in basaltic volcanics which became the focus for metasomatic alteration during the subsequent emplacement of the sodic granitoid. It is evident from petrographic and structural observations that the emplacement of the granitoid preceded both prograde and cataclastic/retrograde metamorphic events. This type of massive ironstone appears to occur in lenses of substantial tonnage, with thickness upto about 20m and considerable strike length, and is responsible for large magnetic anomalies of very high amplitude. Rock chip samples from the massive ironstone outcrops indicate an iron content of around 70% but low base metal and gold values.

Outokumpu's exploration of the Bowry Member is loosely based on the Starra type Cu/Au ore deposit model. Indications thus far, from relatively sparse outcrop chip samples, are that the massive ironstones are essentially barren of copper and gold and that the banded ironstones and associated schists are weakly mineralised in these metals.

However, the results are not especially exciting; selective samples of the banded ironstones indicate rather variable but generally anomalous values upto 0.5% Cu and 0.29g/t Au. Representative chip samples across the zones of mineralised schist with lenses of banded ironstone indicate the following approximate average grades:

Doctor's Creek	:	10m @ 0.12% Cu, 0.045g/t Au
Owen Meredith River:		15m @ 0.02% Cu, 0.008g/t Au

In view of the rather coarse gold evident in panned concentrate stream sediment samples it may be that there is a sampling problem; all of the rock chip samples from this area have been fairly small, around 1 to 2kg, due to the long and steep walk out. It could be argued that the results are not truly representative and this could also apply to the apparently barren massive ironstones. However, the results thus far are reasonably consistent and there is some slight evidence for supergene enrichment of gold which may account for the nuggety material in the streams.

Taking, therefore, the rock chip sample data at face value, the fundamental exploration problems seem to be:

- (1) Does this style of mineralisation have potentially economic tonnage/grade characteristics?

The style of mineralisation and the age and geological environment of the Arthur Metamorphic Complex are so poorly understood that there can be no definitive answer yet; further micropetrographic and geochemical studies might help but could be difficult without fresh rock from drill core. (The only known drill core which may contain some banded ironstone is from two short holes drilled in 1966 at Rocky River.)

- (11) What techniques can be systematically applied to identify zones of higher grades in the banded ironstones? The somewhat hypothetical indications are that there could be greater than 10km of potential strike extent.

More extensive detailed panned concentrate sampling might be considered for problem (11) but the relatively coarse nature of the gold and the variability of trap sites would not permit quantitative assessment. The method may be more workable in the converse sense by identifying sections without gold but A.M.Reid's (1924) report that all the streams flowing westward across the ironstone belt had been worked for alluvial gold suggests that this may not be definitive either.

Systematic rock chip sampling and mapping would be a preferred option except that exposure is limited to discontinuous outcrops in the larger streams and virtually non existent elsewhere. Geochemical methods such as Wacker bedrock sampling might be considered for a trial survey but would, even more than rock chip sampling, suffer from the gold "nugget effect". B-horizon sampling on the original grid was not a success, perhaps because of a lack of significant mineralisation there, but for detection of copper I consider that C-horizon sampling is more likely to succeed.

The banded ironstones and associated schists give a subtle magnetic response on some lines and the associated pyrite should also provide an IP response. These two geophysical methods in combination with outcrop mapping and sampling should be able to trace out the zone of interest which could then be followed up by systematic fairly close spaced C-horizon soil/bedrock geochemical sampling if found to be effective. If soil/bedrock sampling was found to be ineffective then shallow drilling might be an alternative but would be severely restricted by the generally steep terrain and difficult access.

All of the above proposals, if pursued northwards beyond the existing grid, would require extensive further track cutting for access with helicopter transport for survey parties; either on a daily basis or to temporary camps established at strategic intervals of about 3km north of Owen Meredith River.

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Photo 15 View southeast along grid line 14425N from about 9760E and up the Owen Meredith valley; the baseline crossing of the river is about 1cm above the lower edge of the frame.

7. REFERENCES

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Stolz, J.	1990	Report on the petrographic examination of ironstones and associated metamorphic rocks from the Arthur Metamorphic Complex, NW Tasmania. Outokumpu Exploration Australia P/L

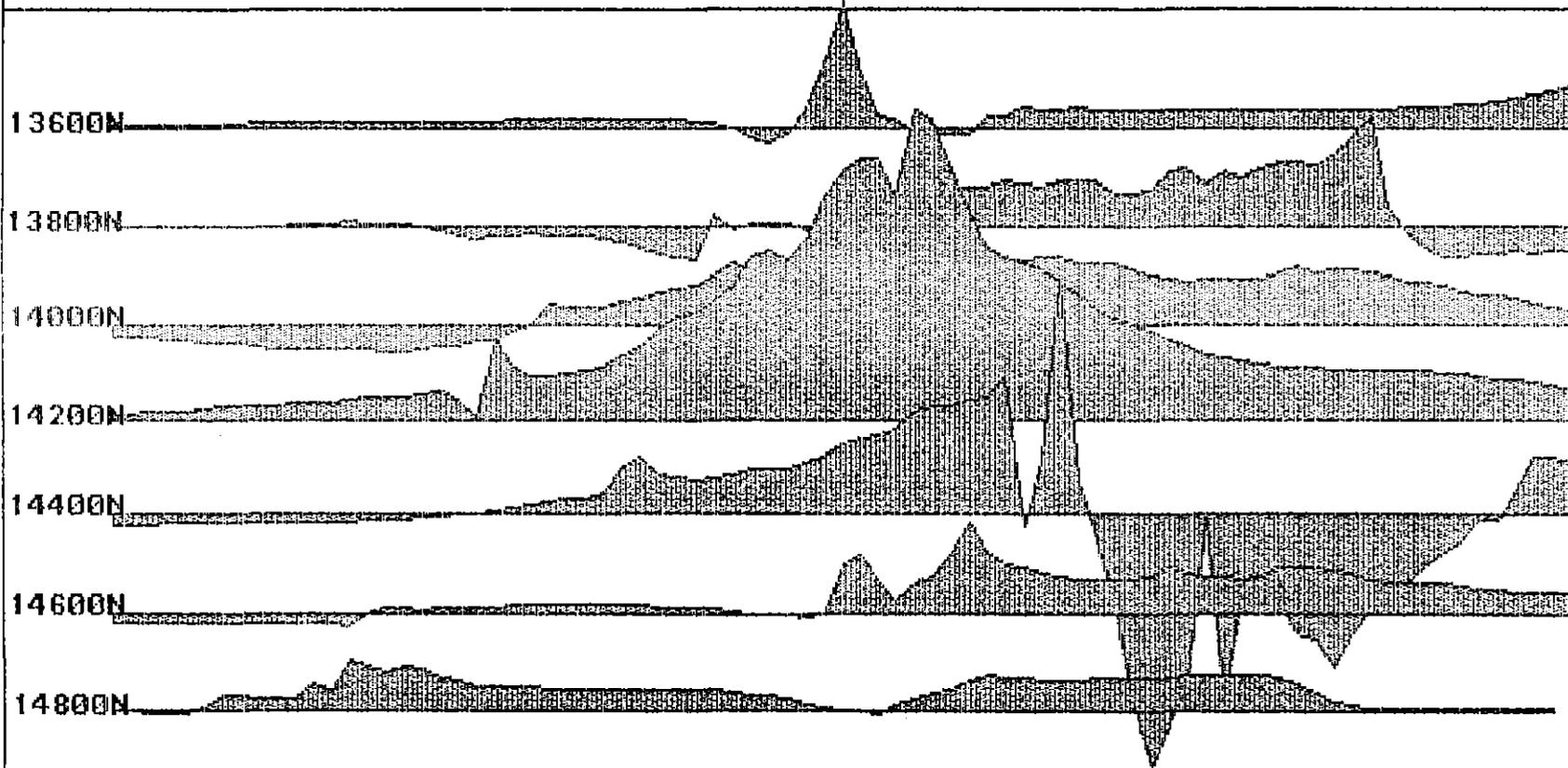
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Appendix I Magnetic Profiles

Client : OUTOKUMPU
Prospect : OWEN/MEREDITH

Surveyed by : B STEDMAN
Survey Date : 21/02/91

STACKED



2500nT
0

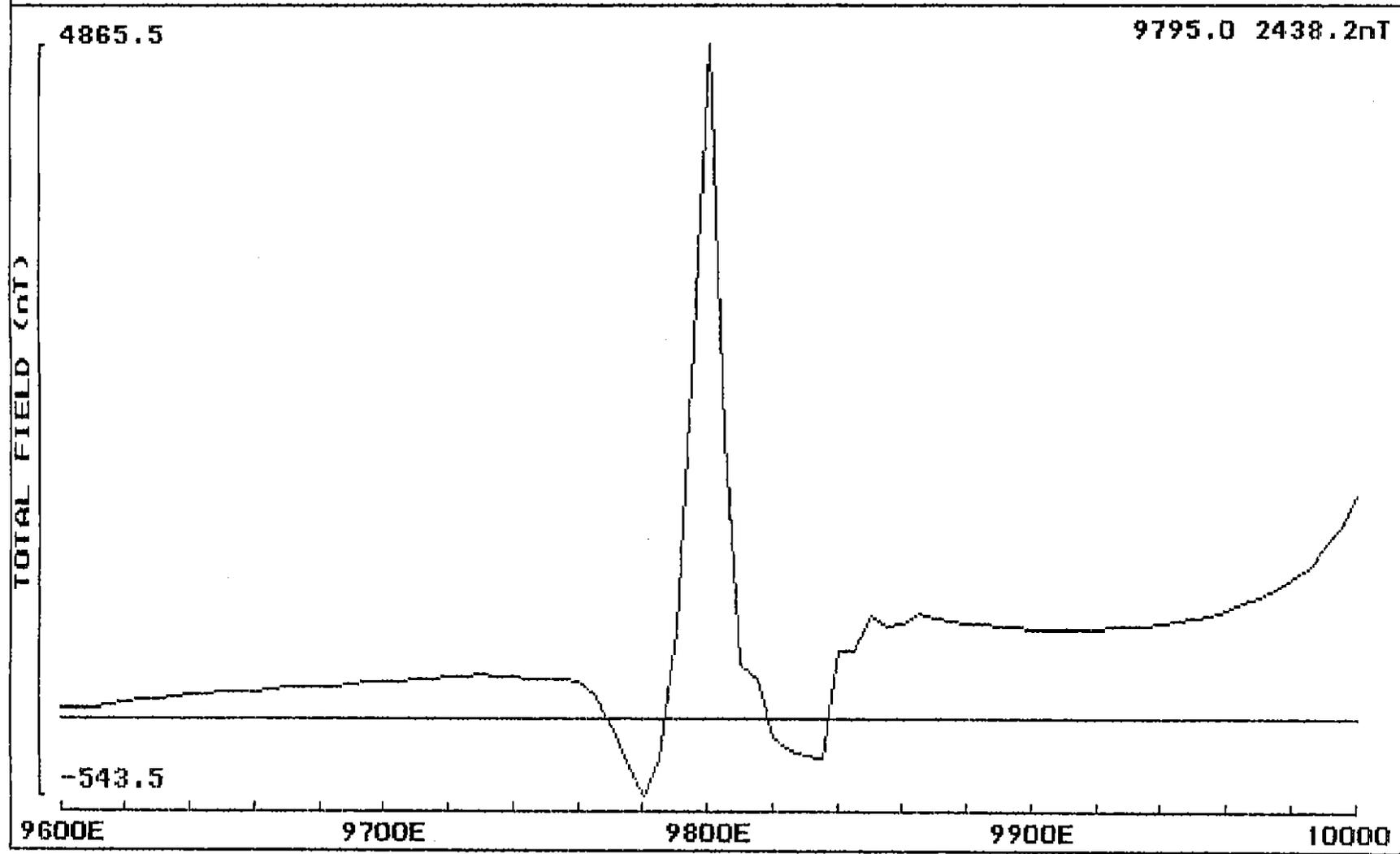
0138

370146

Client : OUTOKUMPU
Prospect : OWEN/MEREDITH

Surveyed by : B STEDMAN
Survey Date : 21/02/91

13600N

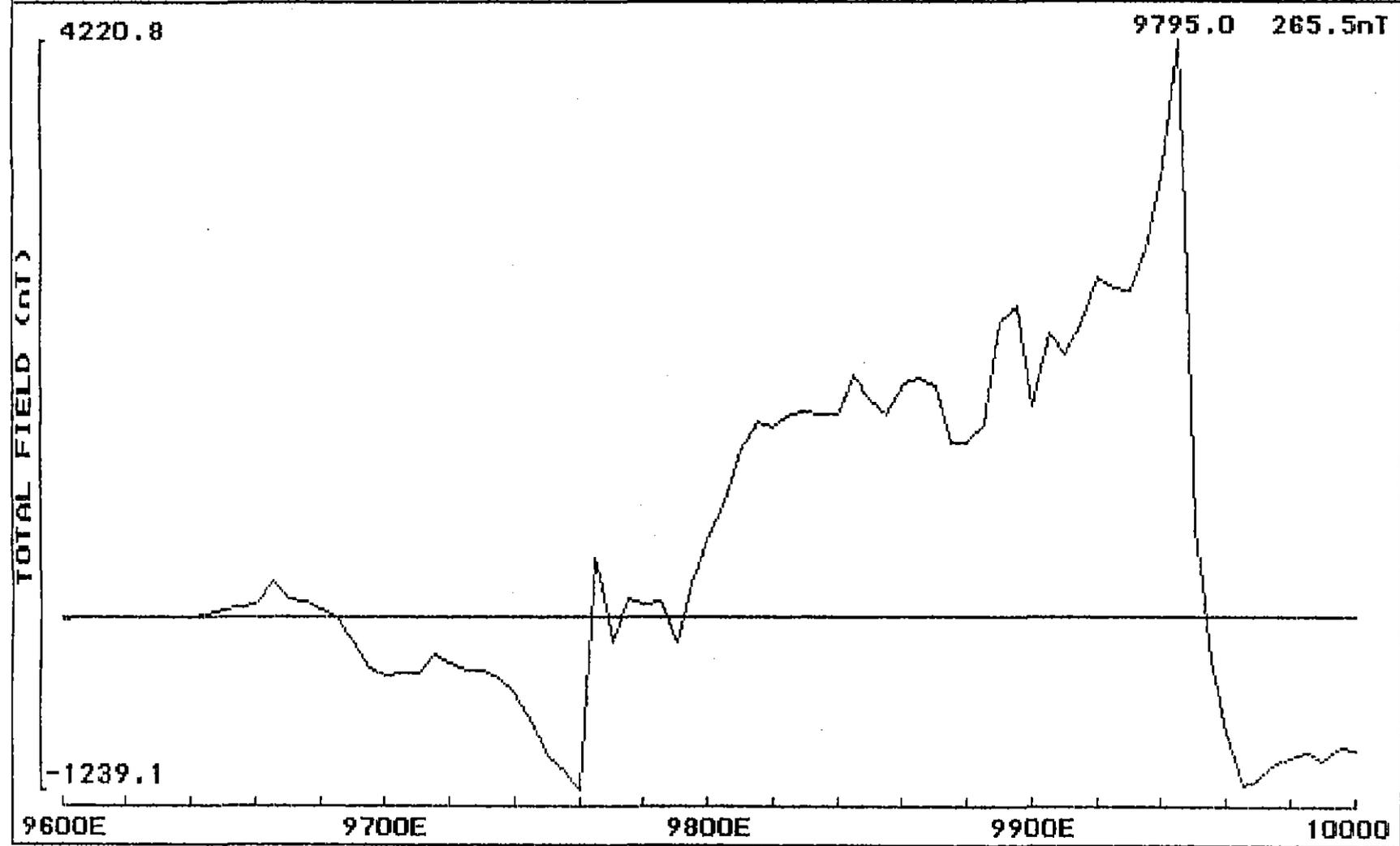


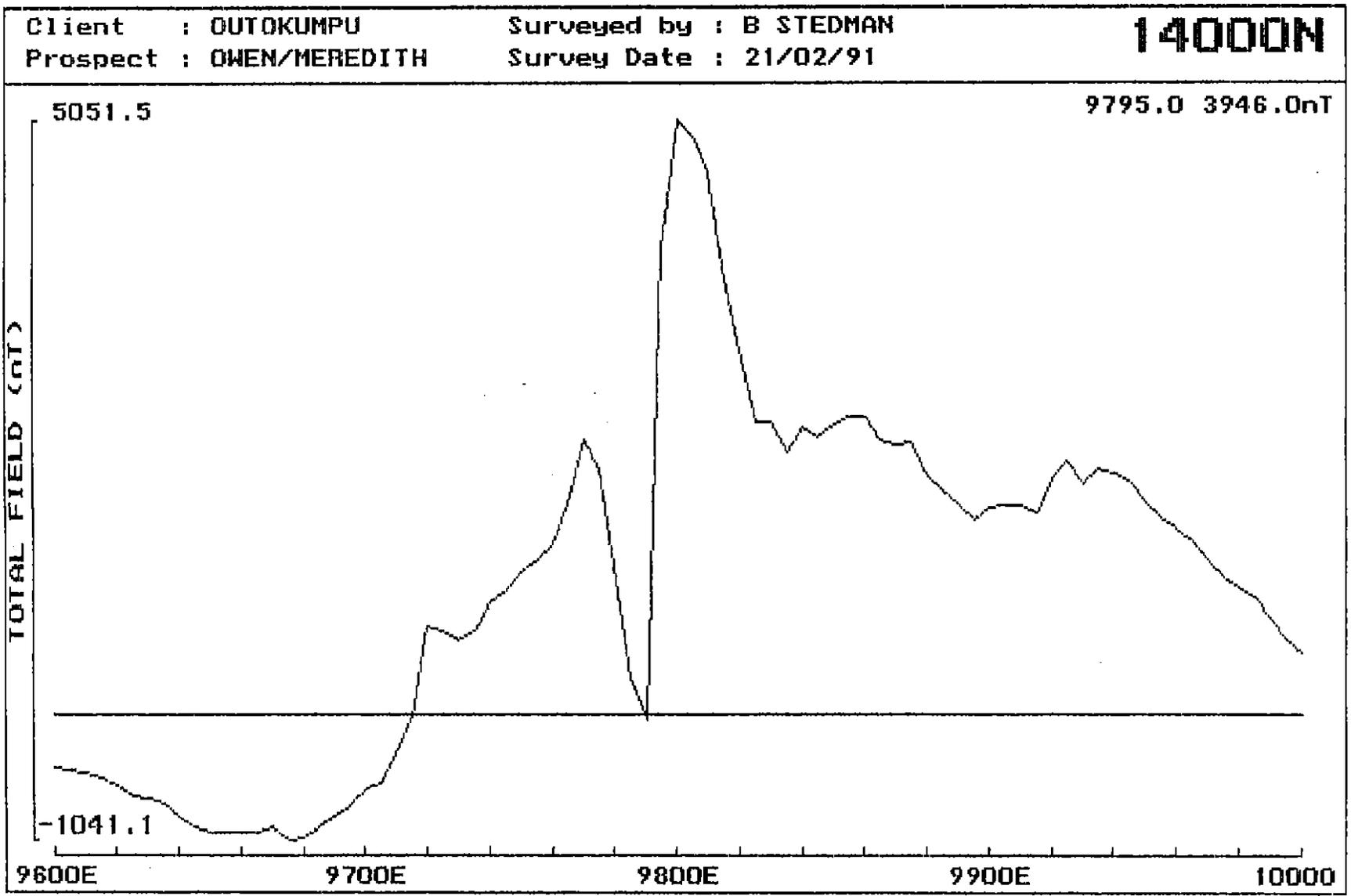
370147

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Client : OUTOKUMPU Surveyed by : B STEDMAN
Prospect : OWEN/MEREDITH Survey Date : 21/02/91

13800N

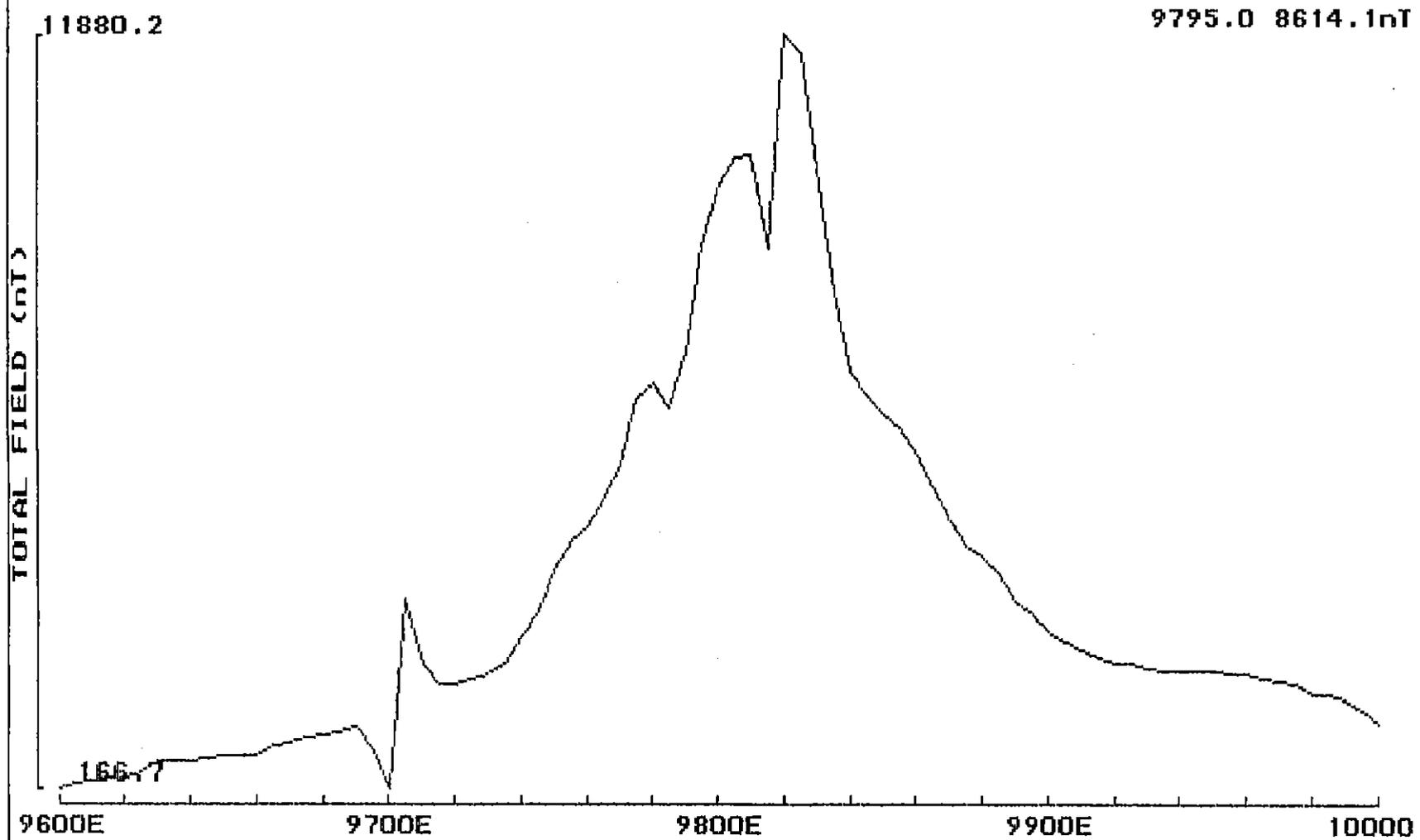




Client : OUTOKUMPU
Prospect : OWEN/MEREDITH

Surveyed by : B STEDMAN
Survey Date : 21/02/91

14200N



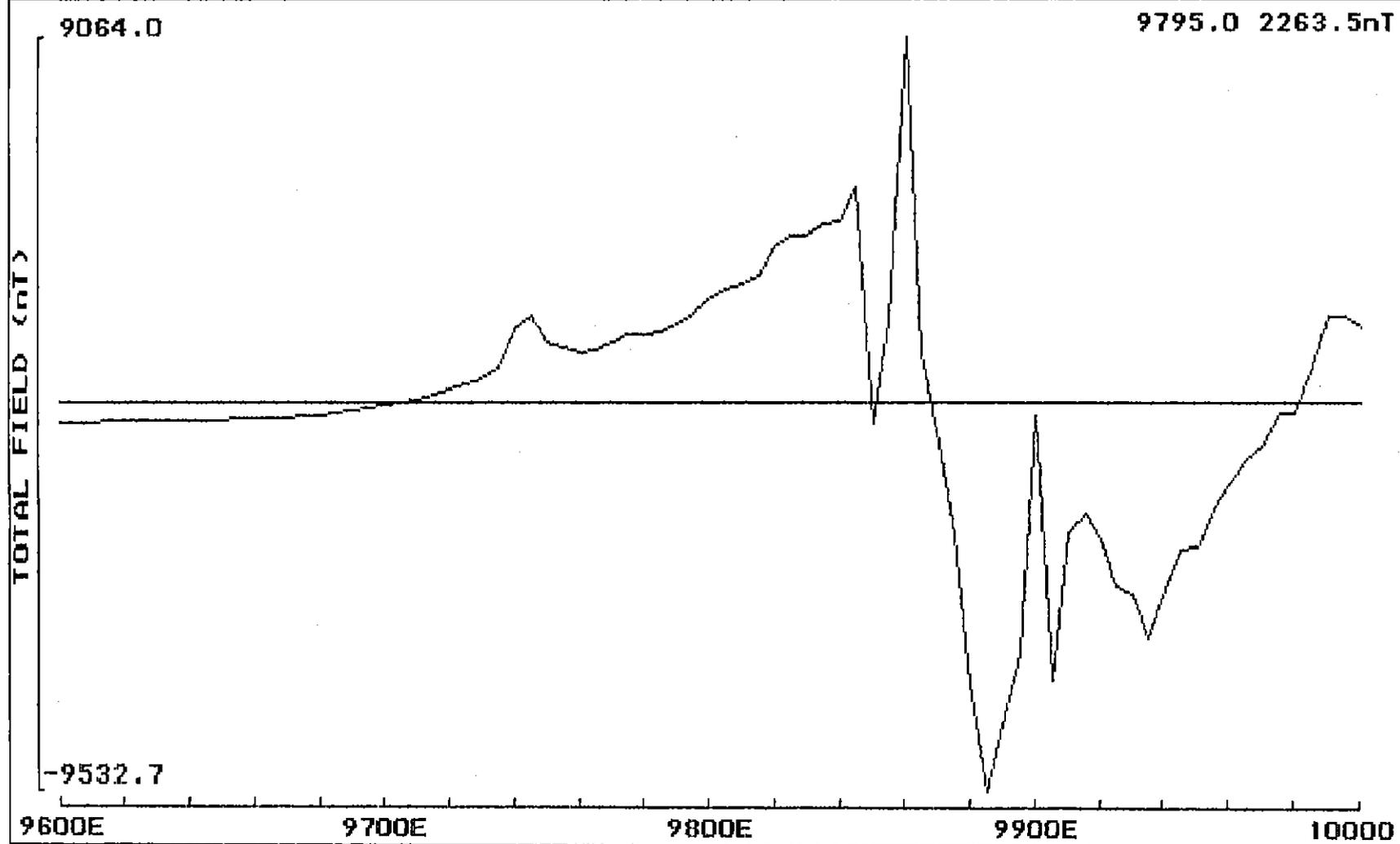
0143

370150

Client : OUTOKUMPU
Prospect : OWEN/MEREDITH

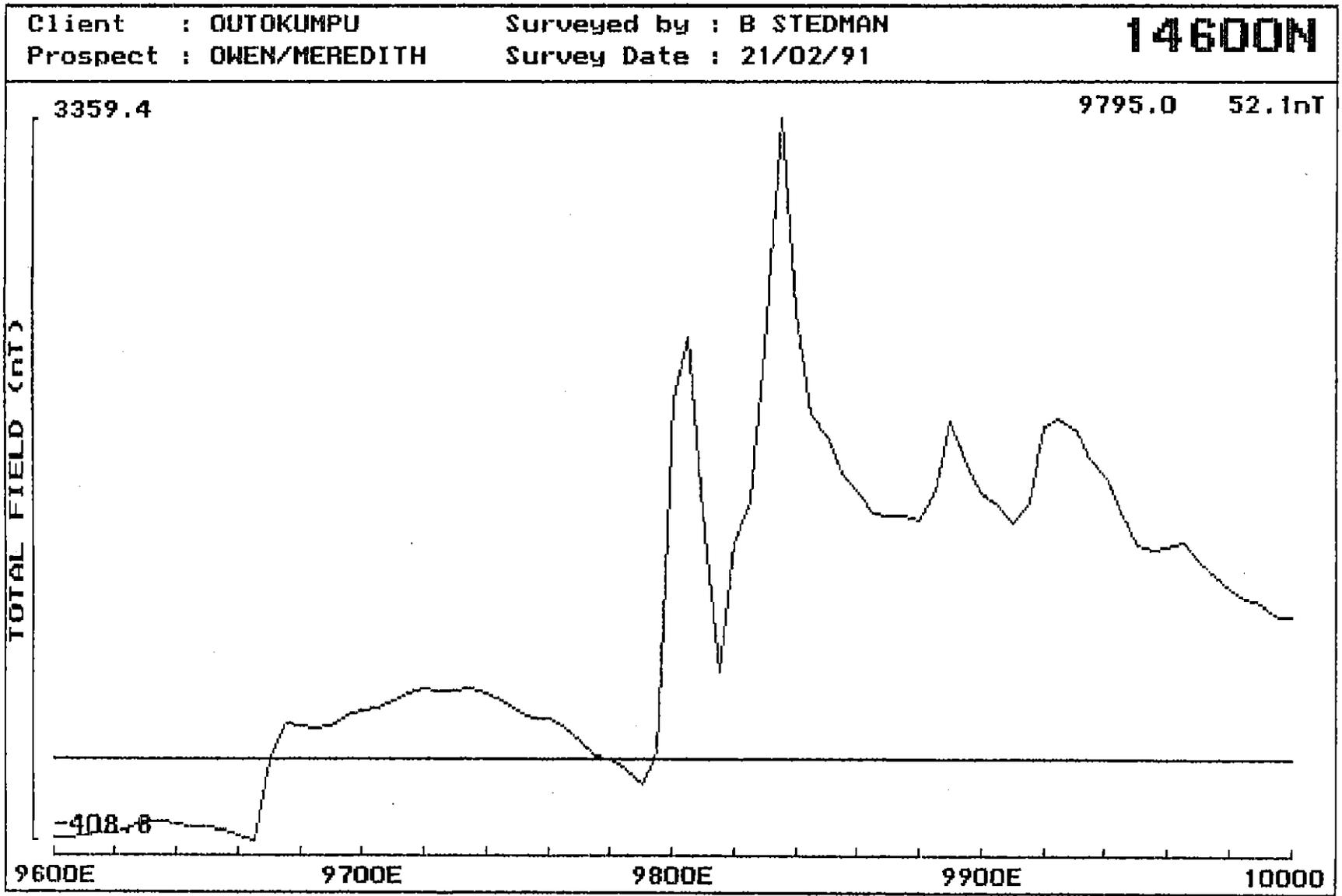
Surveyed by : B STEDMAN
Survey Date : 21/02/91

14400N



0141

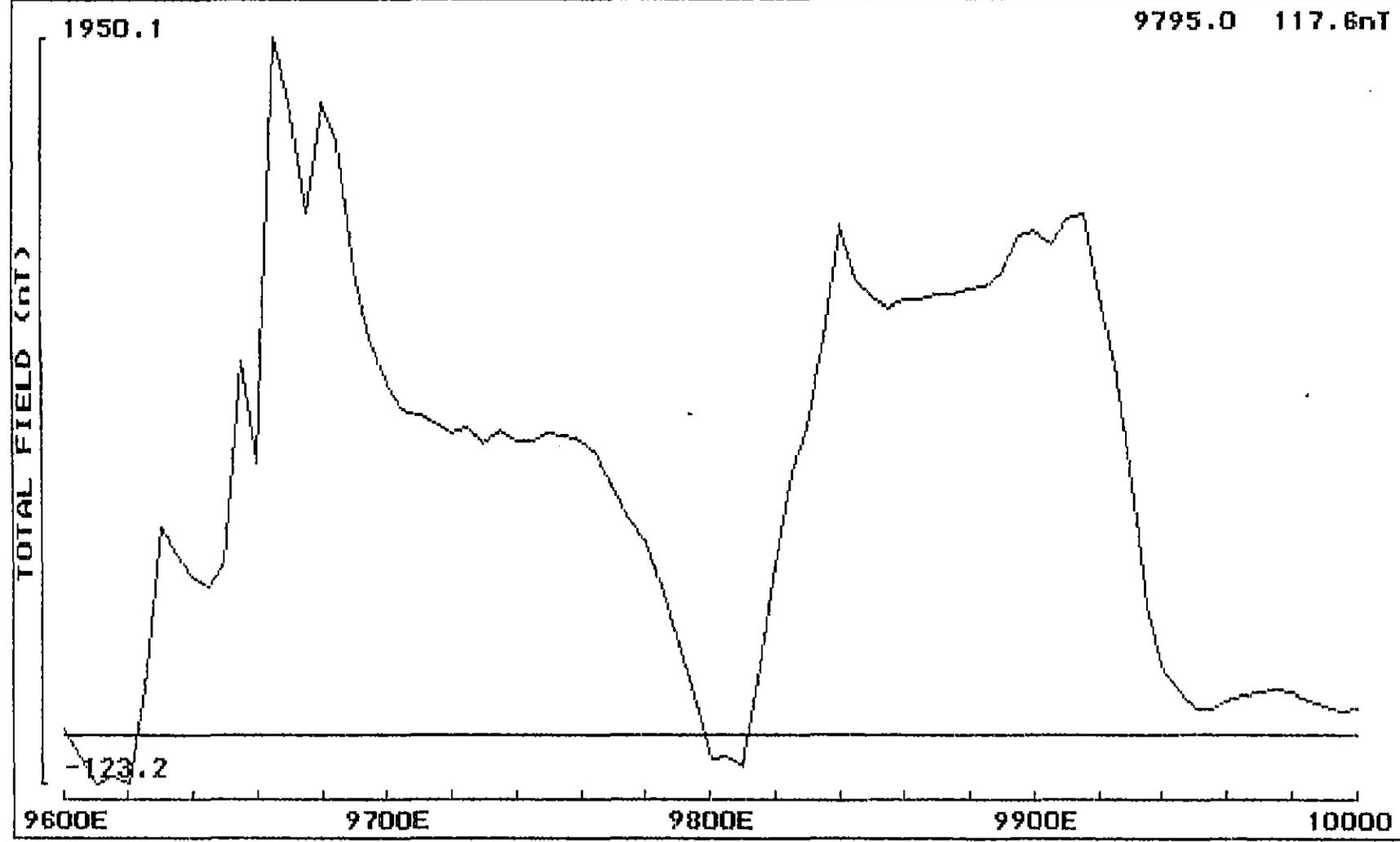
370151



Client : OUTOKUMPU
Prospect : OWEN/MEREDITH

Surveyed by : B STEDMAN
Survey Date : 21/02/91

14800N



01210

370153

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Appendix II Rock Chip Geochemistry

- a Descriptive Data
- b Analytical Report 111060.60.07808
- c Ironstone Geochemistry

ROCK SAMPLE DATA FIELD SHEET

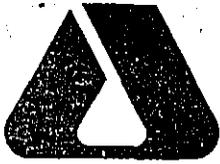
148

PROJECT NAME EL 14/89 CORANNA
PROJECT No. _____

PROSPECT NAME OWEN MEREDITH
PROSPECT I.D. _____
GRID I.D. _____

Sample Number	Field / Station Number	FIELD-GRID CO-ORDINATES			Samp Type	Samp Meth	Samp Length (m)	COMMENTS / ANALYSES (ppm)
		E	N	R.L.				
A 104357	Owen Meredith River				o/c		10cm. band 2% Py, 3% Mt in mafic schist.	
114358	Ox. Crust	10000	14630		:		Wd. mafic schist ± bands / disseminated Mt ± Py.	
114359	"	9950	14600		:		Wd. biotite leucogranite, probably 2% qtz veining, Fe stained	
114360	Owen Meredith River				:		Flinty qtz + tremolite/crocidolite + tourmaline schist, 2% Py.	
114361	"				:		1m. dia. pot or boulder adjacent to massive Mt lode, 90% Py.	
114362	"				:		Tourmaline / tremolite etc. schist also amphibolite.	
114363	"				:		4m wide (ox.) massive magnetite	
114364	"				:		Tourmaline / magnesian silicate schist west of Mt lode.	
114365	"				:		Shd. Mt lode + magnesian silicate schist.	
114366	"				:		5m. dip sample across massive Mt. lode - 70% Mt, 10% Py.	
114367	"				:		20m. wide shd. margin of massive Mt lode, 50% Py.	
114368	"				:		Panned concentrate of -6mm. massive magnetite pebbles. (same site as P/c 114279)	
114369	"				o/c		Ox. massive Mt. on spur, south end of DT, o/c of lode.	
114370	"				o/c		Tourmaline / tremolite boulders adjacent to footwall of lode	
114371	"				:		Massive Mt. o/c adjacent to 114370, oxidized. 80% Fe ox	

370156



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A Division of Incharge Inspection and Testing Services Australia Pty. Ltd.

Analabs - A Division of Incharge Inspection & Testing Services

Phone (004) 31 6837

14 Thirkell St. Coode Tas 7320

Fax No. (004) 31 8890

ANALYTICAL REPORT No. 111060.60.07808

THIS REPORT MUST BE READ IN CONJUNCTION WITH THE ACCOMPANYING ANALYTICAL DATA

INVOICE TO:

Outokumpu Exploration Aust Pty Ltd
Suite 2, Level 6
77 Pacific Highway
North Sydney NSW 2060

ORDER No.

PROJECT

20240

DATE RECEIVED

RESULTS REQUIRED

05/03/91

ASAP

No. OF PAGES OF RESULTS

DATE REPORTED

No. OF COPIES

TOTAL No. OF SAMPLES

2

15/03/91

1

32

SAMPLE NUMBERS

SAMPLE DESCRIPTION

ELEMENT/METHOD

A104640/650,A114351/371

RO Prep: 6P005,6P009,6P018

Cu,Pb,Zn,Ag,Fe,Mn/GA140

A104640/650,A114351/371

RO

Au,Au(R),Au(S)/GG313,Au/RAW,Au/Wt

A104640/650,A114351/371

RO Prep: 6P005,6P009,6P018

Fe,Mn/GA105

REMARKS

RESULTS

TO

Mr. Wally Herrmann
RSD 1066
Devonport
Tasmania 7310

OWEN MEREDITH

ROCK CHIP GEOCHEM.

RESULTS

TO

Outokumpu Exploration Aust Pty Ltd
Suite 2, Level 6
77 Pacific Highway
North Sydney NSW 2060

RESULTS

TO

AUTHORISED OFFICER

0100

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A Division of Incharge Inspection and Testing Services Australia Pty. Ltd.

ANALYTICAL DATA

SAMPLE PREFIX REPORT NUMBER REPORT DATE CLIENT ORDER No. PAGE

111060.60.07808 15/03/91 2 OF 2

TUBE No.	SAMPLE No.	Au	Au(R)	Au(S)
1	A114365	0.010	-	-
2	A114366	0.010	-	-
3	A114367	0.020	-	-
4	A114368	0.010	-	-
5	A114369	0.005	<0.005	-
6	A114370	0.010	-	-
7	A114371	0.005	-	-
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23	DETECTION	0.005	0.005	0.005
24	UNITS	ppm	ppm	ppm
25	METHOD	GG313	GG313	GG313

Results in ppm unless otherwise specified
 T = element present, but concentration too low to measure
 X = element concentration is below detection limit
 - = element not determined

AUTHORISED OFFICER

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A Division of Incharge Inspection and Testing Services Australia Pty. Ltd.

ANALYTICAL DATA

SAMPLE PREFIX REPORT NUMBER REPORT DATE CLIENT ORDER No. PAGE

111060.60.07809 19/03/91 1 OF 2

TUBE No.	SAMPLE No.	Au	Au(R)	Au(S)
1	A104640	0.795	-	-
2	A104641	0.020	0.020	-
3	A104642	0.010	-	-
4	A104643	0.015	-	-
5	A104644	0.005	-	0.005
6	A104645	0.015	-	-
7	A104646	0.075	-	-
8	A104647	0.135	-	-
9	A104648	0.055	-	-
10	A104649	0.070	-	-
11	A104650	0.010	-	-
12	A114351	0.085	-	-
13	A114352	0.005	-	-
14	A114353	0.005	-	-
15	A114354	0.015	-	-
16	A114355	0.005	-	-
17	A114356	0.035	-	-
18	A114357	0.020	-	-
19	A114358	0.180	-	-
20	A114359	0.015	-	-
21	A114360	0.005	-	-
22	A114361	0.020	-	-
23	A114362	0.005	-	-
24	A114363	0.010	-	0.010
25	A114364	0.010	-	-

Results in ppm unless otherwise specified
 T = element present, but concentration too low to measure
 X = element concentration is below detection limit
 - = element not determined

AUTHORISED OFFICER

370158

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ANALYTICAL DATA

SAMPLE PREFIX REPORT NUMBER REPORT DATE CLIENT ORDER No. PAGE

111060.60.07808 15/03/91 1 OF 2

TUBE No.	SAMPLE No.	Cu	Pb	Zn	Ag	Fe	Fe	Mn	Mn
1	A104640	1250	15	215	<1	>10.00	26.78	75	-
2	A104641	180	10	55	<1	>10.00	66.90	80	-
3	A104642	630	10	65	<1	>10.00	67.10	35	-
4	A104643	1000	10	20	<1	7.54	-	50	-
5	A104644	90	15	60	<1	4.86	-	400	-
6	A104645	710	5	70	<1	9.56	-	835	-
7	A104646	3500	10	55	<1	>10.00	14.00	1025	-
8	A104647	3650	10	70	<1	>10.00	26.66	4000	-
9	A104648	1300	10	130	<1	>10.00	18.26	3600	-
10	A104649	440	15	255	<1	>10.00	17.21	4500	-
11	A104650	175	20	345	<1	>10.00	16.79	4300	-
12	A114351	3050	10	160	<1	>10.00	31.51	7600	-
13	A114352	95	10	145	<1	>10.00	24.27	>10000	2.09
14	A114353	170	15	325	<1	>10.00	17.31	3600	-
15	A114354	310	10	345	<1	>10.00	14.16	>10000	1.40
16	A114355	85	15	745	<1	>10.00	13.67	>10000	1.81
17	A114356	795	15	115	<1	>10.00	48.97	1450	-
18	A114357	580	10	140	<1	>10.00	31.20	600	-
19	A114358	670	10	100	<1	>10.00	21.45	650	-
20	A114359	35	5	20	<1	3.80	-	210	-
21	A114360	60	5	10	<1	2.02	-	45	-
22	A114361	205	5	30	<1	>10.00	48.17	25	-
23	A114362	155	5	80	<1	7.80	-	700	-
24	A114363	140	10	50	<1	>10.00	72.90	120	-
25	A114364	545	5	40	<1	>10.00	13.20	240	-

Results in ppm unless otherwise specified
 T = element present but concentration too low to measure
 X = element concentration is below detection limit
 - = element not determined

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ANALYTICAL DATA

SAMPLE PREFIX REPORT NUMBER REPORT DATE CLIENT ORDER No. PAGE

111060.60.07808 15/03/91 2 OF 2

TUBE No.	SAMPLE No.	Cu	Pb	Zn	Ag	Fe	Fe	Mn	Mn
1	A114365	70	5	50	<1	>10.00	66.60	175	-
2	A114366	220	5	45	<1	>10.00	71.00	100	-
3	A114367	2950	5	30	<1	>10.00	37.35	170	-
4	A114368	105	10	70	<1	>10.00	68.90	245	-
5	A114369	215	5	55	<1	>10.00	67.20	115	-
6	A114370	45	5	20	<1	3.85	-	95	-
7	A114371	355	10	55	<1	>10.00	67.10	100	-
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23	DETECTION	2	5	2	1	0.01	10.00	5	0.01
24	UNITS	ppm	ppm	ppm	ppm	%	%	ppm	%
25	METHOD	GA140	GA140	GA140	GA140	GA140	GA105	GA140	GA105

Results in ppm unless otherwise specified
 T = element present but concentration too low to measure
 X = element concentration is below detection limit
 - = element not determined

AUTHORISED OFFICER

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	Sample No.	Cu	Zn	Au	Fe	Mn	(Cu/Au)/1000
		ppm	ppm	ppm	%	%	
BANDED IRONSTONES							
Doctor's Creek							
10cm BIF	104609	5000	55	0.174	24.9		29
Thin BIF lenses	104610	3200	135	0.292	37.4		11
Thin BIF lenses	104611	735	75	0.092	16.4		8
15cm BIF	114647	3650	70	0.135	26.7	0.40	27
Owen Meredith River							
Thin BIF lenses	114351	3050	160	0.085	31.5	0.76	36
20-30cm BIF	114352	95	145	0.005	24.3	2.09	19
3-8cm BIF	114356	795	115	0.035	49.0	0.14	23
Mean		2361	108	0.117	30.0	0.85	20
S.D.		1692	38	0.089	9.8	0.75	19
"MINERALISED" SCHISTS							
Doctor's Creek							
Limonite st. sint/silic rock	104640	1250	215	0.795	26.8	0.01	2
0-2m below contact, fels/mafic	104645	710	70	0.015	9.6	0.08	47
2-4m below contact, felsic/sil	104646	3500	55	0.075	14.0	0.10	47
4-6m below contact, mafic	104648	1300	130	0.055	18.3	0.36	24
6-8m below contact, mafic	104649	440	255	0.070	17.2	0.45	6
8-10m below contact, mafic	104650	175	345	0.010	16.8	0.43	18
Owen Meredith River							
0-5m below contact, mafic	114353	170	325	0.005	17.3	0.36	34
5-10m below contact, mafic	114354	310	345	0.015	14.2	1.40	21
10-15m below contact, mafic	114355	85	745	0.005	13.7	1.81	17
10000E/14630N, ox. mafic	114358	670	100	0.180	21.5	0.07	4
Mean †		818	263	0.048	15.8	0.56	17
S.D. †		1013	204	0.054	3.2	0.58	19

(* excluding 104640)

0153

MASSIVE IRONSTONES

	Sample No.	Cu	Zn	Au	Fe	Mn	(Cu/Au)/1000
		ppm	ppm	ppm	%	%	
14000N/9780E ox.	104641	180	55	0.020	66.9	0.01	9
14000N/9785-9795E ox.	104642	630	65	0.010	67.1	0.00	63
Owen Meredith River							
DMR, N end of E lense, 4m ox.	114363	140	50	0.010	72.9	0.01	14
DMR, N end of W lense	114365	70	50	0.010	66.6	0.02	7
DMR, E lense, 5m	114366	220	45	0.010	71.0	0.01	22
DMR, P/C of ironstone gravel	114368	105	70	0.010	68.9	0.02	11
DMR, S end ox.	114369	215	55	0.005	67.2	0.01	43
DMR, NW margin ox.	114371	355	55	0.005	67.1	0.01	71
Doctor's Creek	104615	130	100	x	66.4		
(all partly oxidised)	104616	145	85	x	67.6		
	104621	210	85	x	66.2		
Mean		218	65	0.007	68.0	0.01	30
S.D.		149	17	0.006	2.0	0.01	26

PYRITIC ROCKS

Doctor's Creek							
50% Py bands in fels/sil sch.	104608	4300	25	0.081	2.5		53
Owen Meredith River							
10cm band 30%Py, 30%Mt, maf.sch.	114357	580	140	0.020	31.2	0.06	29
Floater E side of lode, 90%Py	114361	205	30	0.020	48.2	0.00	10
Shd. E margin of lode, carb+py	114367	2950	30	0.020	37.4	0.02	148

Appendix III Stream Sediment Geochemistry

- a Panned Concentrates - Descriptive Data
- b Analytical Reports 111060.60.07809
111060.60.07810

0100



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A Division of Inchcape Inspection and Testing Services Australia Pty. Ltd.

Analabs - A Division of Inchcape Inspection & Testing Services

Phone (004) 31 8837 14 Thirlall St. Coose Tas 7320 Fax No. (004) 31 8890

ANALYTICAL REPORT No. 111060.60.07809

THIS REPORT MUST BE READ IN CONJUNCTION WITH THE ACCOMPANYING ANALYTICAL DATA

INVOICE TO: **Outokumpu Exploration Aust Pty Ltd**
 Suite 2, Level 6
 77 Pacific Highway
 North Sydney NSW 2060

ORDER No. **20241** PROJECT

DATE RECEIVED **05/03/91** RESULTS REQUIRED **ASAP**

No. OF PAGES OF RESULTS	DATE REPORTED	No. OF COPIES	TOTAL No. OF SAMPLES
1	12/03/91	1	14

SAMPLE NUMBERS	SAMPLE DESCRIPTION	ELEMENT/METHOD
Various	PC Prep: 6P007	Au/66309, Au/RAN, Wt/9903
A114267, A114267A	PC Prep: 6P007, 6P018	Sn/6X401

RESULTS TO: **Mr. Wally Herrmann**
 RSD 1066
 Devonport
 Tasmania 7310

RESULTS TO: **Outokumpu Exploration Aust Pty Ltd**
 Suite 2, Level 6
 77 Pacific Highway
 North Sydney NSW 2060

RESULTS TO: [Signature]

REMARKS: **OWN MERCURY PANNED CONCENTRATES - Au**

[Signature]

AUTHORISED OFFICER

ANALABS

A Division of Inchcape Inspection and Testing Services Australia Pty. Ltd.

ANALYTICAL DATA

SAMPLE PREFIX	REPORT NUMBER	REPORT DATE	CLIENT ORDER No.	PAGE					
	111060.60.07809	12/03/91		1 OF 1					
TUBE No.	SAMPLE No.	All	Wt	Sn					
1	A114251	14.000	5.17	--					
2	A114253	0.318	31.12	--					
3	A114255	<0.008	6.02	--					
4	A114257	413.00	52.13	-					
5	A114259	4.190	11.86	-					
6	A114261	<0.008	13.13	--					
7	A114263	<0.008	14.11	-					
8	A114265	<0.008	21.66	-					
9	A114267	<0.008	24.89	3					
10	A114269	<0.008	27.02	-					
11	A114271	<0.008	18.86	-					
12	A114273	267.90	16.46	--					
13	A114275	<0.008	14.90	-					
14	A114277	0.265	18.52	--					
15	A114279	7.740	36.69	--					
16									
17									
18									
19									
20									
21	N.B. Recommend a gravimetric finish for samples								
22	A114257 and A114273 to ensure increased accuracy								
23	DETECTION	0.008	0.01	3					
24	UNITS	ppm	g	ppm					
25	METHOD	66309	9903	6X401					

Results in ppm unless otherwise specified
 T = element present, but concentration too low to measure
 X = element concentration is below detection limit

AUTHORISED OFFICER

[Signature]

370163



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A Division of Incharge Inspection and Testing Services Australia Pty. Ltd.

Analabs - A Division of Incharge Inspection & Testing Services

Phone (004) 31 6837

14 Thirkell St. Coode Tas 7320

Fax No. (004) 31 8890

ANALYTICAL REPORT No. 111060.60.07B10

THIS REPORT MUST BE READ IN CONJUNCTION WITH THE ACCOMPANYING ANALYTICAL DATA

ORDER No. PROJECT

20242

INVOICE TO:
Outokumpu Exploration Aust Pty Ltd
Suite 2, Level 6
77 Pacific Highway
North Sydney NSW 2060

DATE RECEIVED RESULTS REQUIRED
05/03/91 ASAP

No. OF PAGES OF RESULTS DATE REPORTED No. OF COPIES

TOTAL No. OF SAMPLES

1 15/03/91 1

15

SAMPLE NUMBERS	SAMPLE DESCRIPTION	ELEMENT/METHOD
Various	SS Prep: SP005, SP007	Cu, Pb, Zn, Ag, Fe, Mn/GA101

REMARKS

RESULTS TO Mr. Wally Herrmann
RSD 1066
Devonport
Tasmania 7310

OWEN MERRITT
-80% St. eds.

RESULTS TO Outokumpu Exploration Aust Pty Ltd
Suite 2, Level 6
77 Pacific Highway
North Sydney NSW 2060

RESULTS TO

AUTHORISED OFFICER

ANALABS

A Division of Incharge Inspection and Testing Services Australia Pty. Ltd.

ANALYTICAL DATA

SAMPLE PREFIX REPORT NUMBER REPORT DATE CLIENT ORDER No. PAGE

111060.60.07B10 15/03/91 1 OF 1

TUBE No.	SAMPLE No.	Cu	Pb	Zn	Ag	Fe	Mn	Au
1	A114252	70	20	90	<0.5	2.85	485	14
2	A114254	45	10	60	<0.5	2.49	430	0.318
3	A114256	50	10	120	<0.5	5.70	2300	x
4	A114258	60	15	80	<0.5	4.03	1000	4.13
5	A114260	45	10	35	<0.5	1.73	320	4.19
6	A114262	20	10	40	<0.5	1.33	170	x
7	A114264	10	10	10	<0.5	0.68	45	x
8	A114266	20	15	20	<0.5	1.74	195	x
9	A114268	50	15	30	<0.5	1.27	50	x
10	A114270	20	10	15	<0.5	1.17	50	x
11	A114272	30	20	40	<0.5	1.78	510	x
12	A114274	20	10	20	<0.5	1.25	130	267.90
13	A114276	40	15	25	<0.5	1.38	50	x
14	A114278	65	30	125	<0.5	5.77	1400	0.265
15	A114280	80	10	35	<0.5	4.90	110	7.72
16								
17								
18								
19								
20								
21								
22								
23	DETECTION	5	5	5	0.5	0.01	5	
24	UNITS	ppm	ppm	ppm	ppm	%	ppm	
25	METHOD	GA101	GA101	GA101	GA101	GA101	GA101	

Results in ppm unless otherwise specified
T = element present; but concentration too low to measure
X = element concentration is below detection limit
- = element not determined

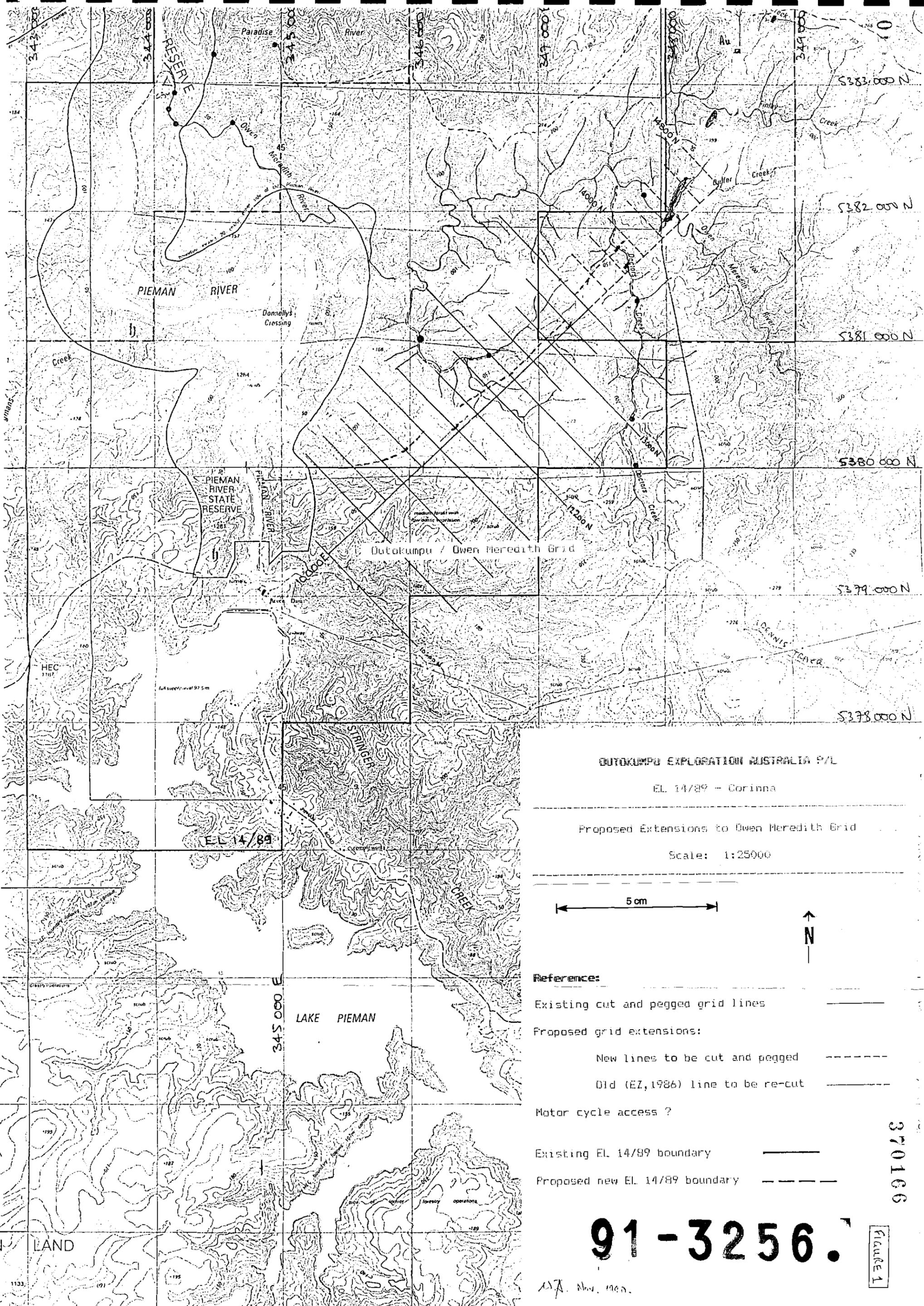
AUTHORISED OFFICER

370104

PANNED CONCENTRATE SAMPLES, A114251 -114279

Visual estimates of sample composition:

Sample No:	Quartz %	Lithics %	Magnet. %	Hemat. %	Pyrite %	Gold
A 114251	30	-	30	20	20	2 wiry specks
53	10	-	70	15	5	-
55	15	10	70 (part ox.)		5	-
57	10	5	80	"	5	1/3mm, 2/1mm
59	90	5	2		3	-; 1/0.5mm Cu
61	95	4	Trace		1	-
63	99	-	-	-	0.2	-
65	90	10	No significant heavies			-
67	90	10	"			-
69	90	10	One or two fine, translucent reddish-pink grains, possibly garnet or cassiterite.			-
71	90	10	Trace			-
73	60		38, part ox.			2/1mm; 1/0.5mm
75	80	10	9 "			1 few fine specks
77	70	20	9 "			1 -
A 114279	5		90 "			5 few fine specks

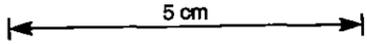


OUTOKUMPU EXPLORATION AUSTRALIA P/L

EL 14/89 - Corinna

Proposed Extensions to Owen Meredith Grid

Scale: 1:25000



References:

- Existing cut and pegged grid lines —————
- Proposed grid extensions:
 - New lines to be cut and pegged - - - - -
 - Old (EZ, 1986) line to be re-cut - - - - -
- Motor cycle access ?
- Existing EL 14/89 boundary —————
- Proposed new EL 14/89 boundary - - - - -

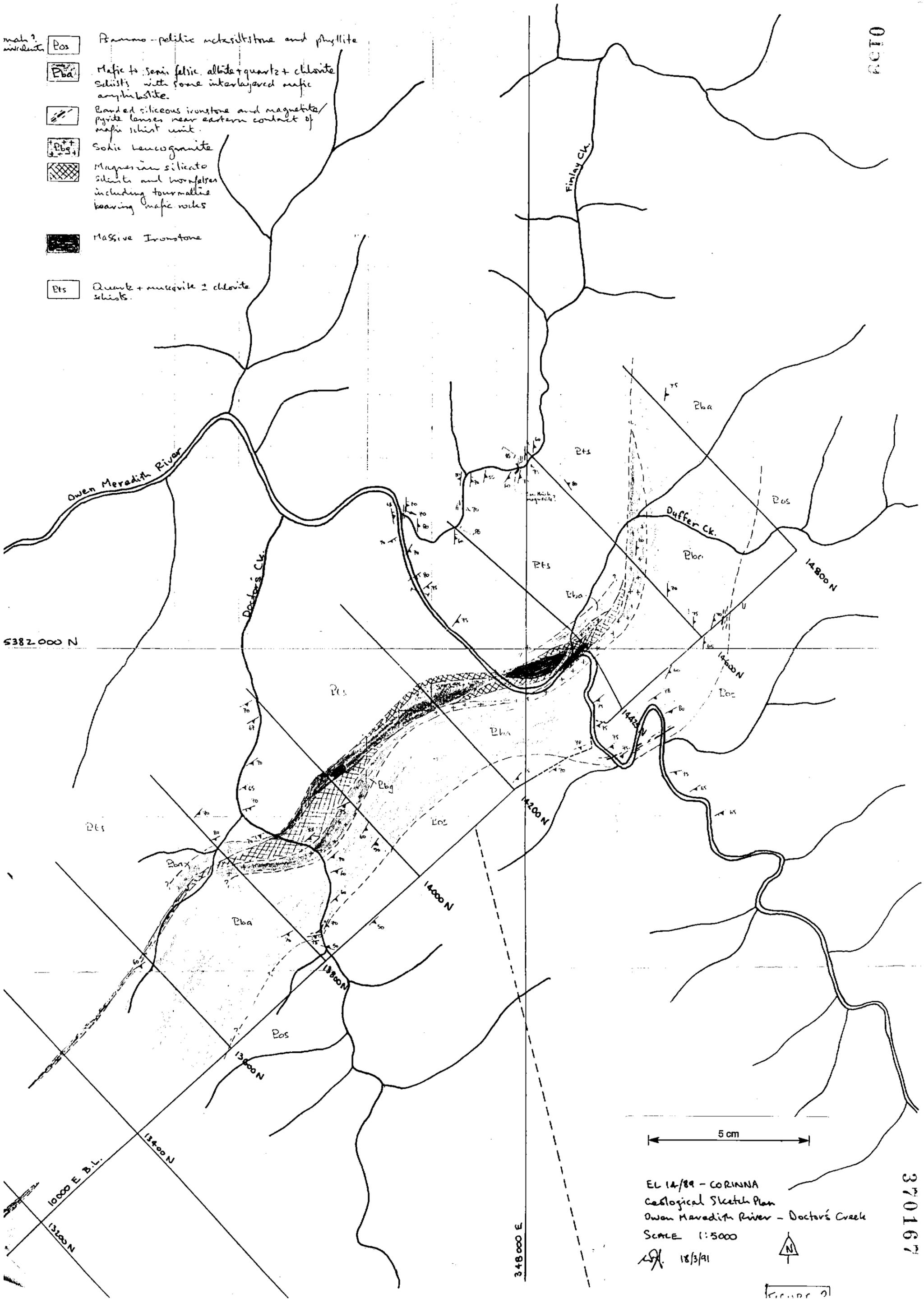
91-3256.

370166

Figure 1

117 Nov. 1989.

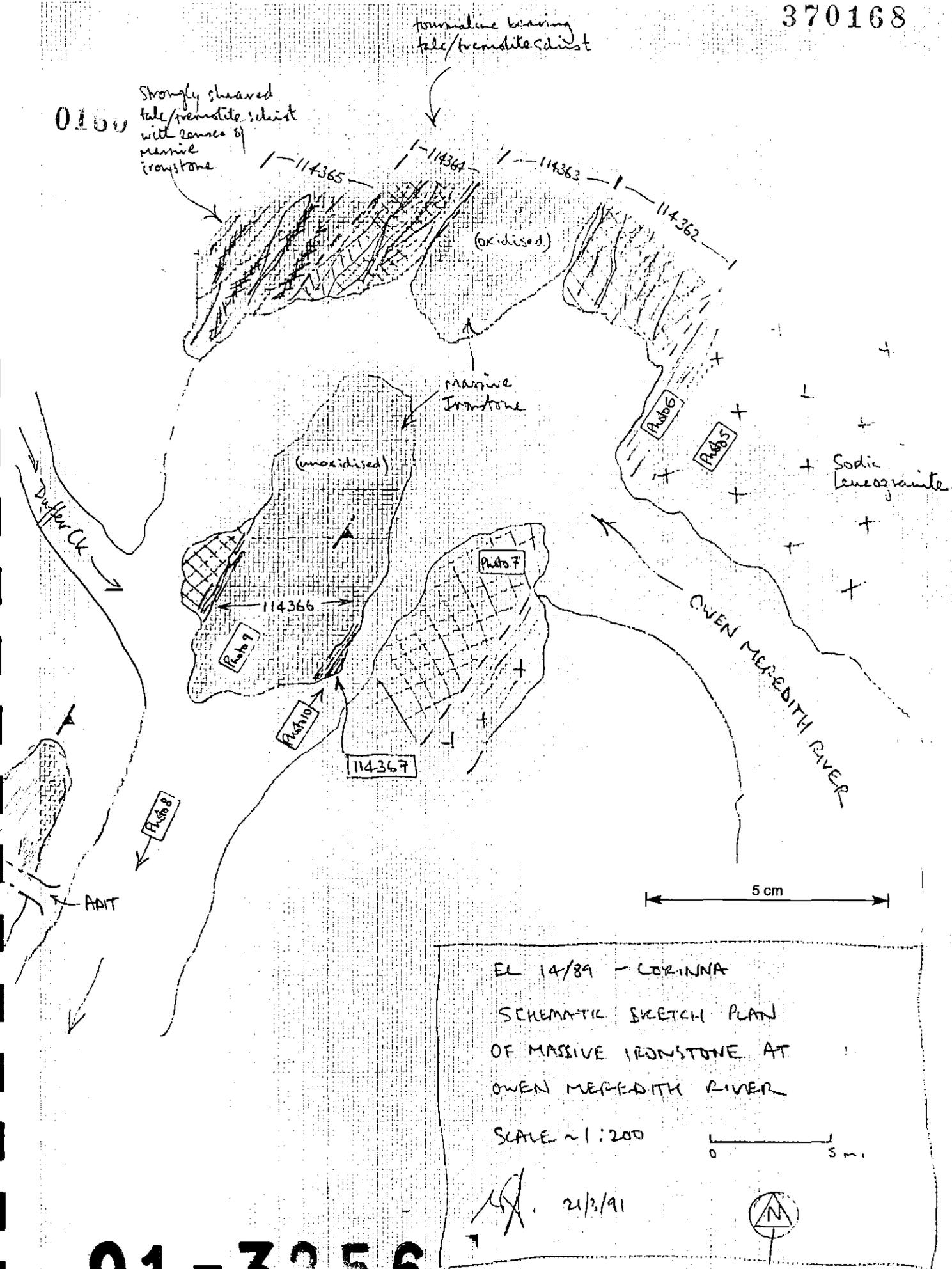
- mal? Pos Basal - pelitic metasilstone and phyllite
- Pba Mafic + semi felsic, albite + quartz + chlorite schists with some interlayered mafic amphibolite.
- Pbs Banded siliceous ironstone and magnetite/pyrite lenses near eastern contact of mafic schist unit.
- Pbt Sodic leucogranite
- Pbc Magnesian silicate schists and hornfelses including tourmaline bearing mafic rocks
- Pbi Massive Ironstone
- Pts Quartz + muscovite ± chlorite schists.



5 cm

EL 14/89 - CORINNA
 Geological Sketch Plan
 Owen Meredit River - Doctor's Creek
 SCALE 1:5000
 18/3/91

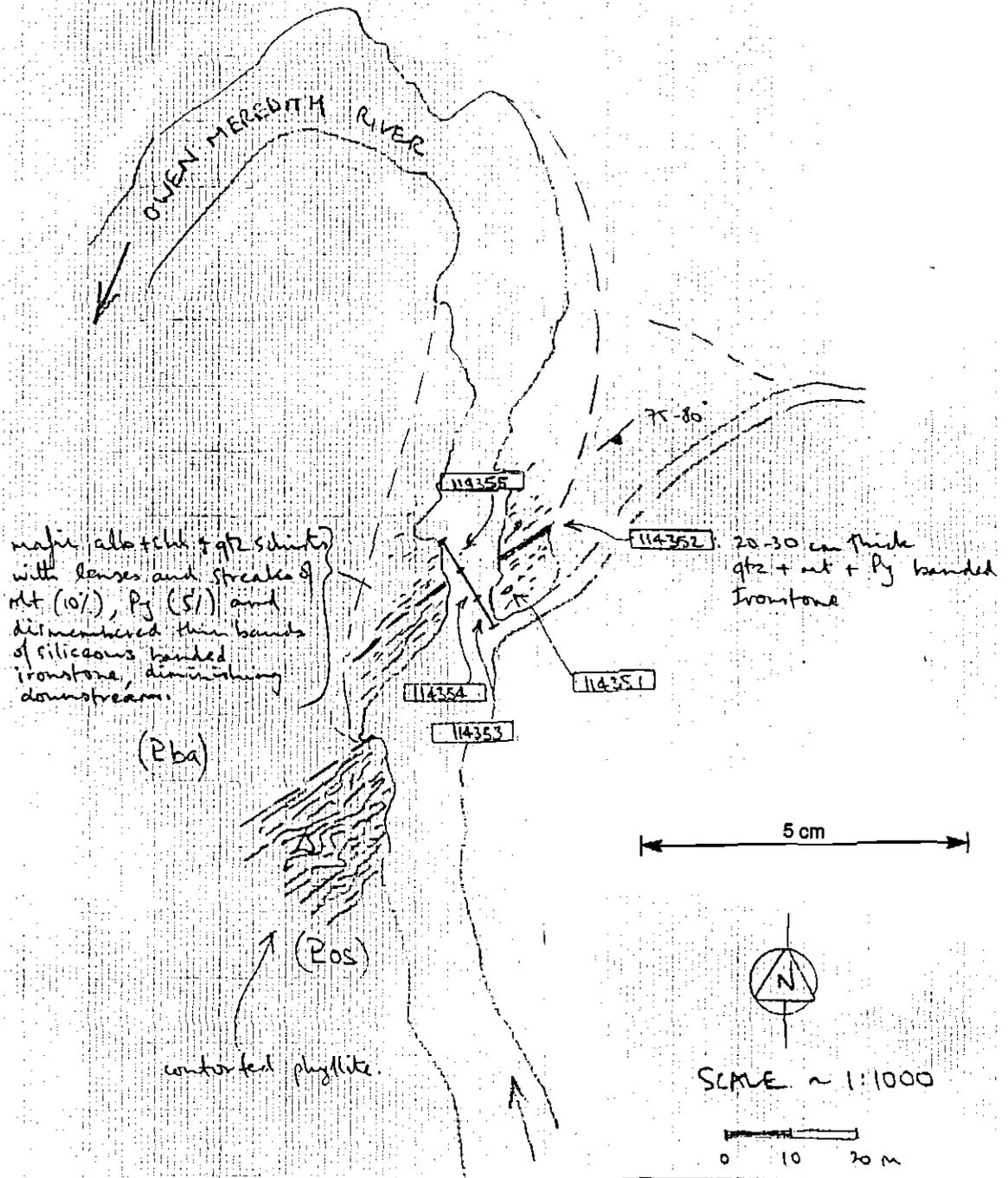




91-3256.

FIGURE 3

01500



91-3256.1

EL. 14/89 - CORINNA
 SKETCH GEOLOGICAL PLAN
 SHOWING ROCK CHIP SAMPLE
 LOCATIONS AT EASTERN CONTACT
 OF (BOWBY) MAFIC SCHISTS IN
 OWEN MEREDITH RIVER
 21/3/91

0163

199

Duffer

191

DUGGS
CREST

CREST

5 cm

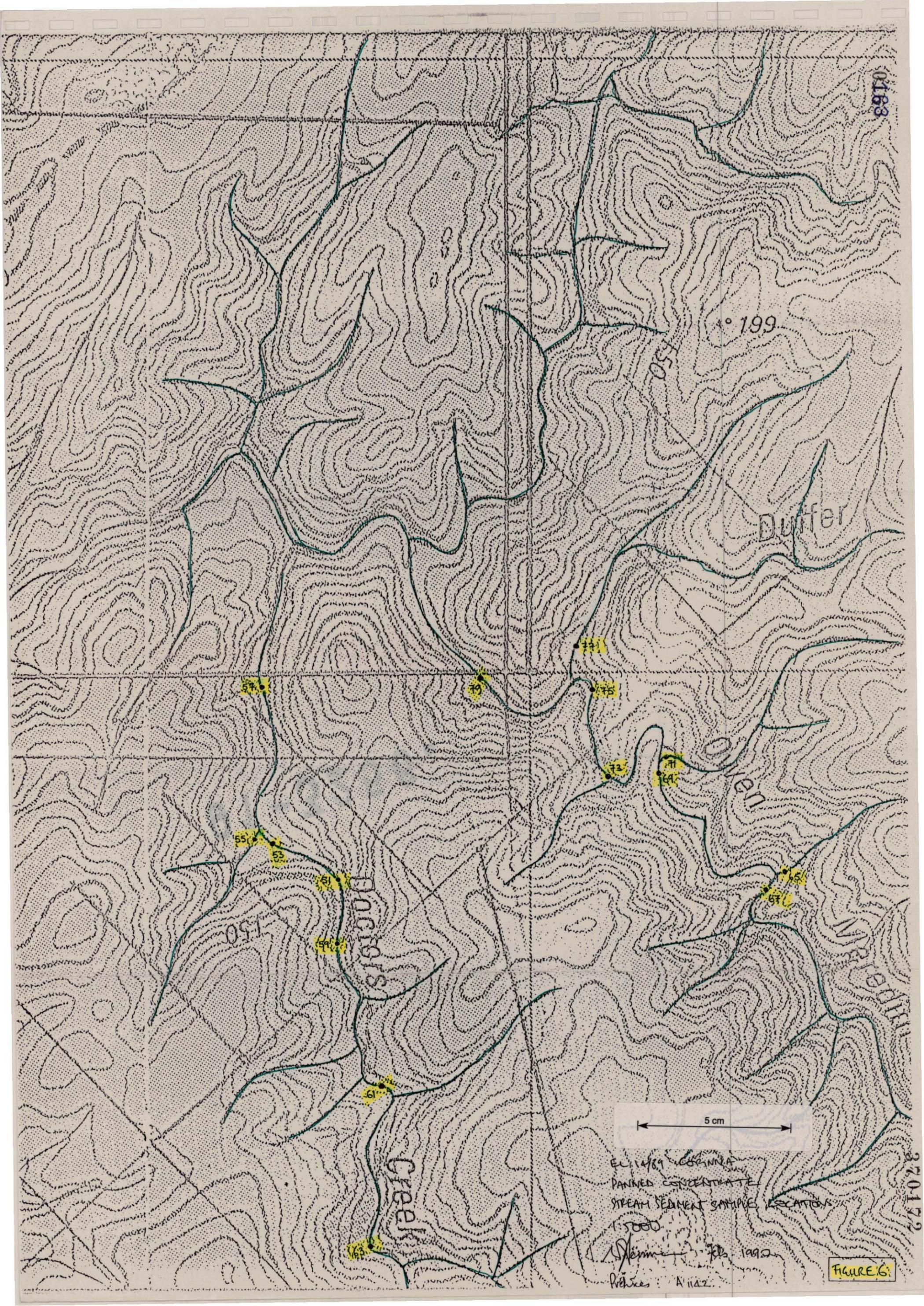
EL. 1489 CORNIA
PANMED CONCENTRATE
STREAM SEDIMENT SAMPLE LOCATION
1:5000

A. J. J. 1992

Princes A 1142

FIGURE 6

320172



APPENDIX 3

Report on the Petrographic Examination of
Ironstones and Associated Metamorphic Rocks
from the Arthur Metamorphic Complex, NW Tasmania

0153

OUTOKUMPU EXPLORATION AUSTRALIA PTY LIMITED

370174

Report No: R72.6
File No: 2.72.9

REPORT ON THE PETROGRAPHIC EXAMINATION
OF IRONSTONES AND ASSOCIATED METAMORPHIC ROCKS
FROM THE ARTHUR METAMORPHIC COMPLEX,
NW TASMANIA

For: Outokumpu Exploration Australia Pty Limited
77 Pacific Highway, NORTH SYDNEY NSW 2060

By: Joe Stoltz, Department of Geology, Univ Tasmania

Date: 26 November 1990

DISTRIBUTION:

1. OEA library
2. W. Herrmann

REPORT ON THE PETROGRAPHIC EXAMINATION OF IRONSTONES
AND ASSOCIATED METAMORPHIC ROCKS FROM THE ARTHUR
METAMORPHIC COMPLEX, NW TASMANIA

: Including material from the Alpine and Owen Meredith Projects.

For: Outokumpu Exploration Australia Pty Ltd
77 Pacific Highway, North Sydney NSW 2060.

By: Joe Stolz

Department of Geology
University of Tasmania
GPO Box 252C,
Hobart Tas 7001.

November 26th 1990.

The Owen-Meredith Area

OBJECTIVES

The specific aims of this study are to determine;

1. the nature of the amphibolites and their likely precursors; comparison with interpretations given by Minpet Services' previous petrographic report
2. the nature of the 'sodic granitoids', for example; is there any evidence for pre-, syn- or post-metamorphic origin? Does the tourmaline (in vein) have affinities with that of samples 104617, 104574?
3. the nature of the ironstones and the style of mineralisation, ie., pre-, syn- or post-metamorphism? Comparison with ironstones from the Alpine area
4. the nature of the tourmaline/actinolite schorls, and in particular, do these have any chemical/mineralogical association with the amphibolites, 'sodic granitoids' or banded/massive ironstones? Is there any textural evidence for a pre-, syn- or post-metamorphic origin?

RESULTS

Detailed petrographic analyses are presented in the following section for the samples previously described by Minpet Services, and an additional 7 samples from the Owen Meredith area provided by W. Herrmann. The mineralogical and textural relationships gleaned from examination of these specimens provide the basis for the following discussion of the problems listed above.

1. Nature of the Amphibolites.

A number of rocks examined by Minpet Services (including 104569, 104593 and 104594) were interpreted as metamorphosed calc-silicate assemblages. However, I would argue on the basis of their mineralogical and chemical characteristics that these rocks (together with 104587, 104580, 104591 and 104595) are regionally metamorphosed mafic volcanics.

The majority of these rocks exhibit similar mineralogical assemblages and proportions of phases. They are dominantly composed of albitic plagioclase, chlorite, amphibole, epidote, magnetite and sphene. Although broadly similar assemblages could be produced by metamorphism of impure limestones, the predominance of albitic plagioclase coupled with low whole-rock CaO in at least one specimen (eg. 104569 CaO = 0.21%) does not support a calcareous sedimentary precursor. The mineralogy of 104569 does not differ significantly from the other rocks considered by Minpet Services to be meta-sedimentary (eg. 104592 -

104594), and although no chemical data are available for those specimens, low CaO would be predicted.

Relatively high Na₂O and low CaO contents are consistent with seafloor alteration of a basalt prior to metamorphism, although some variation in the degree of alteration will result in a range of Ca/Na ratios.

The major elements (particularly Na₂O, K₂O, CaO and MgO) are susceptible to modification during metamorphism, hydrothermal alteration and weathering and hence can be misleading when interpreting precursor compositions. However, Ti and Zr are relatively immobile, except perhaps during intense hydrothermal alteration, and can provide a useful means of identifying precursor lithologies. A plot of Ti versus Zr for the Owen-Meredith host rocks (Fig. 1) indicates a fairly consistent Ti/Zr ratio which is in the range for typical basaltic rocks (ie. Ti/Zr > 60). Even if calc-silicate assemblages with similar Ti/Zr values exist, it is unlikely that a heterogeneous sedimentary sequence would have such consistent Ti/Zr values.

The compositions of tholeiites from the Smithton-Trowutta area (Griffin, 1974), and data for Cambrian Mt Read mafic rocks are plotted for comparison with the Timbs Group Metabasalts. The similarity of the Smithton-Trowutta basalts and those from the Bowry Member is striking, and both are clearly different from the Mt Read basalts. The latter were formed in a convergent margin setting whereas the Smithton and Bowry mafic rocks have compositions typical of continental tholeiites. Their similar compositions indicate they are likely to have formed in a similar tectonic setting, and provides tacit support for the idea that they represent the same sequence (Herrmann, 1989).

2. Nature of the 'Sodic Granitoids'.

The sodic granitoids (eg. 104566, 104596, 104598, 104638) consist dominantly of medium-grained aggregates of albite and quartz. All samples show evidence of moderate dislocation metamorphism. Plagioclase twin lamellae are invariably bent, whereas quartz exhibits undulose extinction and has undergone significant subgrain development. The latter feature has resulted in relatively large plagioclase porphyroclasts being set in a finer recrystallised quartz-rich matrix. Sample 104596 has experienced the most intense deformation, whereas 104598 retains the best textural evidence that these were originally even-grained and medium-grained intrusive rocks. Narrow, very localised zones of more intense cataclasis are evident in 104566 and these contain minor sericite which has grown in random orientations, thereby suggesting they represented a pathway for post-deformation K-bearing fluids.

The textural evidence indicates that the sodic granitoids were emplaced at least prior to the latest deformation, and some (eg. 104598) probably after the most intense phase of deformation which produced the amphibolite facies assemblages. More intense granulation of plagioclase (particularly in 104598) would be expected if it had experienced comparable levels of strain to these rocks. Nevertheless, 104596 contains some blue-green hornblende which is a prograde phase in the

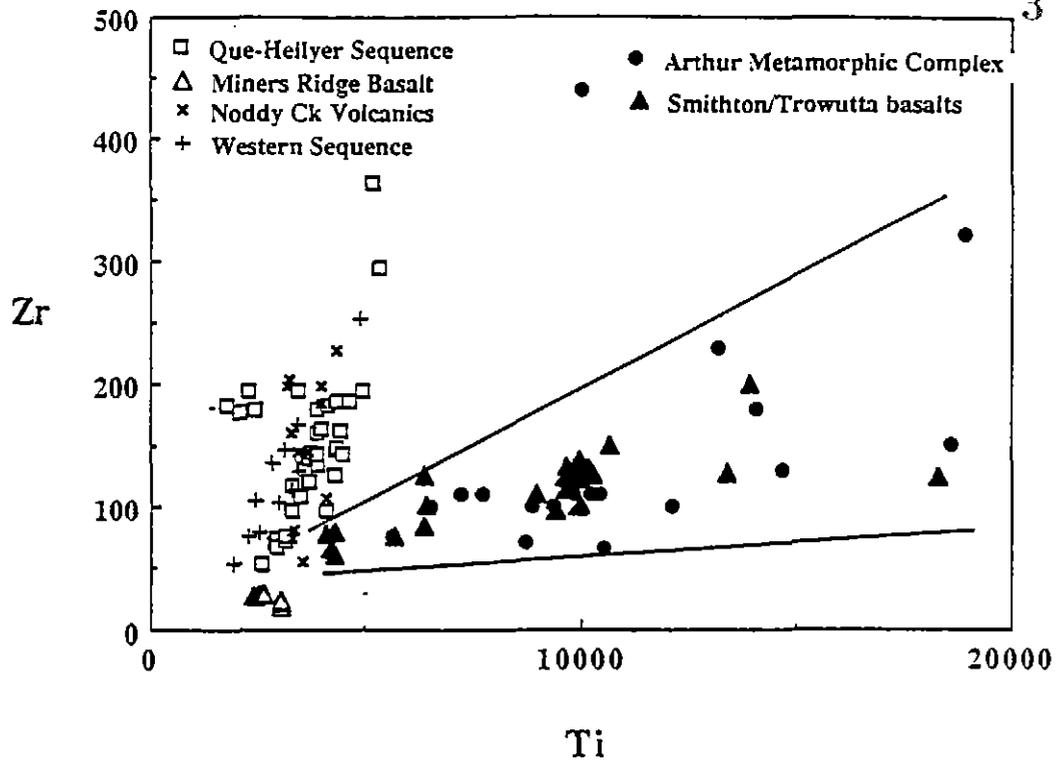


Fig. 1. Plot of Ti versus Zr for metabasaltic rocks from the Arthur Metamorphic Complex and the Smithton-Trowutta area showing their close similarity. Some Cambrian subduction-related volcanics from the Mt Read Volcanic Belt are plotted for comparison.

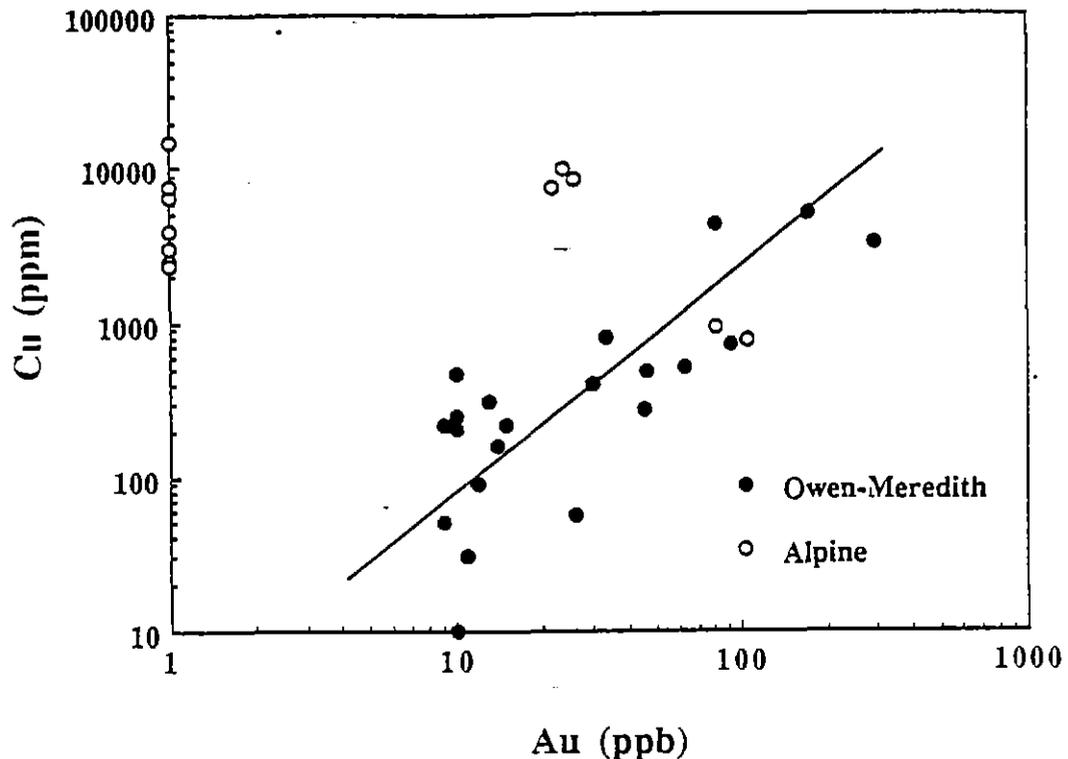


Fig. 2. Plot of Au (ppb) versus Cu (ppm) for ironstones from the Owen-Meredith and Alpine areas. There is a good positive correlation for the Owen-Meredith data, and a very poor correlation for the Alpine ironstones.

amphibolites, therefore suggesting that it was emplaced prior to the peak of metamorphism.

The vein tourmaline in sample 104638 has a very dark blue-green to tan coloured pleochroism which is consistent with iron-rich schorls associated with granitic rocks and pegmatites. On the other hand, the tourmaline in samples 104574 and 104617 has a pale green to yellowish pleochroism which is typical of relatively magnesian or dravitic tourmalines. This is consistent with the higher whole-rock MgO contents (eg. 104574, MgO = 6.2%) and the presence of co-existing tremolitic amphibole.

3. Nature of the Ironstones.

The three ironstone samples examined from the Owen-Meredith area (ie, 104581, 104586 and 105609) consist of interlayered quartz and magnetite-pyrite bands of varying thickness. The broader scale banding in these rocks probably reflects original bedding although in such highly deformed rocks it is difficult to be certain of this. For example, sample 104586 has essentially a mylonitic fabric with strongly recrystallised quartz occurring as elongate crystals, and very fine milled magnetite grains. The segregation of quartz and magnetite could therefore be partly due to differential shear and recrystallisation within the rock.

Pyrite occurs mainly in discrete bands associated with magnetite, and chalcopyrite is closely associated with the pyrite, sometimes occupying cracks and fractures in the pyrite and magnetite. The pyrite and magnetite generally appear to be in textural equilibrium and no evidence was found of pyrite replacing magnetite.

All phases in these rocks have experienced deformation, as evidenced by quartz deformation around annealed pyrite and by cracking in magnetite. Therefore the chalcopyrite-pyrite mineralisation was clearly present before the deformation. Although there is evidence in the host rocks for several episodes of deformation, the absolute timing of which is poorly constrained, the bulk of the textural evidence suggests that the mineralisation occurred prior to the peak of metamorphism and deformation.

The banded ironstones from the Owen-Meredith area are more siliceous than the massive magnetite-pyrite ironstones of the Alpine area. Massive ironstones apparently also occur in the Owen-Meredith area (Herrmann, 1990) but were not included in this study. The most significant differences between the ironstones from these two prospects relate to the nature of the host sequences, and the relative abundance of carbonate. The host sequence to the Alpine ironstones is a mixed psammitic-pelitic sedimentary sequence with some associated interbedded mafic volcanics. In contrast, mafic volcanics (now amphibolites or the retrogressed greenschist equivalents) appear to be more common in the host sequence to the Owen-Meredith ironstones.

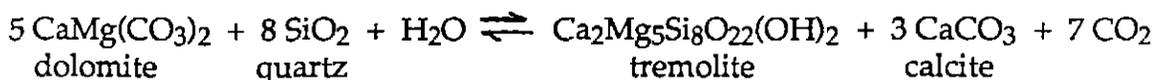
Carbonate is a relatively minor phase associated with both the ironstones and the host rocks in the Owen-Meredith area. However, the Alpine ironstones and host rocks are characterised by an abundance of carbonate. In the host rocks it replaces plagioclase, chlorite and magnetite,

whereas in the ironstones it extensively replaces magnetite and vice versa.

A discussion of the style of mineralisation is included with the discussion of the Alpine ironstones.

4. *Nature of the Tourmaline/Actinolite Schorls.*

The two tourmaline-tremolite/actinolite-rich samples (104574 and 104617) have similar petrographic features and undoubtedly formed in a similar manner. The major differences between the two samples relate to the evidence for some cataclasis and post-deformation recrystallisation in 104574 which is not apparent in 104617. Textural evidence suggests that tremolite/actinolite and magnetite in these rocks crystallised under low strain, contact metamorphic conditions, and this was followed by substantial replacement of the amphibole and magnetite by tourmaline. There is evidence in 104574 that it was affected by mild cataclasis resulting in some granulation of tourmaline and recrystallisation of amphibole. Coarse tremolite-rich veins (free of tourmaline) appear to be due to open space filling by dolomite and quartz followed by contact metamorphism. The inferred reaction for the development of tremolite is as follows;



The above sequence of events implied by the textural relationships suggests that the crystallisation of tourmaline was due to the metasomatic addition of Fe- and B-rich fluids, probably from a granitic source.

The composition of the precursor material is more difficult to ascertain. Limited chemical data supplied by Wally Herrmann indicates that 104574 has Ti and Zr concentrations (and a Ti/Zr value) similar to many of the metabasalts from the Bowry Member of the Timbs Group. This suggests a basaltic precursor. However, the mineralogy seems difficult to reconcile with this unless the basalt experienced significant carbonate alteration prior to metamorphism. There is considerable evidence for late widespread carbonate alteration in the Alpine area but this is not a feature of the samples examined from the Owen-Meredith area.

The bulk of the evidence favours the interpretation that these tourmaline-tremolite rocks are metasomatically altered carbonate-rich assemblages, and that they formed after the regional metamorphism. Some localised shearing, possibly associated with the emplacement of the Meredith Granite, may be responsible for the cataclastic textures in sample 104574.

The Meredith Granite itself may well be responsible for the contact metamorphic effects, and also have been the source for the metasomatic fluids which caused tourmalinisation. Greisens consisting of quartz-tourmaline-cassiterite occur along north-south zones in the Meredith granite and commonly show evidence of strained quartz (Stockley, 1972).

Tourmaline also occurs as fine veinlets in the sodic granitoid 104638 and is observed replacing plagioclase in 104590, and replacing

epidote and magnetite in 104594. All these samples have tourmaline with a blue-green to brownish pleochroism consistent with a relatively Fe-rich schorl composition. The paler colours in the tourmaline from the tourmaline-tremolite rocks may indicate slightly more magnesian compositions due to reaction with a relatively Mg-rich host.

The tourmaline in all samples appears to have formed subsequent to the regional metamorphism and is interpreted to be from a common granitic source (ie, the Meredith Granite).

The Alpine Prospect

1. Nature of the Host Sequence.

As noted earlier the host sequence to the Alpine ironstones appears to contain a greater sedimentary component than the host of the Owen-Meredith ironstones which appear to be predominantly mafic volcanics. The pre-metamorphic sedimentary sequence comprised interbedded quartzo-feldspathic rocks, pelites, and possibly volcaniclastics derived from basaltic volcanism.

These rocks underwent regional metamorphism to mid-upper amphibolite facies with prograde assemblages of garnet-biotite-quartz in the quartzo-feldspathic rocks and garnet-amphibole-plagioclase in the basic volcanic compositions (eg AP2 82). Both assemblages have undergone partial retrogression involving breakdown of garnet, biotite and amphibole to chlorite. Some samples (eg. AP2 82) contain chlorite-rich bands several centimetres thick with albite porphyroblasts. These appear to represent zones of complete retrogression of the prograde assemblage, possibly facilitated by localised shearing.

The relict snowball structures in pseudomorphed garnet porphyroblasts from sample AP1 85.4 provide good evidence for the syntectonic growth of garnet in a medium undergoing simple shear or laminar flow along the foliation. Plagioclase porphyroblasts in several samples exhibit a similar feature, and there is widespread evidence of high strain which caused the granulation of feldspar and recrystallisation of quartz. This is best developed in thin mylonite zones.

2. Paragenetic Sequence in the Ironstones.

Pyrite and magnetite are mainly in textural equilibrium, and at the petrographic scale there is no evidence to support theories of sulfidation involving the replacement of magnetite by pyrite. Sphalerite and galena are only present in some sections from AP1, either as inclusions in pyrite (in textural equilibrium), or as larger grains in which euhedral pyrite has itself been included.

Chalcopyrite is the most obviously remobilised component having migrated into veinlets and fractures within magnetite and pyrite (eg. AP1 92.5). However, this is not surprising for such a ductile phase and does not provide good evidence for an epigenetic origin.

Unfortunately the low Au concentrations of the ironstones resulted in the absence of any observable free Au in the sections, so it is difficult to assess its association with the sulphide or oxide phases. However, a plot of Cu vs Au (Fig. 2) for the Alpine ironstones and Owen Meredith ironstones plus host rocks provides an interesting contrast.

There is a reasonable correlation between Cu and Au in the Owen-Meredith samples suggesting an association of chalcopyrite and Au in the ironstones. On the other hand, the correlation between Cu and Au is poor for the Alpine ironstones. Some of the Cu-enriched samples have relatively high Au, yet Au is below the detection level in the most Cu-rich sample (A104630, 1.5% Cu).

3. Timing of the Mineralisation.

A very strong tectonic overprint has affected all of the ironstones and the petrographic evidence from this study supports earlier work which argued that the mineralisation was in place at least prior to the most recent deformation event. This does not preclude the possibility that the mineralisation was emplaced during or following the main regional metamorphic event, and that a subsequent event produced the cataclastic textures.

Unfortunately the simple mineralogy of the ironstones does not result in any useful information about the maximum grade of metamorphism which they experienced. However, the high strain characteristics (mylonitic fabrics) in some of the ironstones would appear to have been generated during the main phase of deformation and prograde metamorphism which characterises the host sequence. Evidence for subsequent folding of this 'S₁' foliation is present in a number of samples in the form of small scale asymmetric folds with a crenulation cleavage which is often only weakly developed.

In summary, the textural evidence suggests that the ironstones were emplaced prior to peak metamorphism.

4. Style of Mineralisation

The general occurrence of the ironstones, their lateral continuity and strong stratigraphic control within the Bowry Member of the Timbs group provides strong evidence for a syngenetic origin. The conclusion from the textural relationships that the ironstones existed prior to the main phase of deformation and metamorphism also supports this interpretation.

There is no evidence of tourmaline or other phases closely associated with the ironstones which would be considered reliable indicators of the involvement of granitic fluids in the formation of the mineralisation. Further, the petrographic evidence indicates that the tourmalinisation is a very late (Devonian) feature associated with the Meredith Granite, and consequently much later than the pyrite-sphalerite-chalcopyrite mineralisation.

The best available analogue for this type of deposit appears to be the Starra exhalative BIF-Cu/Au deposit. Although the Alpine and

Owen-Meredith ironstones do not have anomalous Sn and W (as is the case at Starra), many do show anomalous Au (i.e. considerably higher values than normal background rock values of 2-5 ppb) which is a feature of the footwall alteration at Starra.

The nature of the footwall alteration, and specific enrichment and depletion characteristics appear to differ between different deposits of this style. For example, Trough Tank does not show the enrichment in Sn and W evident at Starra, but instead shows footwall enrichment in Ni, P, Mo and Co (Davidson, 1989).

Clearly, because of the intense deformation of the ironstones and their hosts, evidence for assymmetric footwall alteration would be difficult to identify. It is conceivable that because of their different competency the ironstones may have been tectonically relocated relative to their original stratigraphic hangingwall and footwall sequences.

The observations that regional metal enrichment seems to be typical of exhalatives is probably the most useful attribute from an exploration viewpoint. At Starra, W, Y and Sn extend beyond Au in any given ironstone (Davidson, 1989). Although these elements do not appear to be useful in the north-west Tasmanian ironstones, a more detailed geochemical study may help to identify other trace elements which are closely associated with the transport of Cu and Au in this particular system. This may help to focus exploration for the high-grade zones of mineralisation (if they exist) in these ironstones.

References

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- Griffin B.J. 1974. Cambrian Tectonism and Volcanism in the Smithton Basin. Unpubl. BSc. Hons. thesis, University of Tasmania, 164 pp.
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PETROGRAPHIC DESCRIPTIONS OF SAMPLES
FROM THE OWEN-MEREDITH GRID.

0177

SAMPLE 104566

Hand-specimen: medium to coarse grained weathered 'granitic' rock.

Thin-section:

Mineral	Percentage abundance (%)
plagioclase	70
quartz	30
zircon	<1
sphene	<1
limonite	<1
tourmaline	trace
muscovite	trace

Mineralogy: plagioclase occurs as intergrown xenoblastic to tabular crystals (0.5 - 3 mm) characterised by abundant lamellar twinning of both albite and pericline. The twin lamellae are invariably bent and display strained extinction. Quartz often occurs as finer recrystallised grains (0.1 - 0.2 mm) intergranular to the feldspars due to subgrain development and recrystallisation of larger xenoblastic crystals.

There are several large euhedral crystals of zircon (0.3 - 1 mm) and some smaller fractured grains, as well as fine granular aggregates of sphene.

The rock has experienced moderate levels of strain resulting in the recrystallisation of quartz and deformation of plagioclase lattices. There are at least two parallel well-defined crush zones which traverse the section. Quartz and feldspar have been extensively granulated and recrystallised in these narrow (0.2 mm) shear zones, and some fine variably oriented muscovite plus a trace of tourmaline also occurs. the lack of preferred orientation of the muscovite suggests that it is post-deformation in origin.

Genetic interpretation: the rock appears to be a sodic granitoid or trondhjemite. The chemical data ($K_2O = 0.10\%$ and $Na_2O = 5.63\%$) reflects the absence of alkali feldspar and together with the very low CaO (0.05%) indicates almost pure albite plagioclase.

SAMPLE 104569

0178

Hand-specimen: fine-grained metabasic rock rich in chlorite and amphibole with a moderate foliation.

Thin-section:

Mineral	Percentage abundance (%)
plagioclase	57
chlorite	30
amphibole	5
quartz	3
magnetite	2
pyrite	2
sphene	1
tourmaline	?

Mineralogy: xenoblastic to tabular albite porphyroclasts (some with simple twinning) occur in a matrix dominated by chlorite and blue-green amphibole. These mafic phases define a strong foliation which has experienced a second phase of folding resulting in small-scale asymmetric folds with a crenulation cleavage. The distinctive blue-green amphibole occurs as prismatic crystals and has a low birefringence and a very low negative $2V$ (probably $<10^\circ$). These optical characteristics are most consistent with a relatively sodic high-pressure amphibole of the glaucophane-riebeckite series. Unfortunately this could not be checked by microprobe as the machine was not functioning during the time of the study. However, by elimination, there are no obvious alternatives to this conclusion. The whole-rock chemistry ($\text{CaO} = 0.21\%$) supports the notion of a Ca-poor amphibole, and the optical characteristics are not consistent with it being one of the orthorhombic amphiboles.

Occasional crystals of biotite and muscovite are associated with elongate pods of recrystallised quartz and minor biotite occurs intergrown with chlorite in the matrix.

Magnetite occurs as elongate laths and as xenoblastic grains and aggregates. The former could be pseudomorphs after primary hematite, but it is more likely original magnetite octahedra have been broken up and strung out during deformation and recrystallisation. Pyrite occurs as discrete rounded or cubic grains, and although pyrite and magnetite are adjacent in several instances, there is no evidence for replacement of magnetite by pyrite.

Genetic interpretation: the rock appears to have been a porphyritic mafic rock with phenocrysts of plagioclase which has experienced very high strain during recrystallisation producing a strong foliation. A subsequent deformation resulted in small scale folding and cleavage development perpendicular to the original foliation.

01/8

SAMPLE 104574

Hand-specimen: very heterogeneous amphibole-tourmaline-rich rock with large (cm size) layers of tourmaline showing a somewhat brecciated or strained appearance.

Thin-section:

Mineral	Percentage abundance (%)
tourmaline	55
tremolite/actinolite	35
sphene	5
carbonate	2
magnetite	3

Mineralogy: The rock consists of some relatively large (2 mm) xenoblastic aggregates of elongate to stumpy tourmaline crystals. These larger aggregates of tourmaline may have replaced some primary phase such as feldspar, although there is no clear evidence for a precursor phase. There is some elongation of the tourmaline aggregates due to cataclasis, and narrow stringers (1 - 2 mm long) of carbonate and minor magnetite occur along grain boundaries.

This contrasts with coarse-grained idioblastic elongate crystals of tremolite which appear to infill fractures within the rock (Fig. 3). There is also a significant amount of carbonate (previously called sphene) associated with the tremolite which appears to be in textural equilibrium.

There are several shear zones through the tourmaline without tremolite which have resulted in some recrystallisation and there is a concentration of granular sphene and granulated magnetite along these zones (Fig. 3).

A fine-grained part of the section is dominated by finer-grained tremolite (0.1 mm) and magnetite porphyroblasts, in textural equilibrium with associated subordinate carbonate. Relatively large subidioblastic to xenoblastic porphyroblasts of tourmaline appear to be replacing this fine tremolite-carbonate matrix and magnetite porphyroblasts.

Occasional inclusions of tremolite in tourmaline are very rare, although some fine carbonate inclusions are observed.

Genetic interpretation: The fine grained tremolitic matrix appears to have formed by contact metamorphism in view of the lack of preferred orientation of elongate amphibole crystals. This matrix then appears to have been partly replaced by tourmaline. Mild deformation of the rock produced some cataclastic textures in the tourmaline and granulation of the tourmaline and magnetite. This appears to have been followed by introduction of dolomitic carbonate plus quartz as an open space filling. Subsequent contact metamorphism has resulted in the recrystallisation of the carbonate to produce tremolite and probably also some recrystallisation of tourmaline.

The fine tremolite in the groundmass appears to represent carbonate replacement of some pre-existing material such as a mafic tuff perhaps, which may have had phenocrysts that had been tourmalinised.

The reaction for the formation of tremolite is as follows;

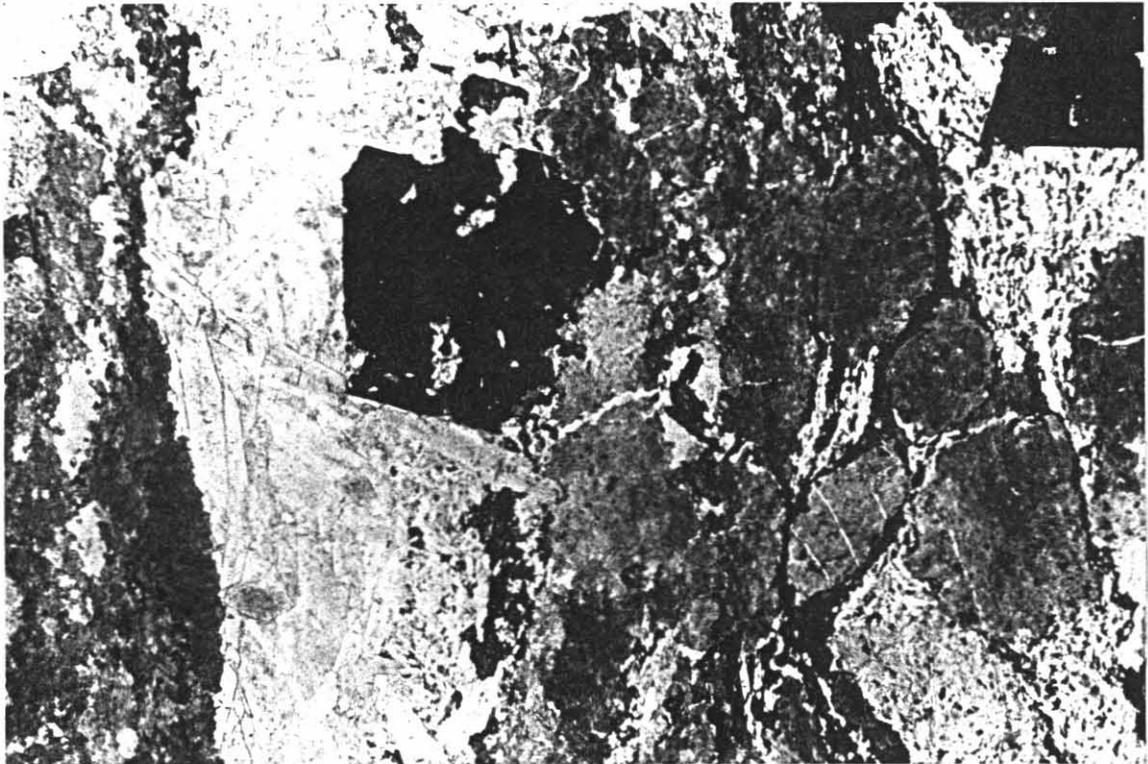
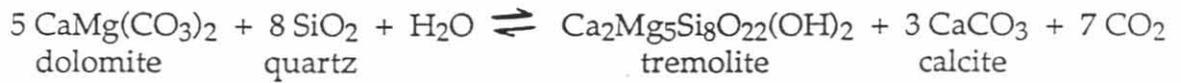


Figure 3. Shearing of tourmaline-rich layers in tourmaline-tremolite rock (104574) with trails of sphene, adjacent to an unstrained vein of tremolite with a magnetite porphyroblast. Magnification X50, PPL.

SAMPLE 104581

Hand-specimen: thin-banded (0.5 - 1 mm) quartz-magnetite-rich rock with dominant pyrite throughout.

Thin-section:

Mineral	Percentage abundance (%)
quartz	75
magnetite	20
pyrite	3
hematite	2
sericite	trace

Mineralogy: alternating relatively quartz-rich and magnetite-rich bands (0.5 - 1 mm wide). The quartz occurs as slightly elongate xenoblastic grains with extensively sutured margins. The larger grains (0.5 - 0.8 mm) exhibit undulose extinction and substantial subgrain development.

Relatively large octahedra (0.1 - 0.5 mm) of magnetite and pyrite are disseminated throughout the quartz-rich layers, occurring as single crystals and aggregates. The magnetite- and pyrite-rich layers appear to represent merely a greater concentration of similar shaped and size grains, although there may be a greater proportion of finer-grained magnetite in these layers. Minor oxidation of magnetite has resulted in minor replacement by hematite.

Genetic interpretation: This rock most likely represents an exhalative chemical sediment which has experienced regional metamorphism. The previous interpretation that it represents an original sandstone on the basis of cross-bedding seems doubtful. The rock has been subjected to considerable strain as evidenced by the nature of the recrystallised quartz and it seems unlikely that primary sedimentary structures would survive such intense recrystallisation.

0182

SAMPLE 104586

Hand-specimen: Very finely-banded quartz-magnetite rock, banding on the scale of 0.08 mm.

Thin-section:

Mineral	Percentage abundance (%)
quartz	80
magnetite	15
hematite	5

Mineralogy: there is moderate variation in grain size in this rock. Some relatively coarse-grained quartz-rich layers (1 - 1.2 mm long) occur with interstitial hematite and minor magnetite. These alternate with very fine-grained bands which consist of small elongate quartz grains (0.1 - 0.2 mm) with very finely disseminated octahedra or cubes of magnetite (0.005 - 0.01 mm) and some larger grains (0.3 mm). These fine-grained zones represent zones of more intense cataclasis in which the magnetite grains have been severely milled (Fig. 4), and the quartz grains more strongly recrystallised.

Genetic interpretation: this rock has experienced very high strain and the cataclasis is mylonitic in character with significant evidence of rotation (Fig. 5). Although the broader banding depicted by alternating quartz and magnetite-rich layers could reflect original bedding, the intense nature of the dislocation metamorphism which has affected this rock suggests that much of the banding may be tectonic in origin.



Fig. 4. Banded siliceous ironstone (104586) showing the finer magnetite and recrystallised quartz in the more deformed layers. Magnification x50, PPL.

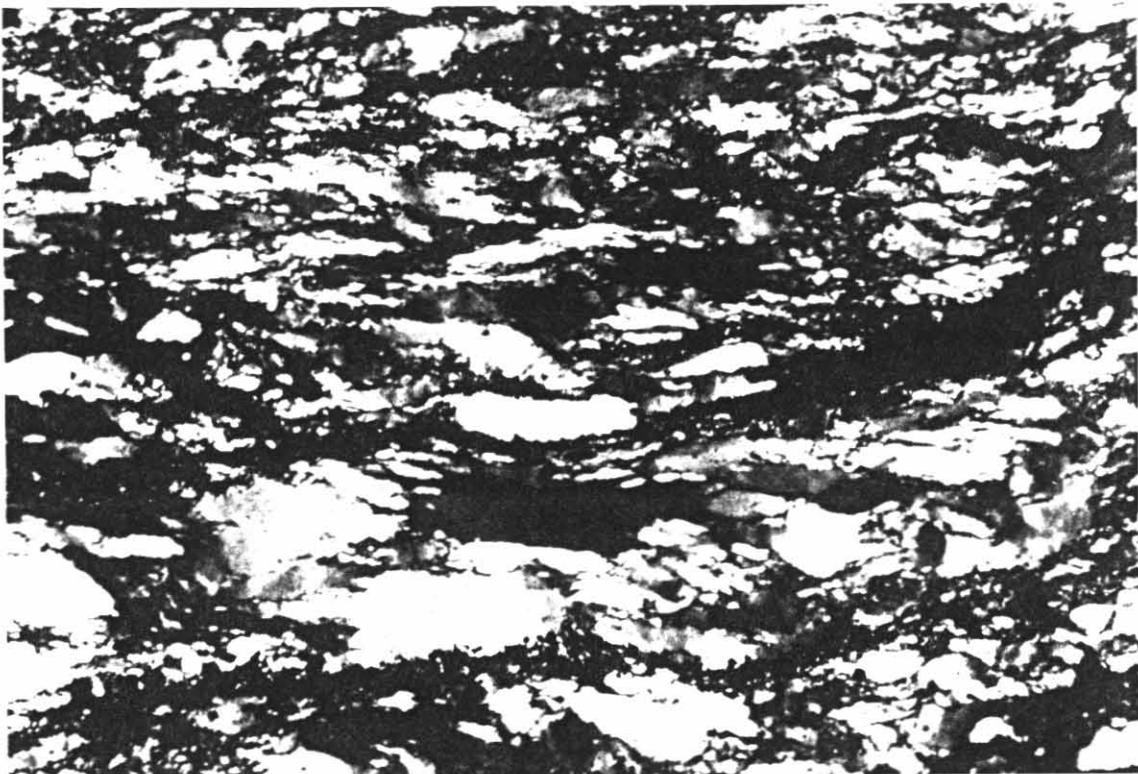


Fig. 5. Banded siliceous ironstone (104586) showing the highly sheared and recrystallised quartz. Magnification x50, PPL.

SAMPLE 104587

0184

Hand-specimen: metamorphic rock rich in chlorite, amphibole and feldspar, which exhibits a contact between a relatively dark coarser-grained zone and fine-grained zone. The contact shows some irregularity and may represent a bedding contact.

Thin-section:

Mineral	Percentage abundance (%)
albite	35
amphibole	50
quartz	5
chlorite	5
sphene	2
pyrite	1
apatite	1
biotite	1

Mineralogy: the section traverses a relatively coarse-grained zone and a finer-grained part which probably reflect original bedding in the rock. The finer-grained portion (0.02 - 0.05 mm) is dominated by granoblastic quartz, albite and amphibole. The latter also occurs as prismatic grains (0.5 mm long). Fine pyrite cubes and aggregates of fine granular sphene are scattered throughout. Minor sheaths of pale green chlorite occur sporadically. Within the fine grained zone there is some variability in the ratio of felsic to mafic components, probably also representing compositional variations in the original bedding.

There is a fairly sharp but irregular boundary between the fine and coarse bands. The relatively coarse material (0.1 - 0.3 mm long prismatic crystals) of albite, quartz and amphibole show granoblastic polygonal textures with individual or aggregate pyrite cubes within aggregates of granular sphene and chlorite patches. This is similar mineralogy and textures to the finer-grained layers, except that there is very little quartz in the finer-grained layers. Most of the colourless material is twinned or untwinned albite.

There are also some very coarse veins cross-cutting the coarse material. They are 2 - 3 mm wide veins rich in recrystallised twinned albite (0.5 mm) with coarse radial aggregates of chlorite and some green biotite (largely replaced by chlorite), interstitial quartz, minor apatite and pyrite cubes up to 0.4 mm (Fig. 6). Textures within the veins are also dominantly granoblastic polygonal, particularly the boundaries between quartz and albite.

Genetic interpretation: The polygonal equi-dimensional textures suggest contact metamorphic recrystallisation. The presence of actinolite suggests a relatively calcic composition which is silica-oversaturated. However, the presence of sodic plagioclase and the paucity of silica throughout the bulk of the rock suggests a mafic volcanic composition which has been contact metamorphosed. The vein material is largely introduced and the veins are where most of the silica is concentrated. The fluid which introduced the silica probably also added the sulphides although this is difficult to prove. One very fine quartz-chlorite-rich vein cross-cuts the coarse material.

01-11-71
Introduction of the vein material appears to have been pre- or syn-
contact metamorphism because of the observed textures. The fluids
produced dominantly quartz-albite-biotite-chlorite assemblages.



Fig. 6. A coarse vein of chlorite, albite, magnetite and biotite cross-cutting a metamorphosed mafic volcanic (104587). Magnification x50, PPL.



Fig. 7. Tourmaline (dark blue) replacing plagioclase porphyroclasts in a sheared mafic volcanic (104590). Magnification x 50, PPL.

SAMPLE 104588

Hand-specimen: banded rock with alternating layers rich in quartz, feldspar and amphibole. The mafic layers exhibit a boudin structure.

Thin-section:

Mineral	Percentage abundance (%)
albite	80
actinolite	10
quartz	6
Fe oxide	2
pyrite	1
sphene	1

Mineralogy: the rock is composed of alternating layers rich in quartz and feldspar and layers relatively enriched in actinolite with subordinate quartz and feldspar. The fine-grained matrix (0.02 - 0.05 mm) is dominated by albitic feldspar (both twinned and untwinned) which has broadly granoblastic textures. The quartz shows undulose extinction, some sutured margins and a partial elongation which imparts a weak foliation to the rock.

The twin lamellae on the twinned albite grains are often slightly bent and do not show uniform extinction. Small prismatic crystals of actinolite (0.05 - 0.15 mm) are scattered throughout the quartz-feldspar-rich layers together with anhedral granules of sphene, sparse disseminated cubes of pyrite (0.08 mm) and occasional rounded zircon grains. The actinolite needles display a very weak sub-parallelism with the foliation but it is certainly not well defined as there are many grains which appear to be oriented at a high angle to the foliation.

The relatively mafic-rich layers have an increased amount of actinolite, sphene and pyrite with lesser amounts of quartz and feldspar. The amphibole tends to occur in elongate pods or stringers. Fine-grained actinolite occurs as a variably oriented to sub-parallel aligned prismatic crystals of similar size to the grains in the feldspar-rich parts.

There is also a relatively coarse pod (which may be part of a vein) dominated by chlorite, quartz, albite, pyrite (up to 0.5 mm), sphene and with minor subordinate actinolite.

Some quite strongly aligned and narrow bands rich in actinolite, sphene, chlorite and pyrite seem to be related to shearing. These seem to be fracture zones along which some recrystallisation of amphibole and sphene has occurred and along which fluids have been introduced producing chlorite. These features are also often coated with limonite due to the breakdown of pyrite, and some pyrites show limonitic rims.

Some similarly oriented fractures have undergone open space filling of quartz, albite and actinolite needles. The latter two have grown with their long axes perpendicular to the walls of the fractures. There are also some oblique fractures running at a high angle to the general cleavage/lineation indicated by the finer actinolite. These oblique fractures (which may be perpendicular to the cleavage) are dominated by sphene and actinolite which has grown with its c-axis parallel to the fracture and uncontrolled by stress. Some of these are also filled with chlorite.

0158
Genetic interpretation: the rock appears to have been contact metamorphosed and subsequently subjected to moderate stress probably for a short time interval as many of the contact metamorphic textures are only partly modified. This rock appears to be more quartz-rich and generally more felsic compared to the previous sample (104587), which suggests a more felsic volcanic or volcanoclastic precursor. The predominance of sodic plagioclase (albite) does not favour a calcareous-siliceous sedimentary precursor. A Ca-rich dolomitic or calcareous sediment would typically have a high Ca/Na and hence plagioclase would be relatively calcic. Evaporitic sequences may be relatively Na-rich but these are usually also Cl-rich and scapolite is a common part of the metamorphic assemblage.

The Na-rich volcanics would presumably be produced by seafloor alteration if it was a sub-marine basalt. there is clearly some Ca in the rock though as actinolite and sphene are present, thus this process could not have been complete.

The presence of coarse pyrite in the quartz-albite-chlorite bands suggests introduction of the pyrite during the chloritic alteration. this appears to have been prior to the last deformation as chlorite is bent and the pyrite partly broken up. The quartz in these veins has sutured margins and does not retain evidence of contact metamorphism. Consequently the veins could have been introduced after the contact metamorphism but before the last deformation. The tension fractures filled with albite and fibrous actinolite appear to have formed last and possibly post-deformation as they cut across and disturb the foliation and shear-controlled actinolite foliation.

The coarse porphyroblasts of actinolite were also prior to the last deformation as they show some evidence of deformation and they are variably oriented i.e. not always in the general foliation some are perpendicular to this feature.

SAMPLE 104589

Hand-specimen: quartzite with some bands 2 - 3 mm wide relatively enriched in limonite.

Thin-section:

Mineral	Percentage abundance (%)
quartz	97
limonite	2
muscovite	1

Mineralogy: the rock is essentially a quartzite with a weak fabric due to the elongate crystals of quartz (0.2 - 0.3 mm) which have recrystallised in a moderate stress field. The quartz grains exhibit sutured margins and undulose extinction due to the stress. One patch of relatively fine-grained quartz (0.03 - 0.05 mm) has minor associated crystals of muscovite (1 - 2 mm long). These are bent and kinked indicating relatively low temperature deformation without significant recrystallisation.

There is a variability in the quartz textures which suggests that the deformation again was of limited extent and time. In some areas the quartz has a granoblastic polygonal form without sutured margins or undulose extinction and is only weakly deformed. This is consistent with recrystallisation under a pressure load that was equivalent in all directions as opposed to directed stress ie. contact metamorphism.

The last deformation does not appear to have been responsible for crystallisation of muscovite as the stress has caused translation of the cleavage in the muscovite at an angle of about 60° to the cleavage orientation. The muscovite shows minor staining by limonite around its margins and Fe-oxides have penetrated along quartz boundaries tending to occur in zones which represent fluid paths, These patches are unlikely to represent carbonate pseudomorphs.

Genetic interpretation: The rock was probably a quartz-rich sandstone which experienced moderate- to low-grade regional metamorphism resulting in the elongate quartz fabric and crystallisation of muscovite. Subsequent minor shear at low temperature has resulted in cleavage translation in muscovite and some recrystallisation of quartz.

0190

SAMPLE 104590

Hand-specimen: a strongly banded metabasic rock with alternating layers relatively rich in chlorite or quartz. The quartz appears to form stringers and lenses due to dislocation and dynamic metamorphism.

Thin-section:

Mineral	Percentage abundance (%)
chlorite	40
plagioclase	30
quartz	20
magnetite	1
tourmaline	<1
hematite	<1
muscovite	<1

Mineralogy: this is a very chlorite-rich rock. The chlorite-rich matrix consists of intergrown platy chlorite which has a strong foliation that has been partly disrupted by deformation subsequent to the major recrystallisation. Within the chlorite matrix some subhedral to rounded albitised plagioclase phenocrysts have been retained due to the differential shear characteristics of the two phases. Feldspar generally seems to survive deformation reasonably well. In one part of the section along a layer parallel to the shear direction, some of the plagioclase phenocrysts have been replaced completely by tourmaline or tourmaline and quartz (Fig. 7). The tourmaline is a deep blue-green colour typical of Fe-rich schorls associated with granites.

Other chloritic layers include variable amounts of elongate angular pods of recrystallised quartz. The angular character of the quartz aggregates appears to be due to a later deformation which has caused partial break up of the quartz aggregates and recrystallisation of some chlorite oblique to the main stress direction (Fig.8). There is also some micro folding which appears to support this evidence. Relatively large magnetite octahedra/euhedra are also present within the chlorite-rich layers.

There is also some muscovite which appears to have been produced before the second deformation event as it is intergrown with the chlorite and deformed within it. Some of the muscovite has also recrystallised in the fractured quartz aggregates with chlorite. The potassic metasomatism which has produced the muscovite was probably related to a granite and the same fluids which produced the tourmaline. The hand-specimen texture of the rock is due to the differential weathering and hardness of the quartz-rich pods in the soft chloritic matrix.

Genetic interpretation: the abundance of chlorite in this rock is more consistent with a mafic precursor unless some pre-metamorphic hydrothermal alteration has occurred. This rock would have experienced some seafloor alteration producing the sodic plagioclase. It may also have been somewhat silicified accounting for the abundance of quartz. This may have occurred at the same time as tourmalinisation of the feldspar and sericitisation (as indicated by the association of quartz and tourmaline).

0111

The elongate prismatic Fe-oxides are hematite or magnetite after primary hematite. These appear to have crystallised during the major deformation as they are quite strongly aligned in the primary cleavage.

0193

370200

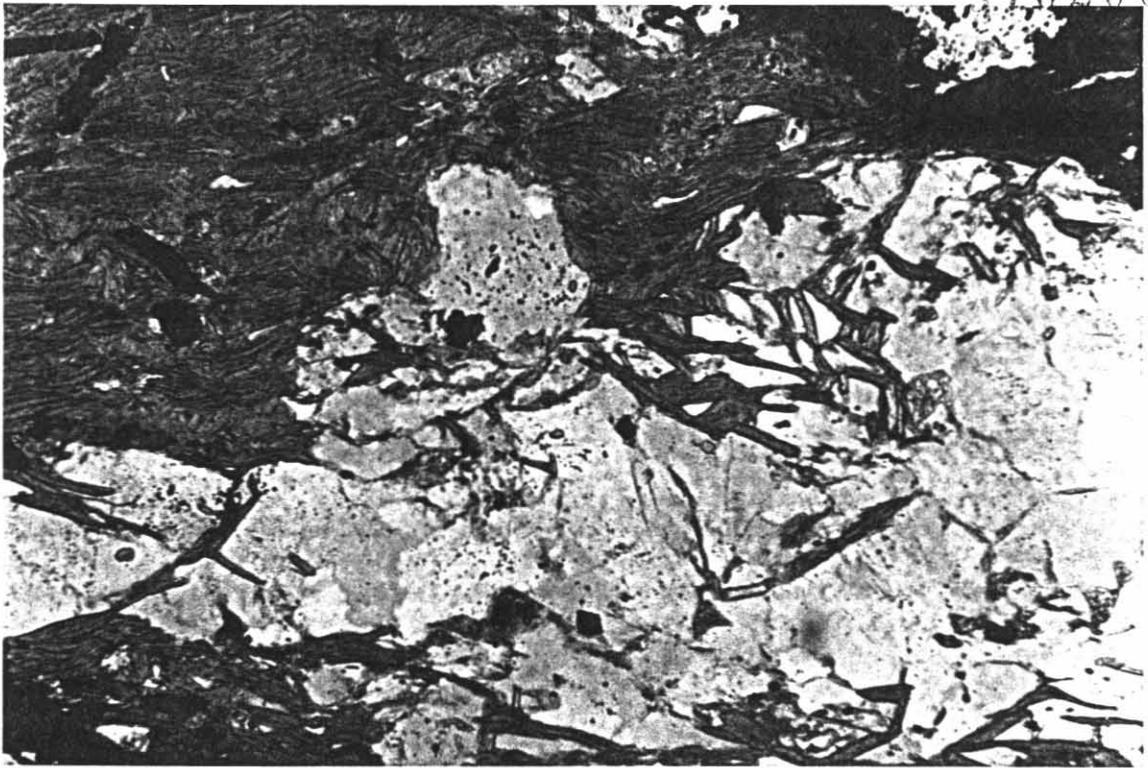


Fig. 8. Growth of chlorite oblique to the principal cleavage in fractured quartz following a second deformation. Sample 104590. Magnification x100, PPL.

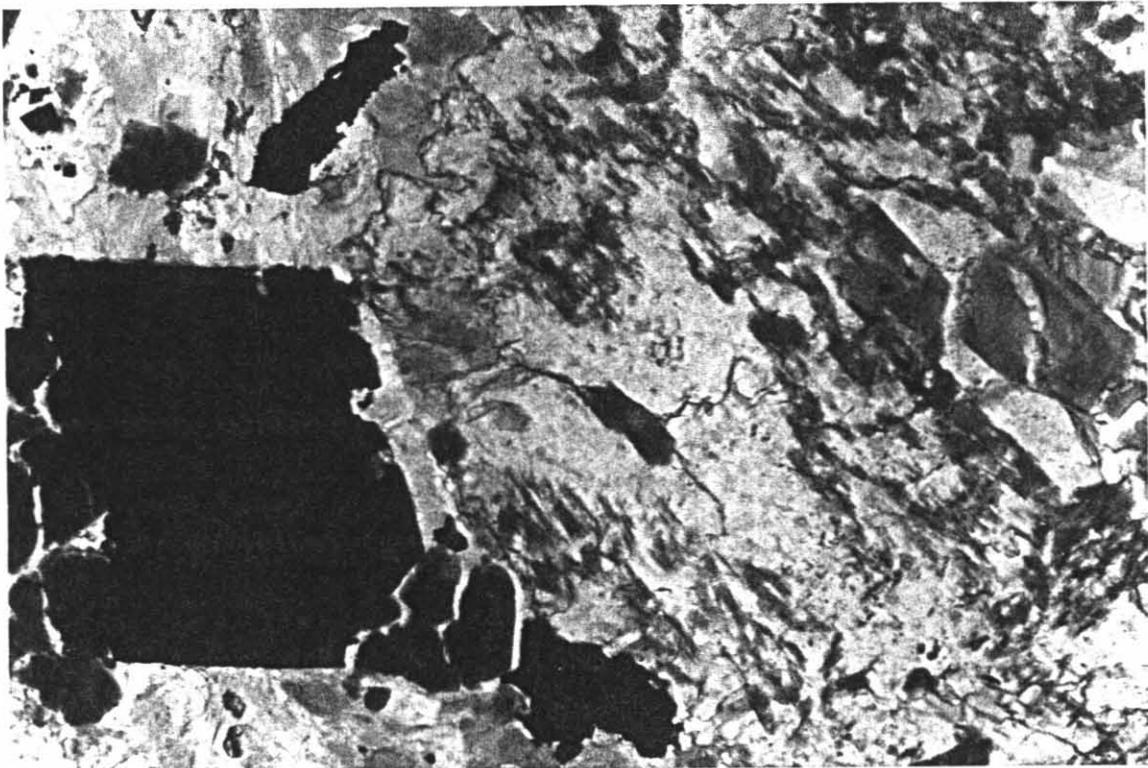


Fig. 9. Tourmaline replacing epidote and magnetite porphyroblasts in amphibole 104594. Magnification x200, PPL.

SAMPLE 104591

Hand-specimen: a weakly foliated metabasic rock with plagioclase and chlorite cut by a vein of feldspar and magnetite.

Thin-section:

Mineral	Percentage abundance (%)
plagioclase	55
chlorite	32
actinolitic amphibole	8
magnetite	4
tourmaline	<1

Mineralogy: tabular to equant crystals of plagioclase (0.1 mm) which often exhibit polygonal granoblastic texture are abundant, but with slightly sutured margins suggesting some stress. They may show simple, multiple or no twinning and twin lamellae are typically not bent. Plagioclase is sometimes intergrown in the groundmass with decussate chlorite aggregates but chlorite dominantly occurs in larger decussate clots (1 - 2 mm) which probably represent pseudomorphs after pyroxene. Most of these have ragged cores of blue-green amphibole which is partially chloritised resulting in some exsolution of fine magnetite.

A small amount of tourmaline euhedra occur throughout the rock but do not obviously replace other phases.

The rock does have a weak fabric defined by a slight flattening of the chlorite/amphibole aggregates, although individual crystals within the aggregates are not strongly aligned with this cleavage.

Xenoblastic patches of brown translucent material (possibly leucoxene), also exhibit a slight elongation (0.1 - 0.5 mm long) and these include relatively abundant magnetite octahedra or cubes (0.05 - 0.1 mm).

The euhedral, prismatic crystals of tourmaline show zoning from dark bluish-green cores to pale rims. They occur intergrown with chlorite and feldspar and do not appear to be replacing either of these phases.

The section is cut by several veins of relatively coarse albite which has grown as tabular crystals with their long axes perpendicular to the vein walls.

Genetic interpretation: this originally basic volcanic rock may have recrystallised initially under contact metamorphic conditions and was subsequently subjected to relatively minor dislocation metamorphism.

SAMPLE 104592

0191

Hand-specimen: a weakly foliated metabasic rock rich in chlorite, epidote and plagioclase with disseminated euhedral magnetite porphyroblasts and subordinate disseminated pyrite cubes.

Thin-section:

Mineral	Percentage abundance (%)
albite	60
chlorite	14
blue-green amphibole	10
epidote	8
magnetite	4
sphene	2
calcite	1
biotite	<1
tourmaline	trace

Mineralogy: the rock has a moderately strong cleavage defined by intergrown subparallel chlorite and blue-green amphibole crystals. These are moulded around rounded xenoblastic albite crystals (typically 0.1 - 0.3 mm across). Trails of aligned chlorite, amphibole or sphene inclusions within albite phenocrysts occasionally show evidence of rotation. Relatively large porphyroblasts or aggregates of epidote (typically 1 - 2 mm) show a yellowish-green to pale green pleochroism in grain margins and an unusual pale pink pleochroism in the crystal interiors which suggests a significant piemontite (Mn) component. Some epidote porphyroblasts appear to be aligned with the cleavage whereas others appear to be cross-cutting and may be associated with coarse crystals of calcite.

Magnetite occurs as octahedral crystals (0.3 - 1 mm) which may be partially enclosing feldspar, epidote or chlorite. Sphene occurs in well defined trails parallel to cleavage and closely associated with chlorite and amphibole. The magnetite porphyroblasts appear to have been preernt prior to metamorphism as the relatively large grains of chlorite have grown in adjacent pressure shadows, and the foliation often appears to wrap around them.

There is also a trace of deep blue-green (schorlite) tourmaline occurring in prismatic crystals which cross-cut the cleavage.

Genetic interpretation: the mineralogical and textural evidence suggests that this rock was a metabasalt which experienced strong dynamic metamorphism with consequent recrystallisation of albite, chlorite, amphibole and possibly some epidote.

The tourmaline appears to be due to metasomatic introduction of Fe- and B-rich fluids.

SAMPLE 104593

Hand-specimen: a fine-grained metabasic rock with abundant chlorite, plagioclase, epidote, magnetite porphyroblasts and minor disseminated pyrite.

Thin-section:

Mineral	Percentage abundance (%)
albite	65
chlorite	10
amphibole	10
epidote	8
magnetite	4
sphene	2
limonite	1

Mineralogy: this sample has essentially identical mineralogy to 104592, but is finer-grained. Texturally, this rock exhibits a less well defined foliation. Intergrowths of chlorite and prismatic amphibole crystals only show a very weak preferred orientation and many crystals cross-cut this general direction, as do elongate porphyroblasts of epidote (in aggregates). The boundaries of the feldspar with each other are sutured and while they may have been polygonal or porphyroblastic, subsequent recrystallisation in a weak stress field has modified these.

Euhedral porphyroblasts of magnetite (0.1 - 0.2 mm) appear to be late and cross-cutting. They rarely include epidote only. Albite is generally fine-grained (0.03 - 0.08 mm), whereas amphibole is typically larger (0.05 - 0.2 mm) and epidote porphyroblasts range up to 0.2 - 0.7 mm long. Sphene tends to occur as granular aggregates disseminated throughout the rock.

The specimen has been substantially fractured and veined. One particular vein is characterised by an abundance of relatively coarse epidote (0.1 - 0.5 mm) which is very similar to the epidote porphyroblasts. The vein also includes several small and larger (0.5 mm) magnetite euhedra which partially enclose epidote and albite. These appear to have grown across the vein and wall-rock. The vein has had some recent movement and fracturing which has resulted in a limonite filling, which has also fractured the epidote and magnetite. Another vein is dominated by relatively coarse chlorite, albite and magnetite. Again some late movement has fractured the magnetite with minor limonitic alteration.

Genetic interpretation: this does not appear to be as highly strained as 104592. The presence of epidote in the veins implies that some may have been introduced during metasomatism.

0193 SAMPLE 104594

Hand-specimen: foliated amphibolite with magnetite porphyroblasts.

Thin-section:

Mineral	Percentage abundance (%)
albite	50
amphibole	27
chlorite	8
epidote	5
magnetite	4
sphene	4
tourmaline	2

Mineralogy: this specimen has similar mineralogy to 104592 and 104593.

However it shows some quite different and variable textures. The bulk of the rock has a fairly unstrained appearance similar to 104593, although it is slightly finer-grained. Albite grains are typically 0.02 - 0.05 mm across and display a weak elongation. The mafic minerals appear to be slightly more abundant in this rock than 104593. The blue-green amphibole typically has actinolite overgrowths however the epidote does not exhibit the zoning that is apparent in 104592.

Subparallel alignment of intergrown amphibole and chlorite, with some trails of sphene define a weak metamorphic foliation. The rock also exhibits several narrow zones of high strain (1 mm to several mm wide). these zones are parallel to the cleavage and display several different features. One has abundant chlorite and magnetite, the latter appears to have been partially hematized and granulated and there is evidence for growth of sphene on these broken magnetite fragments. Several other bands have abundant chlorite and zoned crystals of tourmaline (0.3 mm long). Any magnetite in these zones exhibit reaction rims of hematite. Epidote occasionally grows in these rims and may be locally concentrated along the margins, although chlorite and tourmaline are generally dominant.

A wider zone shows evidence of higher strain with strongly aligned amphibole and chlorite and trails of sphene. The latter trace out a second deformation of small scale asymmetric folds with a crenulation cleavage. The amphibole and chlorite (0.05 - 0.1 mm long) host large porphyroblasts of epidote, tourmaline (0.5 - 1 mm) and magnetite. The latter appear somewhat more rounded and broken than those in the less strained portion of the rock.

Tourmaline is clearly replacing epidote porphyroblasts in places and possibly replacing magnetite although this is more equivocal (Fig. 9).

Genetic interpretation: the epidote and magnetite porphyroblasts appear to have been present in this metabasic rock during a high strain event. The magnetite shows less wrapping around by chlorite and amphibole than the epidote but may have survived due to its strength in a relatively soft deforming matrix (as feldspar does). The tourmaline definitely appears to be later, probably post-deformation.

Epidote and amphibole in this rock are also zoned. The amphibole varies from blue-green cores to actinolite rims and the epidote has yellow-green rims to more colourless cores. This is in the opposite sense to 104592.

SAMPLE 104595

Hand-specimen: foliated amphibolite with minor disseminated pyrite.

Thin-section:

Mineral	Percentage abundance (%)
amphibole	63
albite	20
epidote	8
sphene	6
magnetite	3
chlorite	<1

Mineralogy: this rock is relatively coarse-grained and enriched in mafic minerals compared with 104592 and 104594, and has experienced moderate to high strain. The amphibole in the rock is essentially all blue-green amphibole without the actinolitic rims present in the preceding samples. Chlorite is also only present in trace amounts indicating that there has been minimal retrogression of the higher grade assemblages.

Untwinned albite is intergrown with amphibole but is in relatively low abundance compared with the previous samples, and it typically occurs as slightly elongate grains with sutured margins. The elongate, prismatic amphibole crystals are generally strongly aligned depicting a moderate cleavage/lineation. However, there has been some refolding of the original cleavage into small scale folds.

Relatively large (1 - 2 mm long) stringers of sphene aggregates occur parallel to the foliation but also exhibit this refolding. These often have ragged cores of opaque material within them (probably ilmenite) which acted as nuclei for the crystallisation of sphene.

Xenoblastic aggregates of epidote (including grains 0.1 - 0.5 mm long) tend to be concentrated in feldspar-rich pods or bands, whereas the more mafic (amphibole-rich) layers contain the sphene. There are a few relatively large (1 mm long) porphyroblasts of amphibole which occasionally cut across the foliation direction. Porphyroblasts of magnetite (0.05 - 0.1 mm) are typically euhedral where not in contact with sphene aggregates. The magnetite seems to be finer-grained, more irregular and broken up in the highest strain portions of the rock.

The rock is cut by a vein of albite and amphibole. The albite has grown with the long axes perpendicular to the walls and the vein runs at a high angle to the foliation. Fibrous amphibole has grown across the vein from the walls, indicating that the vein may have been pre-deformation.

Genetic interpretation: The feldspar-poor nature of the rock indicates a very mafic basaltic composition, more so than samples 104593 and 104594.

SAMPLE 104596

Hand-specimen: banded quartzo-feldspathic with some relatively large plagioclase crystals in a finer matrix, and with minor chlorite.

Thin-section:

Mineral	Percentage abundance (%)
plagioclase	70
quartz	12
carbonate	5
epidote	4
chlorite	3
magnetite	3
amphibole	2
sphene	1
pyrite	trace

Mineralogy: this rock has experienced moderate to high strain. Relatively coarse (1 - 2 mm) xenoblastic crystals of sodic plagioclase (albite) with sutured margins occur in a matrix of finer (0.2 - 0.3 mm) xenoblastic to tabular plagioclase and extensively recrystallised quartz aggregates. The quartz occurs in elongate grains (0.1 - 0.2 mm long) with strongly sutured margins and shows strain extinction. The plagioclase often exhibits albite twinning and occasionally also carlsbad twinning. The twin lamellae are generally bent and display variable extinction.

Elongate quartz crystals are strongly aligned depicting a foliation which has been refolded in small scale folds. The quartz aggregates are often wrapped around larger plagioclase crystals which are regarded as porphyroclasts that have preferentially survived the granulation and recrystallisation under high strain.

Carbonate is a relatively abundant phase in this feldspathic rock and appears to be replacing plagioclase in part. Ferromagnesian phases include prismatic crystals of blue-green hornblende (0.1 - 0.4 mm long) and epidote (0.1 - 0.5 mm long), some of which are fractured and broken. Both these phases are aligned in the foliation direction and together with some retrogressive chlorite and trails of sphene help define secondary fold patterns.

Magnetite octahedra (0.1 - 0.2 mm) and aggregates of grains are scattered throughout the rock but in the higher strain zones the magnetite occurs as stringers and highly irregular elongate grains.

Genetic interpretation: this rock appears to have been some sort of sodic granitoid or trondjemite with no K-feldspar, abundant plagioclase and quartz and minor ferromagnesian phases. It has experienced moderate to quite high strain conditions during dislocation metamorphism that has resulted in a significant decrease in the grain size of some plagioclase and most of the quartz. However some relatively large plagioclase porphyroclasts have survived.

0199

SAMPLE 104597

Hand-specimen: banded quartzo-feldspathic rock with a foliation defined by chlorite-rich bands.

Thin-section:

Mineral	Percentage abundance (%)
plagioclase	70
quartz	15
chlorite	8
magnetite	3
carbonate	2
epidote	1
tourmaline	<1
muscovite	<1
zircon	<1
sphene	<1

Mineralogy: this sample is very similar in mineralogy and texture to 104596. It differs in the absence of amphibole and has lesser amounts of epidote. However, the textural features and grain size characteristics are closely comparable. Relatively large (1 - 2 mm) plagioclase porphyroclasts are preserved in a fine-grained matrix of plagioclase and extensively recrystallised quartz. Plagioclase twin lamellae are invariably bent with variable extinction (Fig. 10).

Chlorite is the dominant mafic mineral. It occurs as subparallel plates often wrapped around the larger plagioclase grains but still defining a foliation through the rock together with elongate aggregates of quartz. Epidote is a relatively minor phase which occurs partly replaced by chlorite and sphene aggregates and occasionally with minor muscovite.

Several euhedral crystals of zircon (0.1 mm) and zoned schorl-rich tourmaline (deep blue-green to brown pleochroism) are scattered throughout the rock, and sphene occurs in granular aggregates with chlorite and epidote. Magnetite octahedra are disseminated throughout but a considerable amount of the magnetite occurs as irregular elongate stringers due to granulation during dislocation metamorphism. Some show weak marginal alteration to hematite. Carbonate is abundant through the groundmass and is found partially replacing plagioclase.

Genetic interpretation: this rock appears to be closely related to 104596 and 104598. They appear to be oversaturated sodic intrusives with minor mafic minerals which were emplaced prior to the major deformational event. This deformation has resulted in significant granulation and grain-size reduction, plus development of a foliation in the rock.

0299



Fig. 10. Bent twin lamellae in plagioclase porphyroclasts, and fine recrystallised matrix quartz in deformed sodic granitoid 104597. Magnification x50, PPL.



Fig. 11. Albite, chlorite and apatite (pigmented with Fe-oxide) vein in metabasalt 104620. Magnification x50, PPL.

023

SAMPLE 104598

Hand-specimen: a medium-grained quartzo-feldspathic rock with a weak foliation.

Thin-section:

Mineral	Percentage abundance (%)
plagioclase	76
quartz	12
chlorite	5
biotite	2
hematite	2
sphene	2
zircon	<1

Mineralogy: this sample has similar mineralogical and textural characteristics to 104596 and 104597. However it appears to have experienced less intense granulation and a greater proportion of coarse plagioclase porphyroclasts have survived the deformation. Nevertheless, both the coarse and fine plagioclase and the matrix quartz have extensively sutured margins and display strain extinction. The plagioclase twin lamellae are invariably bent. In addition, elongate quartz grains in the matrix, together with platy chlorite, define a moderately strong foliation. Chlorite occurs in bands intergrown with biotite and granular aggregates of sphene, often wrapped around the larger plagioclase porphyroclasts.

A few prismatic crystals of zircon and tourmaline (0.1 - 0.2 mm) are scattered throughout the matrix. The tourmaline is zoned from blue-green cores to darker grey-green rims and appears to be a schorl-rich type. Hematite pseudomorphs after magnetite octahedra are disseminated throughout.

Genetic interpretation: this rock has had a similar history to the previous two samples and probably represents a related intrusive if not part of the same intrusive. Granulation has been less intense, hence the coarse and even-grained character of the precursor intrusive is more apparent in this sample.

EXTRA OWEN-MEREDITH SAMPLES

SAMPLE 104609

Thin-section:

Mineral	Percentage abundance (%)	Size (μm)
Quartz	70	500
Magnetite	20	40
Pyrite	3	150
Chalcopyrite	<0.5	150
Carbonate	trace	50
Goethite	5	
Covellite	<0.5	

Host-rock: a highly deformed rock consisting of interlayered quartz and magnetite-pyrite bands, up to 1 cm thick. The thicker of these have planar contacts which may well constitute bedding, whereas most of the thin (<1 mm wide) magnetite layers are interlaced and irregular, suggestive of syn-tectonic magnetite growth. Euhedral to subhedral pyrite particularly concentrates in the thicker magnetite bands, but is also present in disseminated form throughout the quartz bands. Chalcopyrite is confined to the thicker magnetite bands where it is disseminated within pyrite, but more commonly occupies cracks and fractures in pyrite and magnetite.

Deformation is mainly expressed via quartz. Quartz displays strong elongation, with new growth of fine polygonal quartz on the sutured contacts of larger quartz grains approaching a sub-mylonitic texture. Magnetite and pyrite have both experienced the deformation, as evidenced by quartz deformation around annealed pyrite and by cracking in magnetite.

Significant supergene oxidation has occurred concentrating on fine fractures. Limonite and goethite fill fractures adopting a mammillary form, and concentrically altering pyrite, magnetite and chalcopyrite. Covellite is distinctly replacing chalcopyrite in most instances. Cuprite may also be present, intergrown with limonite adjacent to chalcopyrite; this is difficult to verify because the two phases share similar petrographic features.

Genetic interpretation: All components have experienced the dynamic metamorphism. Some magnetite was precipitated and recrystallised in fractures during tectonism. The layered nature of quartz and magnetite is evidence that the rock developed as a sedimentary iron formation containing some pyrite and chalcopyrite, although this needs to be viewed in the context of the outcrop pattern. Oxidation of magnetite and sulphides is evidence of proximity to meteoric waters in the present day, or close to the bedrock water table.

SAMPLE 104617

Hand-specimen: a tourmaline-rich rock with no distinctive fabric.

Thin-section:

Mineral	Percentage abundance (%)
tourmaline	70
tremolite	30
magnetite	<1

Mineralogy: interlocking prismatic crystals of tremolite (0.3 - 0.5 mm long) which often exhibit simple twinning occur in the interstitial areas between large (1 - 2 mm) xenoblastic aggregates of tourmaline. The latter comprise aggregates of prismatic crystals which commonly display colour zoning from pale buff to blue-green cores to pale brown to dark brown rims. Sometimes the complete aggregate shows a rim of the darker brown pleochroic variety. Fine randomly oriented trails of granular sphene (0.1 - 0.2 mm) occur as inclusions within the tourmaline and also as slightly coarse aggregates with the interstitial tremolite.

The rock is largely devoid of opaques except for a few angular fractured grains of magnetite (0.1 mm).

Genetic interpretation: this rock has close mineralogical affinities with 106574, and although they have the mineralogical characteristics of skarn rocks, 104574 has a Ti/Zr ratio and concentrations of Ti and Zr (immobile elements) which suggest it had a basaltic precursor. Both rocks appear to have experienced extensive alteration by granitic fluids. the zoning in the tourmaline appears to be from a more magnesian core to a more Fe-rich composition. This change in composition possibly occurred in response to dilution of Mg in the original rock by relatively Fe-rich fluids.

SAMPLE 104620

Hand-specimen: amphibolite cut by a coarse vein of chlorite and albite.

Thin-section:

Mineral	Percentage abundance (%)
plagioclase	50
amphibole	45
sphene	3
magnetite	2
Vein	
albite	70
chlorite	25
apatite	4
biotite	1

Mineralogy: a very weak foliation is indicated by the preferred orientation of intergrown prismatic amphibole crystals (0.1 - 0.2 mm long) although there is some evidence of a second foliation direction perpendicular to the first. The amphibole is pleochroic from a deep blue-green to a buff colour, occasionally with narrow pale-green actinolitic rims.

Plagioclase is usually untwinned or rarely albite twinned, and occurs as small (0.05 - 0.1 mm) xenoblastic grains with slightly sutured margins. Sphene occurs in granular aggregates which are not significantly strung out or aligned. Euhedral octahedra of magnetite (0.03 - 0.1 mm) are disseminated throughout the rock.

The section is traversed by several coarse-grained veins rich in albite, chlorite and quartz with subordinate apatite and magnetite.

The plagioclase occurs as tabular crystals (0.3 - 1 mm) with albite twinning which is commonly bent indicating mild deformation since their emplacement. Chlorite occurs as decussate aggregates interstitial to the feldspars or in pods with minor associated green-brown biotite. Apatite occurs as large (0.5 - 2 mm) individual crystals with the feldspar but is distinguished by an unusual cloudy alteration (Fig. 11). This is the only occurrence of apatite observed in any of the rocks studied, and although uncommon, does occur as large hydrothermal crystals in the Mt Lyell ore body.

One of the veins also contains elongate quartz crystals with sutured margins that are oriented perpendicular to the vein walls. The veins are clearly cross-cutting the host amphibolite and the lower apparent strain levels they have experienced suggest a late-deformational timing for their emplacement.

A few porphyroblasts of magnetite occur within the veins and several straddle the boundary between the vein and the host minerals, suggesting that this coarse magnetite crystallised very late.

Genetic interpretation: this sample appears to be a metamorphosed mafic volcanic that has experienced several episodes of deformation and metamorphism to amphibolite facies grade. There seems to be minor evidence of retrogression in the form of actinolitic rims on some of the higher pressure-temperature amphiboles. This rock has not experienced the very high strain which characterises many of the other metamorphosed mafic rocks.

0205
SAMPLE 104635

Hand-specimen: banded amphibolite with alternating amphibole and plagioclase-rich bands.

Thin-section:

Mineral	Percentage abundance (%)
albite	65
chlorite	20
quartz	15
epidote	5
magnetite	3
sphene	2

Mineralogy: tabular to xenoblastic porphyroclasts of plagioclase (0.1 - 0.3 mm) display subparallel alignment and are wrapped around by thin layers of intergrown chlorite which define a strong foliation. Elongate pods or aggregates of strongly recrystallised quartz grains also occur between layers relatively rich in chlorite which have associated prismatic crystals of epidote.

Magnetite occurs disseminated throughout the rock as elongate irregular grains and only rarely with octahedral outlines.

Genetic interpretation: this rock may have been a relatively evolved intermediate to mafic volcanic with a greater proportion of felsics to mafics than 104620. This specimen has also been subjected to much greater strain resulting in the substantial granulation of feldspar and magnetite and recrystallisation of quartz. Original higher grade phases (eg. amphibole) appear to have been completely retrogressed to chlorite and epidote.

SAMPLE 104636

Hand-specimen: quartz-feldspar-chlorite-muscovite schist.

Thin-section:

Mineral	Percentage abundance (%)
quartz	55
plagioclase	30
muscovite	10
chlorite	5
spene	<1
zircon	<1

Mineralogy: untwinned or simply twinned albite occurs in augen shaped aggregates which are draped by thin continuous bands (0.1 - 0.2 mm wide) of intergrown chlorite and muscovite. These bands are separated by layers of elongate quartz aggregates which have intricately sutured margins and undulose extinction. Individual feldspar grains in the aggregates often have aligned or curved rows of inclusions which indicate substantial rotation of the porphyroclasts during shearing.

Genetic interpretation: this rock could have been a quartzo-feldspathic sedimentary rock with interlayered pelitic bands or a granitic intrusive. The presence of relict plagioclase porphyroclasts is not definitive, however the relative abundance of muscovite would suggest a more potassic precursor than the sodic trondjemite intrusives such as 104596, 104597 and 104598. This rock has been subjected to very high strain and is very sheared. This is consistent with the field observations. However, the quartz- muscovite-rich mineralogy is more consistent with a sheared psammo-pelitic schist than a sheared mafic volcanic rock.

SAMPLE 104637

Hand-specimen: unfoliated amphibolite rich in amphibole and plagioclase.

Thin-section:

Mineral	Percentage abundance (%)
amphibole	55
plagioclase	25
epidote	10
chlorite	5
carbonate	3
garnet	2

Mineralogy: this rock does not display a foliation or any preferred mineral orientation. It consists of felted masses of prismatic amphibole crystals (0.1 - 0.5 mm and up to 3 mm long). The amphibole is pleochroic from deep blue to a buff colour with an intermediate pale lilac colour. Narrow rims of pale-green actinolitic amphibole represent a retrogressive phase. The blue-green amphibole in this case is probably a ferro-actinolite in view of its relatively high $2V$ ($\sim 70^\circ$), and high birefringence compared with the blue-green amphiboles from some other mafic schists which have optical characteristics transitional to glaucophane. The amphibole-rich aggregates also contain clots of decussate green chlorite, aggregates of pale brown idioblastic garnet and sphene (Fig. 12).

The remaining areas are dominated by untwinned plagioclase feldspar and abundant prismatic or granular epidote plus minor amounts of garnet. The plagioclase occurs as relatively large (0.3 - 0.5 mm) xenoblastic grains including the epidote and garnet, as well as some strongly zoned amphibole crystals. The epidote is also typically zoned having cores with a pink to pale brown pleochroism rimmed by narrow zones of more typical pale green to yellow pleochroic epidote. The cores are likely to be Mn-rich piemontites which would suggest that the garnets are also Mn-rich.

Genetic interpretation: the rock has experienced very little strain compared with 104636. In view of the close proximity of the samples in the field, their different textural features would suggest that 104637 was emplaced after the main deformation events. Alternatively it may represent a kernel of material that escaped the high strain which was preferentially taken up by the enclosing rocks.

It is difficult to determine from the mineralogy alone whether the precursor of this rock was a mafic volcanic or intrusive or some sort of calcareous metasediment. Some geochemical data (eg. Ti/Zr values) would help resolve this problem. However, the presence of Mn-rich epidotes and probably Mn-rich garnets would suggest some metasomatic modification of the rock, as these are both common skarn-related phases.



Fig. 12. Aggregate of idioblastic garnet crystals with blue-green amphibole, epidote and chlorite. Sample 104637. Magnification x100, PPL.

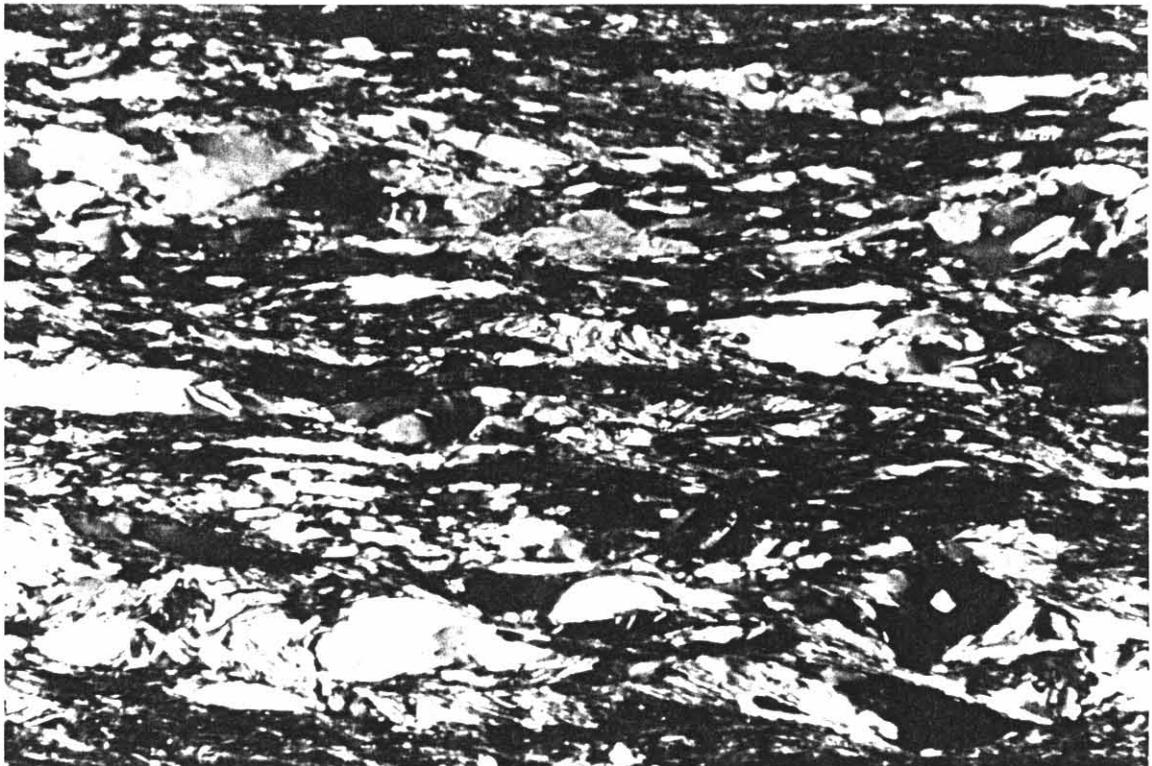


Fig. 13. Transposition of an early cleavage by the horizontal cleavage, delineated by the parallel platy muscovite and chlorite. Sample AP1 70.7. Magnification x100, CPL.

SAMPLE 104638

Hand-specimen: leucocratic medium grained silicic intrusive rock with minor disseminated magnetite, pyrite and tourmaline veins.

Thin-section:

Mineral	Percentage abundance (%)
plagioclase	65
quartz	30
magnetite	1
chlorite	1
sphene	1
zircon	<1
Vein	
tourmaline	2

Mineralogy: this sample consists of xenoblastic to tabular plagioclase crystals (0.3 - 1 mm long) which have albite twin lamellae that are bent and hence exhibit variable extinction. The plagioclase crystals often have sutured margins and if not intergrown are typically separated by fine aggregates of recrystallised quartz. The quartz exhibits strain extinction and tends to occur in elongate aggregates with a consistent preferred orientation.

Other intergranular phases include minor prismatic crystals of blue-green amphibole (0.1 - 0.2 mm long), aggregates of chlorite and sphene and idiomorphic zircon crystals. Octahedral crystals of magnetite (0.1 - 0.2 mm) are also disseminated throughout.

The section is also transected by two veins of tourmaline (0.1 - 0.3 mm wide). The tourmaline shows concentric colour zoning in sections normal to the c-axis from greenish brown margins to almost black in the core. The pleochroism is from dark greenish-brown to a reddish-brown. Introduction of the tourmaline has caused some oxidation of the magnetite porphyroblasts to hematite. Several prismatic tourmaline crystals appear bent and have therefore probably experienced some dislocation metamorphism. The bulk of the rock has experienced moderate levels of strain resulting in the recrystallisation of quartz and destruction of any primary igneous textures.

Genetic interpretation: This particular sample is very similar to the other 'sodic granitoid' samples described by Minpet Services (and again in this report) ie. 104566, 104596 - 104598.

The tourmaline in this sample is similar to that occurring in veins within 104598, however the different pleochroism in samples 104617 and 104574 suggest a different composition, probably more magnesian. This would be consistent with the reaction of the introduced fluids with a moderately Mg-rich basaltic precursor, in contrast to the Mg-poor sodic granitoid host. The inferred Fe-rich schorl composition of the tourmaline from the granitoids would reflect the Fe-rich nature of the introduced fluids. This is the most common type of tourmaline developed around granitic intrusives, and these veins may in fact be derived from late-stage fluids evolved from unconsolidated parts of the same intrusive.

PETROGRAPHIC DESCRIPTIONS OF IRONSTONES
AND HOST ROCKS FROM THE ALPINE AREA.

SAMPLE AP1	70.7 m
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Hand-specimen: quartz-muscovite-chlorite schist.

Thin-section:

Mineral	Percentage abundance (%)
quartz	40
muscovite	35
carbonate	15
plagioclase	5
chlorite	5
pyrite	<1
zircon	trace
tourmaline	trace

Mineralogy: this is a strongly foliated rock consisting of layers relatively enriched in muscovite which alternate with relatively quartz- and carbonate-rich layers. Untwinned or simply twinned xenoblastic to tabular grains of plagioclase exhibit evidence of rotation and are wrapped by intergrown crystals of muscovite and chlorite. The muscovite-rich layers vary in thickness (up to 2.5 mm) and exhibit a strong preferred orientation or crenulation cleavage. They are separated by relatively quartz-rich layers in which the muscovite and chlorite are oblique to the dominant S_2 foliation and depict the refolded S_1 foliation (Fig. 13).

The presence of small scale kink folds in the muscovite-chlorite-rich layers which depict S_2 suggest the presence of a third minor deformation event.

The quartz-, feldspar- and carbonate-rich layers have abundant quartz occurring as slightly elongate and sutured grains with ubiquitous strain extinction. Some of the carbonate occurs as similarly elongate grains with strain extinction, however there are also some larger xenoblastic pods which exhibit no evidence of strain. These may have crystallised late-syn or post-deformation. Some unstrained carbonate appears to have been remobilised into late fractures which are oriented approximately perpendicular to the implied stress direction of the youngest deformation event. A few ring grains of tourmaline and zircon are scattered throughout the rock.

Genetic interpretation: the precursor to this specimen was probably a thin bedded mudstone/siltstone with alternating layers relatively enriched in quartz, feldspar and clays. The present banding is unlikely to reflect the original bedding, considering the rock has been subjected to quite high strain and multiple deformation and recrystallisation events.

SAMPLE AP1	77.0 m	Pyrite-filled vein , shear or band.	GJD
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Hand-specimen: A pyrite-filled vein or shear 1.5 cm wide containing small slivers of wallrock (with a sinistral shear sense to their shapes) hosted within a plagioclase-quartz-muscovite schist containing a moderately well-developed differentiation cleavage. Thin (2 mm wide) carbonate \pm pyrite veins anastomose at a high angle to the foliation. They do not cross-cut the pyrite zone.

Thin-section:

Mineral	Percentage abundance (%)	Size (μm)
Pyrite	80	150
Carbonate	20	80
Chalcopyrite	<0.5	<5
Sphalerite	~0.5	20-25
Pyrrhotite	<0.5	5-10
Galena	<0.5	10-15

Host-rock: The host-rock is a plagioclase-muscovite-quartz \pm K-spar \pm chlorite \pm pyrite \pm sphalerite schist, with minor tourmaline, magnetite and carbonate. It is severely strained, exhibiting an early slaty cleavage overprinted strongly at a high angle by muscovite and highly preferred orientations of quartz. A uniform sinistral movement sense is suggested by the S-C relationships associated with the second cleavage, particularly around knots of quartz feldspar and clots of pyrite. Sphalerite occurs as fine (10-15 μm) disseminated grains throughout the host.

Pyrite Vein/Shear: This feature is notable for the absence of magnetite, and the presence of fine sphalerite as rounded inclusions in pyrite. Such sphalerite is dotted with fine chalcopyrite inclusions (chalcopyrite 'disease'). Galena and sphalerite have a similar included form, and all are in syn-metamorphic equilibrium with coarse pyrite. Pyrite itself occurs as coarse primary fragments which exist as larger kernels amongst finer fractured pyrite embayed by carbonate, quartz, and minor sphalerite. At the edge of the sulphide zone, pyrite forms thin slivers and trains around lenses of strongly reshaped muscovite. An important observation is that massive muscovite occurrences are confined to the interior of the pyrite zone, or to 1 cm of one margin of this zone, which may therefore have constituted a former sericitic alteration selvage which has been recrystallised.

The younger vein which transects host-rock, but not sulphide, contains carbonate \pm pyrite, with ubiquitous and comparatively coarse sphalerite (with inclusions of chalcopyrite). This vein seems likely to predate the main pyrite-sphalerite zone, because pyrite would commonly fracture brittly, as it has elsewhere in the collection. This relationship, and the parallelism of the major pyrite vein with the cleavage, is the best evidence for its epigenetic origin, but in detail the grain-textures are ambiguously syn-tectonic.

SAMPLE AP1	81.7m	Massive pyrite	GJD
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Hand-specimen: Massive granular pyrite containing uncommon quartz-filled fractures.

Thin-section:

Mineral	Percentage abundance (%)	Size (μm)
Carbonate	10	120
Quartz	2	120
Muscovite	2	30
Sphalerite	3-5	100
Pyrrhotite	tr	10
Galena	tr	10
Chalcopyrite	<0.5	10
Tourmaline	tr	4

Mineralogy: This is a relatively less-deformed rock compared to others within the examined suite.

Pyrite takes two forms: (1) very coarse zones 0.5 - 2cm across with obvious carbonate-filled extension fractures, and (2) fine recrystallised pyrite in a carbonate-sphalerite-quartz matrix, where pyrite forms euhedral cubes averaging 150 μm across, surrounded by splinters of finer sphalerite (Fig. 15). The contact between the two is relatively sharp, with few gradational fragment sizes, but in places there is clear evidence of separation of small pieces away from the main pyrite nucleus, as of icebergs calving from a stable icesheet (not intended to be an analogous process!).

Sphalerite is mainly confined to the second textural association, of which it comprises ~20%, and may have facilitated the recrystallisation of the pyrite. Minor sphalerite, galena, pyrrhotite and chalcopyrite occur as rounded inclusions in coarse pyrite in syn-metamorphic equilibrium.

There is no evidence at the slide scale of the growth of this pyrite by replacement of magnetite, because no relict magnetite is anywhere evident.

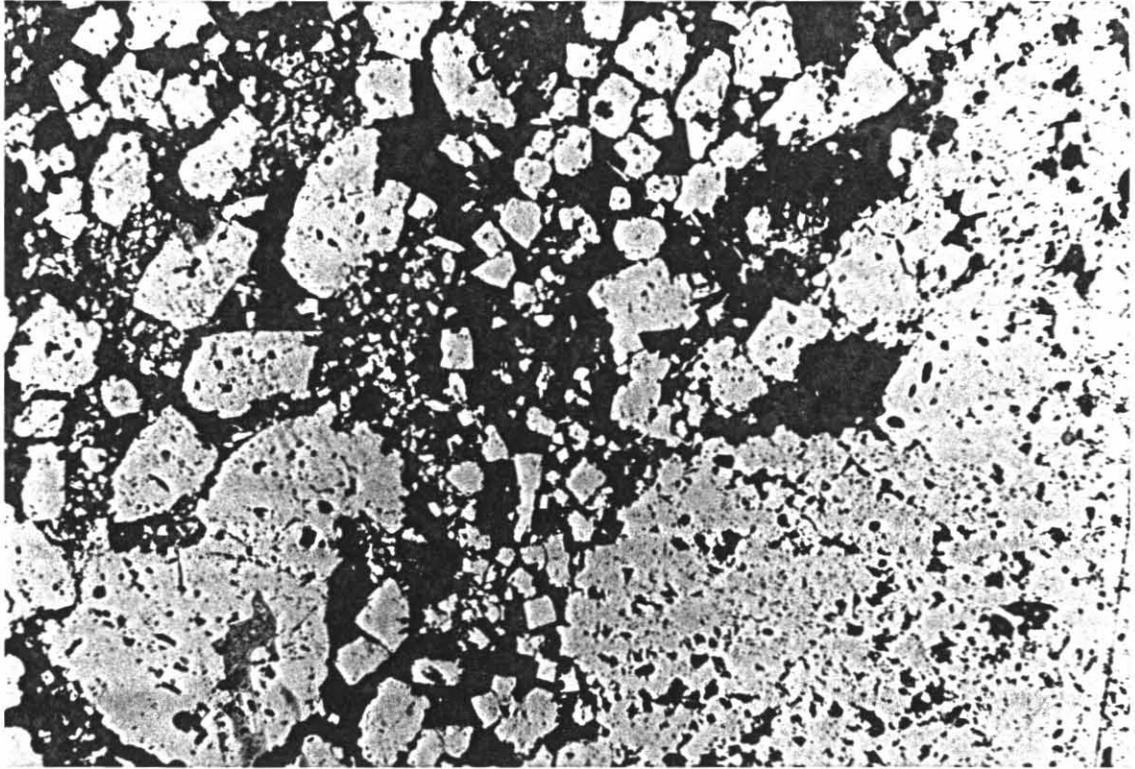


Fig. 15. Granulation of pyrite and recrystallisation as idioblastic porphyroblasts in a matrix of sphalerite (light grey) and carbonate (dark grey). Sample AP1 81.7. Magnification x100, RL.

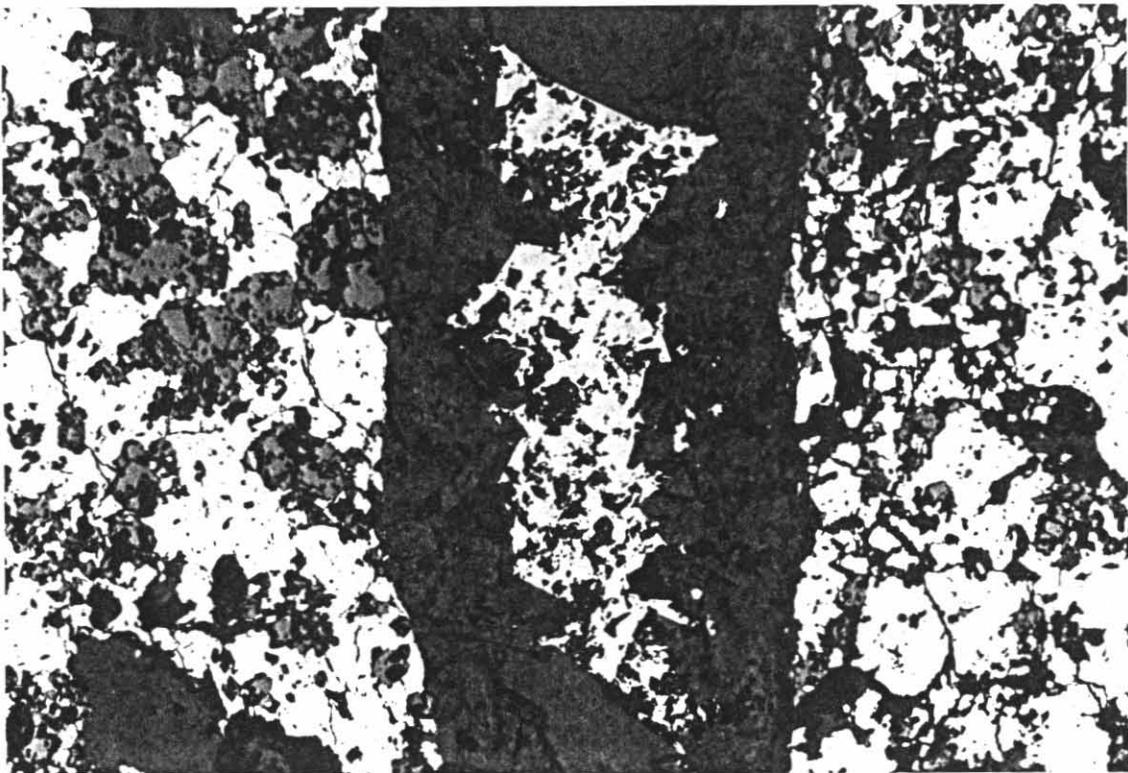


Fig. 16. A vein zoned from carbonate at the margins to quartz and chalcopyrite in the centre. The vein transects pyrite and magnetite but there is no evidence of sulfidation of magnetite or alteration of pyrite by chalcopyrite. Sample AP1 85.0. Magnification x100, RL.

SAMPLE AP1 85.0 m Strongly foliated pyrite-magnetite \pm chalcopyrite GJD

Hand-specimen: A strongly foliated rock in which crudely defined bands of pyrite are distinctively separate from these rich in chalcopyrite-quartz, and a single which (2cm) pyrite-magnetite layer.

Thin-section:

Mineral	Percentage abundance (%)	Size (μm)
Pyrite	40	100
Magnetite	40	120
Carbonate	8	100
Quartz	10	80
Chalcopyrite	2	50
Muscovite	tr.	120
Barite	tr.	250

Mineralogy: Pyrite and magnetite are closely intergrown in this slide, although this was not apparent in the hand-specimen. The extent of deformation is strong, but not as severe as found in AP2 sections.

Chalcopyrite, as noted in hand-specimen, is confined either to more siliceous zones between pyrite layers, or to discrete, late-tectonic, cross-cutting veins (~2mm wide) zoned inward from carbonate to polygonal quartz + coarse chalcopyrite (Fig. 16). This vein-type transects pyrite, but adjacent chalcopyrite shows no tendency to react or replace this pyrite. Chalcopyrite confined to more siliceous bands forms intricate networks defining quartz grain boundaries; these arrays have a broad linear concentration at $\sim 50^\circ\text{C}$ to the main foliation. No evidence was found of replacive relationships between pyrite and magnetite. Either pyrite formed subhedral crystal in a magnetite matrix, or the two were inextricably intergrown. Within the thickest band, pyrite forms irregularly shaped fractured aggregates with distinct magnetite cusps.

In several areas, carbonate displays uncharacteristically matchstick-like morphology, suggestive of replacement of deformed muscovite during tectonism.

0218

SAMPLE AP1 85.4m

Hand-specimen: strongly foliated psammo-pelitic schist.

Thin-section:

Mineral	Percentage abundance (%)
chlorite	20
quartz	60
plagioclase	10
sphene	6
biotite	2
magnetite	2

Mineralogy: this section contains superb examples of chloritic pseudomorphs after classic snowball garnet porphyroblasts (typically 0.5 - 1 mm). The evidence for rotation (about 95°) is retained by curved inclusion trails of quartz. The pseudomorphed porphyroblasts are wrapped by chlorite (and minor relict biotite) which define the strong foliation; together with trails of sphene and elongate magnetite grains. The latter are likely to be a residue from the retrogression of prograde biotite to chlorite. Elongate quartz crystals are the other major phase and they exhibit preferred directional orientation due to plastic deformation and recrystallisation.

Genetic interpretation: The prograde assemblage for this specimen was probably a garnet-biotite-quartz schist, suggesting amphibolite facies regional metamorphism. Subsequent retrogression has produced a greenschist assemblage. the precursor for this specimen was most likely a quartzo-feldspathic sediment.

SAMPLE AP1	88.1m	Well-banded pyrite-magnetite rock	GJD
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Hand-specimen: A well-banded sulphide-oxide dominated rock, in which individual undulating bands 1 to 2 mm thick are alternatively pyrite-rich and poor. Pyrite mobilisation into fine cross-fractures and some possible boudinage is evident.

Thin-section:

Mineral	Percentage abundance (%)	Size (μm)
Magnetite	40	40
Quartz	38	100
Pyrite	20	80
Carbonate	10	120
Chalcopyrite	0.5	60
Chlorite	tr.	60
Hematite	tr.	25
Tourmaline	tr.	40

Mineralogy: Textural relationships are for the most part not diagnostic of the formative processes in this rock because of substantial tectonic and metamorphic overprint. What appeared to be layering at hand-specimen scale resolves to networks of pyrite and chalcopyrite parallel and perpendicular to the foliation. Most components are subhedral, related in part to moderate degrees of recrystallisation, and in part to crystal fragmentation during deformation, suggesting tensile fracturing perpendicular to compression. Quartz is markedly undulose, with polygonal subgrain development. Some carbonate-magnetite fractures have subsequently been folded. 1% of the magnetite is present as porphyroblasts, which can contain complex trails of fine inclusions.

Moderately well-defined compositional bands are nevertheless present for all components, e.g., carbonate-dominated bands contain no quartz, less magnetite, and more pyrite than elsewhere. Chalcopyrite is disseminated throughout the rock, but displays no particular exclusion to other phases, for instance carbonate zones are not enriched or depleted in chalcopyrite, and all phases make contact with chalcopyrite somewhere in the slide.

Of greatest interest is the relationship between pyrite and magnetite, and between pyrite and chalcopyrite. Within the slide isolated instances of replacement between these phases exist, but mainly ambiguous or metamorphic equilibrium textures dominate (Fig. 17).

Overall the rock is interpreted as a tectonised and recrystallised but pre-existing ore.

0218

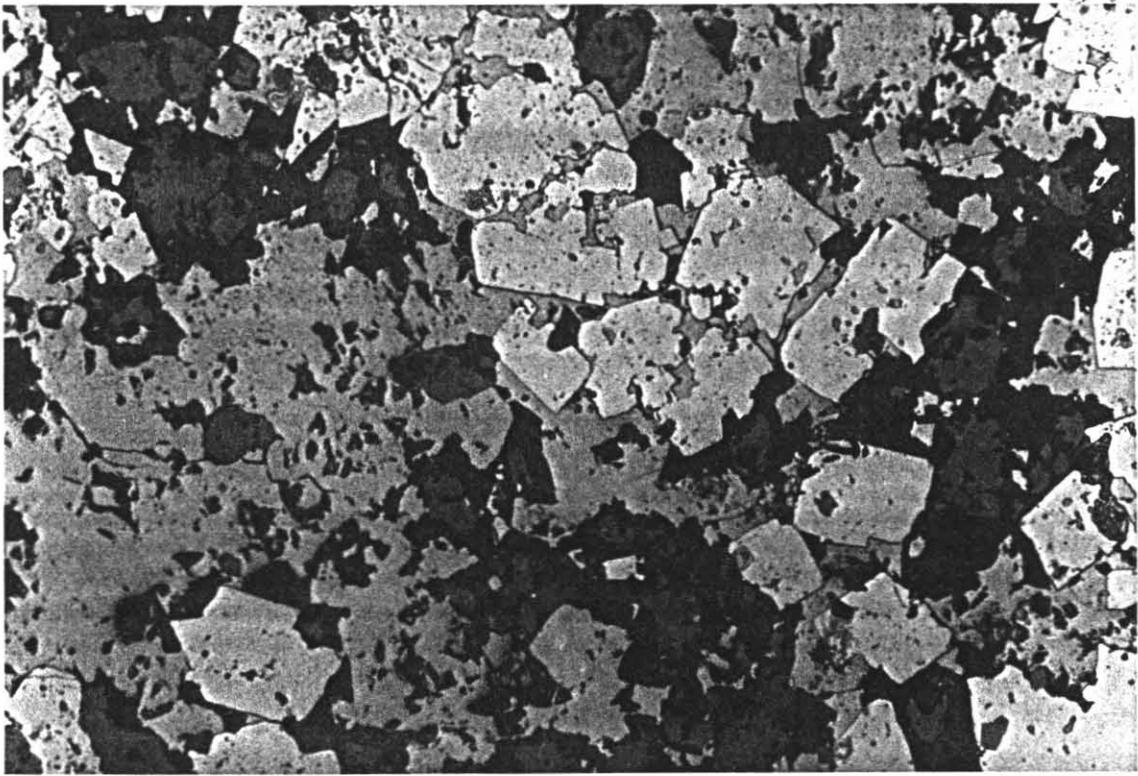


Fig. 17. Typical late syn-deformational intergrown texture showing metamorphic equilibrium between pyrite, magnetite and chalcopyrite. Sample AP1 88.1. Magnification x50, RL.

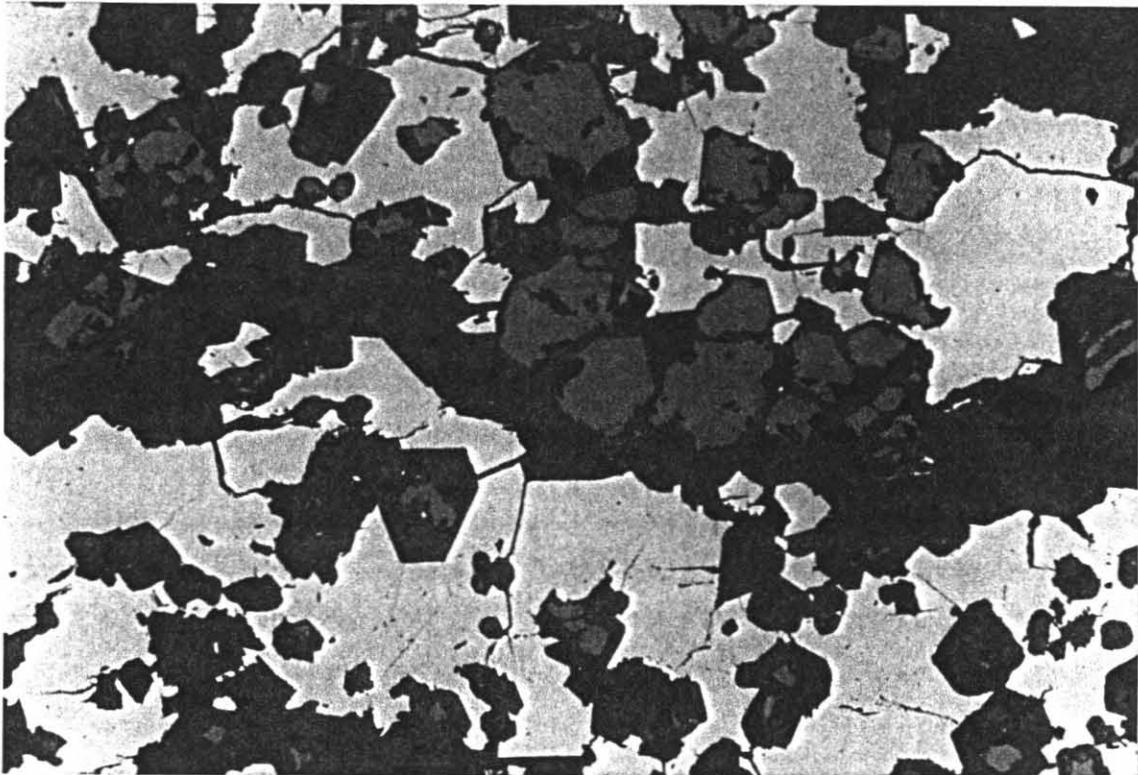


Fig. 18. Replacement of idioblastic magnetite by carbonate post-peak metamorphism. Sample AP1 92.5. Magnification x200, RL.

0210

SAMPLE API 90.5m

Hand-specimen: banded quartz-magnetite-carbonate rock.

Thin-section:

Mineral	Percentage abundance (%)
quartz	52
carbonate	25
magnetite	20
biotite	2
pyrite	1
chlorite	<1

Mineralogy: this sample displays a weak banding of alternating relatively quartz-rich and magnetite-rich bands. The quartz-rich bands are composed of xenoblastic aggregates of quartz (0.1 - 0.3 mm) which display strained extinction and sutured margins but which are not particularly elongate or aligned. Sporadic biotite crystals do not show a preferred orientation. Carbonate is abundant and occurs in irregular patches and as veins cutting across the weak banding.

The magnetite-rich layers consist of an increased abundance of idioblastic magnetite crystals (0.03 - 0.1 mm) and fractured grains, together with quartz, carbonate and minor biotite. Idioblastic cubes of pyrite (0.1 - 0.3 mm) and minor xenoblastic grains of chalcopyrite are concentrated in several of the magnetite-rich layers.

Genetic interpretation: the mineralogy of this sample is consistent with an origin as an iron-bearing siliceous submarine exhalative. The carbonate appears to be a relatively late alteration feature. The pyrite and chalcopyrite appear to be in textural equilibrium with magnetite and there is no evidence that they are associated specifically with the carbonate or that they are replacing magnetite.

0229

SAMPLE API	92.5 m	Complex massive pyrite and vein quartz	GJD
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Hand-specimen: A complex zone of massive pyrite, deformed vein quartz, vein pyrite, and two distinct magnetite bands 0.5 and 2cm wide, with probable zones of pyrite replacement.

Thin-section:

Mineral	Percentage abundance (%)	Size (μm)
Pyrite	35	100
Magnetite	20	60
Carbonate	30	130
Quartz	15	50
Chlorite/biotite	tr.	50
Chalcopyrite	<0.5	80

Mineralogy: Surprisingly, this slide contains good evidence of equilibrium metamorphism of pyrite in contact with magnetite, and also the best available evidence of the replacement of euhedral magnetite, in the presence of pyrite, by carbonate (Fig. 18).

In general, textures are deformed, but less so than in other slides, on the basis of the preferred elongation of quartz. Much of the opaque matrix consists of interlocked recrystallised quartz and carbonate, with rare flecks of green biotite retrogressed to chlorite. In one small portion of the slide, this forms a thin monomineralic discontinuous band.

Euhedral magnetite is commonly intergrown with anhedral pyrite, a relatively unusual texture in the collection provided. This relationship is destroyed when carbonate has infiltrated and preferentially replaced magnetite leaving unaltered pyrite, a carbonate magnetite pseudomorph, and anhedral wisps of magnetite relicts. At its most extreme, only a sieved pyrite-carbonate aggregate remains. Splinter-like trains of carbonate within quartz are also likely to indicate replacement of a sheet silicate.

Pyrite is commonly fractured sub-perpendicularly to the predominant fabric, with infiltration of carbonate into fractures. Minor chalcopyrite also occurs in these sites (Fig. 19). A final event in the rock history was the development of fine continuous brittle fractures which have locally channelled carbonate and quartz deposition through the magnetite zone, and are sites of millimetric displacement. These are the only sites in the rock which contain coarse chalcopyrite, although this is not common.

Genetic interpretation: In summary, there is evidence that pyrite and magnetite recrystallised in equilibrium throughout the metamorphic history, whereas some carbonate infiltration replaced magnetite after peak-metamorphism, and prior to brittle fracture development.

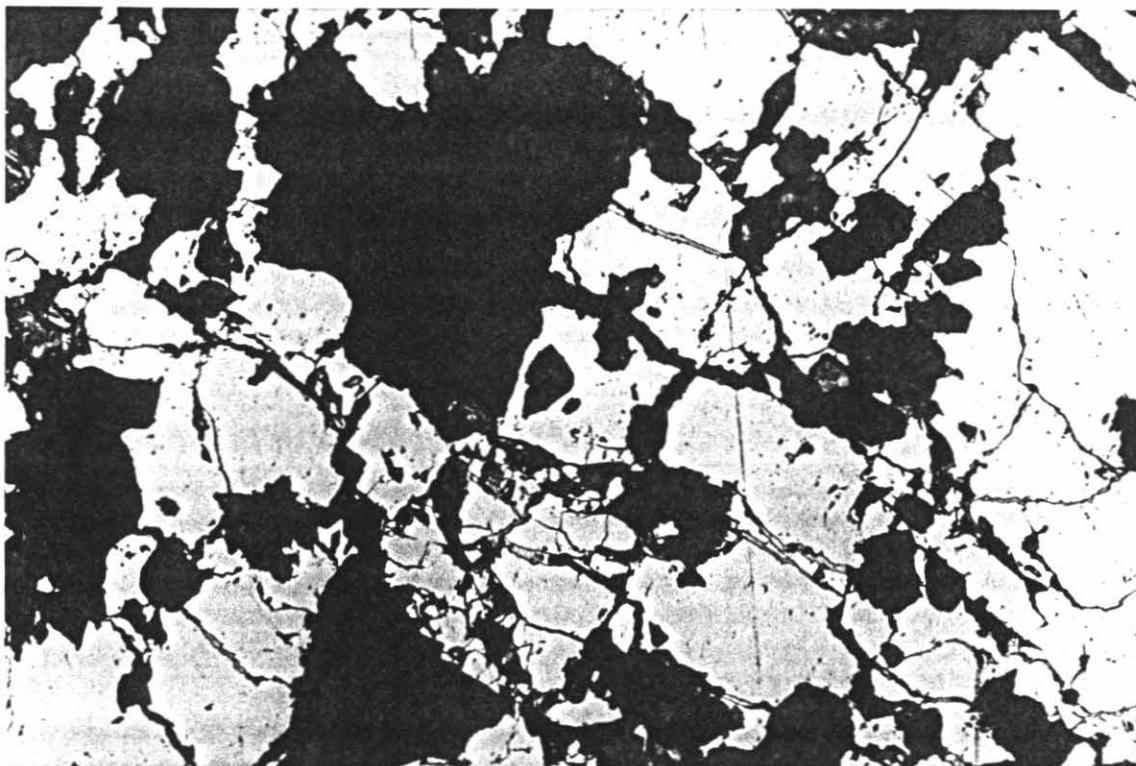


Fig. 19. Typical cataclastic texture with chalcopyrite along grain boundaries and filling fractures in pyrite. Magnetite is also being replaced by carbonate. Sample AP1 92.5. Magnification x100, RL.

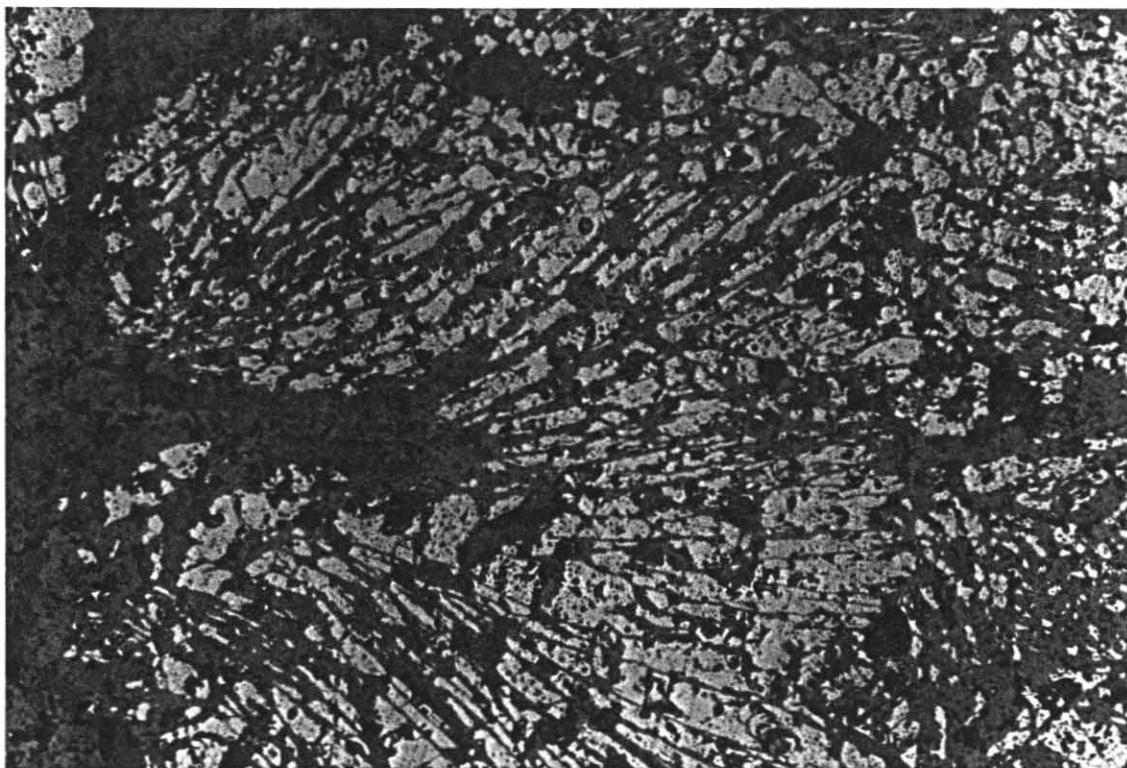


Fig. 20. Magnetite replacing carbonate along twin planes (?). Sample AP2 56.1. Magnification x100, RL.

SAMPLE AP1 96m

0222

Hand-specimen: graphitic-quartz-sericite phyllite.

Thin-section:

Mineral	Percentage abundance (%)
muscovite	43
quartz	40
carbonate	12
chlorite	2
graphite	2
magnetite	1
sphene	<1

Mineralogy: This sample has a strong foliation defined by parallel bundles of muscovite/sericite which have associated fine graphite. This imparts a dark colour to the sericite-rich bands in hand specimen. Intervening quartz-rich bands (or elongate pods) consist of elongate quartz crystals (0.1 - 0.2 mm long) with sutured margins, undulose extinction and a strong preferred directional orientation. The quartz in the matrix is somewhat finer-grained (0.01 - 0.02 mm). Carbonate appears to have completely replaced plagioclase porphyroblasts which were wrapped by the muscovite foliation.

There is abundant evidence in the section for a second deformation which has produced small scale asymmetric folds of S_1 with localised development of a crenulation cleavage. The initial phase of deformation involved high strain as evidenced by the strong foliation and plastic deformation of the quartz. The subsequent folding of this foliation seems to have been short-lived and characterised by lower strain.

Genetic interpretation: the precursor to this rock was probably a mixed psammitic-pelitic sedimentary rock ie. interbedded thin quartzo-feldspathic and mudstone layers.

SAMPLE AP2	56.1m	Complex pyrite-carbonate veins in a dark matrix	GJD
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Hand-specimen: A complex of pyrite, pyrite-carbonate veins, and pervasive pyrite alteration imposed on a dark fine-grained lithology.

Thin-section:

Mineral	Percentage abundance (%)	Size (μm)
Carbonate	75	10
Pyrite	~16	300
Magnetite	~7	100
Quartz	~7	100
Chalcopyrite	~0.25	30
Carbonaceous matter		<5

Mineralogy: This rock is dominated by alteration-related carbonate and pyrite, which has experienced strong brittle-ductile deformation.

Deformation is reflected as a strong preferred fabric in the original rock, affecting all hydrothermal components. The fabric is partitioned into zones of severe foliation (1 to 3 mm wide) in which pre-existing textures in carbonate are pervasively flattened, between more granoblastic fabrics. Pyrite and magnetite have mainly been brittly fractured and brecciated, with the fracture-filling by carbonate. Carbonate surrounding larger relict pyrite has recrystallised to polygonal grains. It is evident from the varying degrees of internal deformation, that the obvious cross-cutting carbonate veins (1 - 4 mm wide) developed at different stages during the deformational history, but none are wholly devoid of the effects of tectonism.

Genetic interpretation: A broad paragenetic sequence is suggested from relict textures. The most likely precursor was a silicified carbonaceous sediment, still preserved as disoriented kernels resulting from brecciation. Silicification may therefore have been the earliest hydrothermal event to affect the rock. Initially minor carbonate-chalcopyrite developed, followed by major carbonate-pyrite alteration and magnetite replacement of carbonate (Fig. 20). The latter has resulted in well-developed fan-fabrics in which magnetite has replaced the cleavage of sprays of carbonate. As a late stage or metamorphic process, most pyrite was embayed by carbonate, as was recrystallised quartz. Chalcopyrite locally replaces pyrite along fractures.

0232

SAMPLE AP2	61.3 m	A strongly foliated jasper-pyrite-mag rock	GJD
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Hand-specimen: A strongly foliated rock consisting of discontinuous 1 to 5 mm thick bands of red jasper, pyrite and mag-qtz. Some layers are clearly tightly folded, with transposition evident parallel to layering. At this scale it the rock has been severely tectonised with a strong sense of simple shear.

Thin-section:

Mineral	Percentage abundance (%)	Size (μm)
Quartz	50	120
Magnetite	15	80
Pyrite	5	160
Carbonate	25	100
Goethite	2-5	20
Chalcopyrite	<1	50
Hematite	1-3	30
Chlorite	<1	40
Plagioclase	<1	120

Mineralogy: The section is dominated by severely deformed sub-mylonitic microtextures in which phases are ambiguously related to one another paragenetically. Red chert-like bands in hand-specimen are here resolved as discrete layers of deformed carbonate containing a multitude of ultra-fine hematite inclusions, most of which cannot be seen at 400 X, but which are inferred to be hematite from the constellations of strong red internal reflections. Thin mylonites (0.2 - 0.4 mm wide) probably represent local transposition zones, with a dextral shear sense.

Throughout the slide quartz exhibits marked grain-size reduction, common severe undulose extinction with new grain growth at $\sim 45^\circ$ to the foliation, and lobate to serrated grain-boundaries. Carbonate has recrystallised to a greater degree, and in places "splinters" of carbonate are interpreted as carbonate twins which have separated and continued to individually deform.

Magnetite occurs as euhedra along quartz-carb grain boundaries, but is more common within the carbonate. Pyrite and cpy are more domainal within the fabric, in zones in which qtz is more common than carbonate. Chalcopyrite is found mainly at the edges and within cracks in pyrite, with very local evidence of replacement.

Genetic interpretation: No paragenetic importance is attached to the grain-scale replacement textures because of the clear dominance of the tectonic overprint; there is no strong evidence favouring a late tectonic introduction of metals or carbonate. Notably, these textures are far more strained than those of AP1, and also do not contain signs of brittle fragmentation.

SAMPLE AP2	67.7 m	Finely foliated/banded mag-py-siderite	GJD
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Hand-specimen: A foliated magnetite-pyrite-siderite-silicate rock in which the constituents occur in fine ragged bands (1 to 10 mm thick), continuous at the core-width scale. Some reddish carbonate bands have pyrite bands symmetrically disposed at either contact, suggestive of vein and selvedge relationships. A prominent magnetite porphyroblast or fragment 1.5 cm X 2.5 cm has deformed brittly, and is wrapped plastically by sulphide and carbonate bands.

Thin-section:

Mineral	Percentage abundance (%)	Size (μm)
Magnetite	30	150
Carbonate	25	60
Quartz	25	80
Pyrite	20	100
Chalcopyrite	<5	40

Mineralogy: Compositional bands which were relatively discrete in hand-specimen seem less so in thin-section; nevertheless, some thick compositional bands seem to represent an original layering despite a strong tectonic textural overprint. On a finer scale it is evident that this banding is also close to the plane of deformational flattening. In places an earlier foliation is defined by folded and recrystallised mag-carb layers, in panels bounded by the later dominant foliation, which is sub-mylonitic.

Original fragments or metamorphic porphyroblasts of magnetite developed prior to the main foliation, subsequently behaving brittly while sulphides and carbonates flowed around them. A dextral shear sense is indicated.

For the most part py, cpy, mag and carb are in syn-tectonic equilibrium. However, there were several clear examples of millimetre-scale replacement of magnetite by pyrite, and magnetite by carbonate, associated with the brittle extension of magnetite during shearing. Some pyrite has clearly replaced magnetite in ribbons parallel to the foliation (Fig. 21). More clearly, pyrite is only present in mag porphyroblasts/fragments, within tensile quartz-filled fractures and clustered around grain margins (Fig. 22), evidencing some mobility during tectonism. Lastly, tendrils of siderite have replaced magnetite around tensile fractures in isolated instances, and there is evidence of carbonate filling a flexural slip dilation zone.

It is vital to see that these are only instances, whereas most of the fabric is in syn-tectonic textural equilibrium.

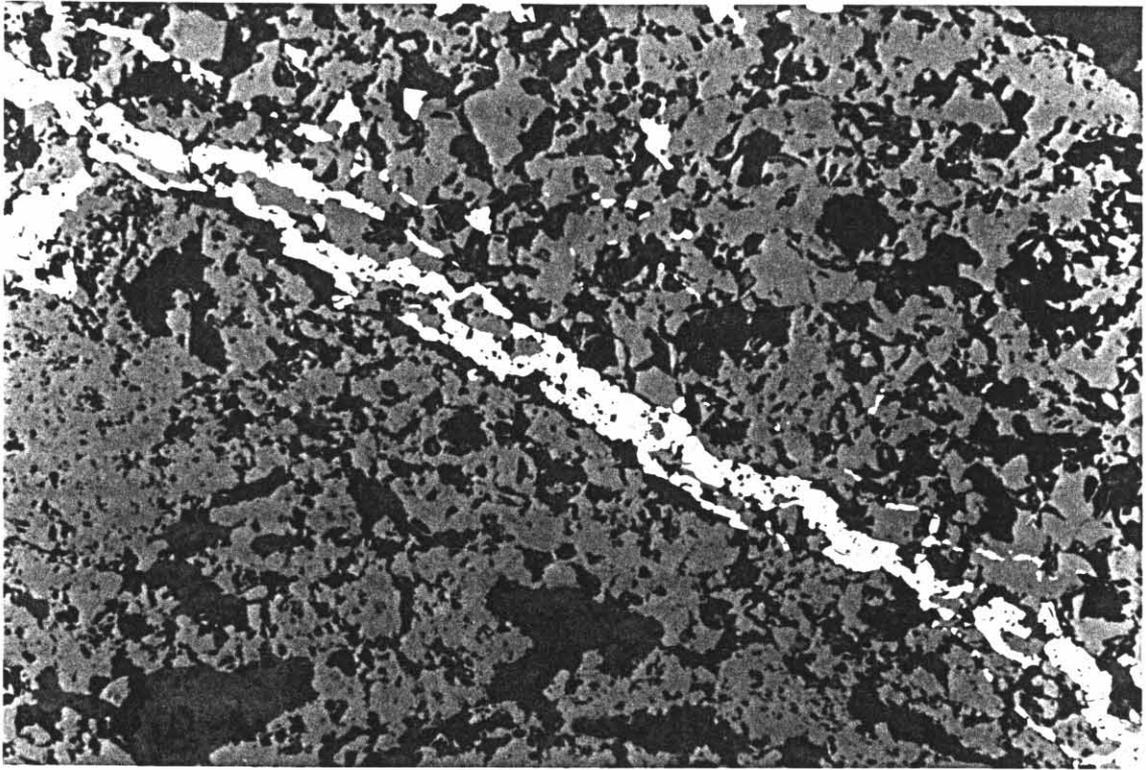


Fig. 21. *Minor sulfidation of magnetite along fractures, late syn-deformational. Sample AP2 67.7. magnification x200, RL.*

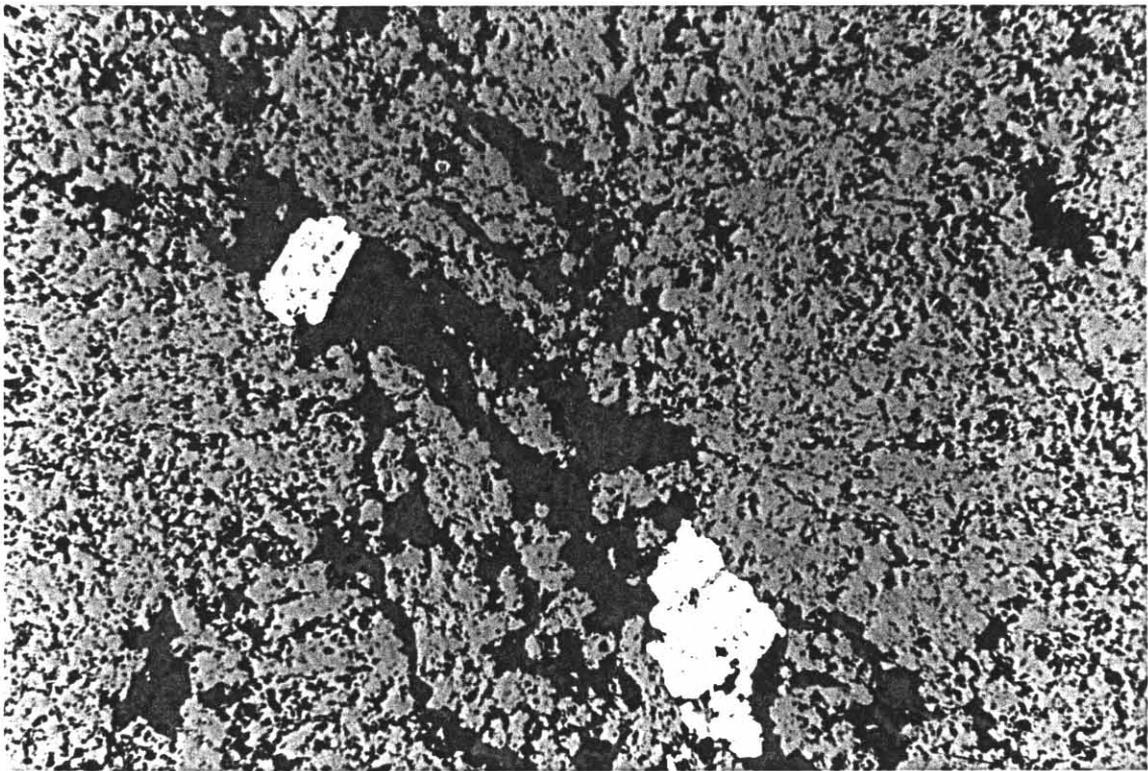


Fig. 22. *A magnetite clot with tension gashes from fracturing, into which there has been some remobilisation, or sulfidation by pyrite. Sample AP2 67.7. Magnification x100, RL.*

0227

SAMPLE AP2 68.4 m

Hand-specimen: moderately foliated psammo-pelitic schist.

Thin-section:

Mineral	Percentage abundance (%)
quartz	73
feldspar	15
chlorite	5
carbonate	5
magnetite	2
sericite	<1

Mineralogy: intergrown elongate crystals of quartz (0.3 - 0.7 mm long) which show strain extinction and extensively sutured grain margins are abundant and in some cases are recrystallised into finer grained aggregates (0.01 - 0.03 mm).

Dispersed plates of chlorite are aligned subparallel to the elongate quartz crystals and define a foliation which has been folded on the scale of the thin section. Xenoblastic to tabular porphyroclasts of feldspar have been occasionally replaced by carbonate aggregates. The orientation of the tabular plagioclase grains suggests some rotation during deformation. Carbonate aggregates are also disseminated throughout the rock which are not obviously related to pre-existing feldspar grains.

A thin layer (0.2 - 2 mm) of carbonate plus magnetite and minor sericite occurs within the quartz-rich matrix which is parallel to the general foliation and has been folded. The magnetite and carbonate both occur as xenoblastic grains and this layer may have originally represented a vein which has subsequently been recrystallised. There is very little disseminated magnetite through the rest of the rock.

Genetic interpretation: the precursor to this sample was probably a quartzo-feldspathic sedimentary rock which may have been derived from a silicic volcanoclastic, or a weathered sodic granitoid. The rock has experienced quite high strain resulting in the granulation and recrystallisation of feldspar, quartz and chlorite. Subsequent deformation has caused moderately open folding of the initial foliation.

0276

SAMPLE AP2	70.0 m	Semi-massive pyrite and mag-qtz-siderite	GJD
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Hand-specimen: Semi-massive pyrite kernels 1 - 4 cm across separated by cusped magnetite-quartz-siderite zones, broadly parallel and defining a preferred fabric.

Thin-section:

Mineral	Percentage abundance (%)	Size (μm)
Pyrite	50	150
Carbonate	30	80
Quartz	10	100
Magnetite	10	80
Chlorite	1-2	60
Chalcopyrite	<1	100
Covellite		"

Mineralogy: The orientation of the slide has selectively intersected a 2 cm wide higher strain zone in addition to the dominant lower strain texture of the semi-massive pyrite. High strain is reflected in a very strong preferred orientation, marked sub-grain development and sutured boundaries of quartz and carbonate orientations in pressure shadows. Quartz predominates in the non-pyrite zones. In the high strain zone pyrite and magnetite occurs in 0.5 to 2cm long trains parallel to the foliation, in detail consisting of fragmented and separated grains in a quartz-carb matrix.

The more massive pyrite aggregates are in detail highly sieved and cracked, with widespread evidence of replacement by carbonate and quartz inwards from cracks. At its most extreme, this process has resulted in the isolation of small sutured and embayed pyrites in a matrix of carbonate, quartz and magnetite.

There is evidence that some magnetite has replaced deformed sprays of recrystallised carbonate in this area.

Chalcopyrite has an interesting occurrence. Whilst some occurs on fractures and as inclusions in the massive pyrite, most is found in the carbonate-qtz matrix, both in the sheared and less-sheared portions of the slide. Approximately half of any cpy grain has been replaced about its margins by covellite and some chalcocite, which given a lack of similar replacement in cpy at higher levels in the drillhole, may be evidence of a discontinuity or fault, open to surface waters nearby.

0229

SAMPLE AP2 70.9 m

Hand-specimen: moderately banded quartzo-feldspathic rock containing a significant amount of sideritic? carbonate. The carbonate occurs partly parallel to banding but is also transgressive and is cut by later quartz veins.

Thin-section:

Mineral	Percentage abundance (%)
albite	45
quartz	30
carbonate	15
chlorite	8
sphene	2
muscovite	<1
pyrite	<1

Mineralogy: the section traverses a contact between a relatively carbonate-rich recrystallised quartzo-feldspathic assemblage and a carbonate-poor equivalent. The carbonate-poor layer is characterised by recrystallised aggregates of quartz and plagioclase (0.05 - 0.2 mm) with randomly oriented crystals of chlorite (0.2 - 0.3 mm), minor aggregates of carbonate, and accessory sphene, magnetite and pyrite. The quartz shows slightly sutured margins and undulose extinction, the plagioclase is untwinned or exhibits albite twinning.

In the carbonate-rich layer, the matrix plagioclase and quartz is slightly finer-grained (0.02 - 1 mm) and the texture more granoblastic polygonal. The carbonate occurs in coarse aggregates (0.3 - 1 mm) closely associated with fine (0.05 mm) aggregates of sphene. A narrow vein (0.15 mm) cutting this part of the section is characterised by muscovite, magnetite, chlorite and sphene, and a relatively wide cross-cutting vein is rich in quartz and carbonate.

Genetic interpretation: the equigranular polygonal texture of this sample and the random orientation of the platy minerals (eg. chlorite) indicate recrystallisation occurred under low strain conditions compared with many of the samples from this area. Carbonate is abundant, but there is a distinct paucity of Ca-bearing metamorphic phases such as actinolite or epidote, even though the rock has experienced metamorphic recrystallisation probably under lower greenschist facies. This suggests that much of the carbonate is very late and has been introduced subsequent to peak metamorphic conditions.

SAMPLE AP2 78.1 m

Hand-specimen: alternating relatively chlorite-rich and quartz-feldspar-rich banded sediment with some small scale folding evident in core.

Thin-section:

Mineral	Percentage abundance (%)
chlorite-rich layers	
chlorite	50
plagioclase	39
carbonate	10
sphene	1
pyrite	<1
felsic layers	
quartz	42
plagioclase	30
carbonate	15
chlorite	10
sphene	3

Mineralogy: this sample includes folded alternating bands which are rich in quartz and feldspar and chlorite and feldspar respectively. The sharp nature of the boundaries between these layers and the absence of very high strain features suggests that these may represent original compositional banding in a sedimentary rock.

The felsic-rich layers consist of recrystallised xenoblastic to weakly polygonal quartz and feldspar aggregates (0.1 - 0.3 mm). Poorly aligned plates of chlorite (0.2 - 1 mm) define a weak foliation and xenoblastic carbonate appears to have replaced the other phases initially along the grain boundaries and subsequently along cleavage planes in plagioclase. Quartz displays undulose extinction and weakly sutured boundaries but does not display a strong directional preferred orientation that is a feature of the higher strain rocks. Minor aggregates of sphene are typically associated with carbonate.

The chlorite-plagioclase-rich layers consist of tabular to slightly rounded plagioclase porphyroblasts (0.5 - 1 mm) set in a chloritic matrix which displays a weak foliation. However, many bundles of chlorite crystals are oriented oblique to this foliation suggesting fairly low strain conditions during metamorphism. Carbonate is relatively abundant replacing chlorite along the cleavage direction and replacing plagioclase around grain boundaries and along cleavages. Euhedral crystals of sphene occur throughout the chlorite matrix.

Genetic interpretation: the precursor to this specimen was probably a sedimentary rock comprising alternating layers of quartzo-feldspathic material and tuffaceous material derived from mafic volcanism. The carbonate appears to have been introduced post-deformation at relatively low temperatures.

0251

SAMPLE AP2 81.5m

Hand-specimen: moderately foliated interbedded psammitic and mafic schists.

Thin-section:

Mineral	Percentage abundance (%)
chlorite-rich layers	
chlorite	80
plagioclase	15
carbonate	3
magnetite	2
felsic layers	
quartz	65
plagioclase	15
biotite	10
carbonate	7
chlorite	3
pyrite	<1
epidote	trace

Mineralogy: the section traverses a chlorite-rich band and a quartzo-feldspathic band which have some similarities to the layers evident in AP2 78.1m. The quartzo-feldspathic band is rich in quartz which show evidence of recrystallisation under moderate to relatively low strain conditions. The quartz grain boundaries are slightly sutured and there is ubiquitous strain extinction together with dimensional preferred orientation. A moderate cleavage is defined by subparallel aligned biotites and subordinate chlorite. Carbonate occurs in aggregates and partially replacing plagioclase porphyroblasts, as well as in veinlets cross-cutting the foliation.

There is a sharp contact with the chlorite-rich layer. It consists of abundant chlorite with a strong foliation enclosing tabular to slightly rounded plagioclase porphyroblasts (0.5 - 1.5 mm). These are either untwinned or display simple twinning and typically show partial replacement by carbonate around their grain boundaries and along cleavage planes. Elongate grains of magnetite (0.05 - 0.3 mm long) occur aligned with the chloritic matrix with disseminated aggregates of carbonate. A few small relict grains of epidote occur as inclusions in the plagioclase porphyroblasts.

The contact between the chloritic and quartz-rich layers displays an increased abundance of biotite and a small amount of biotite occurs within the mafic layer close to the contact. The lack of biotite in the chloritic layer would appear to be a compositional effect due to the lack of potassium.

Genetic interpretation: this sample is very similar to AP2 78.1m in containing the alternating mafic and quartzo-feldspathic layers which probably represent interbedded psammitic sediment and mafic volcanoclastic material.

As with the other samples, the carbonate appears to be introduced quite late and has not taken part in the pro-grade metamorphic reactions. The predominance of biotite over chlorite in the quartzo-feldspathic layer of this specimen compared with chlorite only in AP2 78.1 probably represent complete retrogression of biotite.

SAMPLE AP2 82m

Hand-specimen: compositionally banded mafic-psammitic schist.

Thin-section:

Mineral	Percentage abundance (%)
hornblende	30
chlorite	25
quartz	15
biotite	15
albite	10
magnetite	3
garnet	1
carbonate	1

Mineralogy: this specimen shows considerable heterogeneity in mineral assemblages ranging from a chlorite-rich band (similar to those in AP2 78.1 and AP2 81.5), to an amphibole-garnet-rich band, and an amphibole-biotite-quartz-rich zone.

The chlorite-rich band has essentially identical mineralogy and textures to the mafic layers described for the above two samples. In this sample, the distinction between the chloritic and adjacent bands is not clear-cut and there is a gradational transition to an amphibole-biotite-plagioclase-chlorite-magnetite assemblage (Fig. 14). Simple twinned xenoblastic porphyroblasts of plagioclase (0.3 - 1 mm) are set in a strongly foliated matrix of intergrown prismatic blue-green amphibole, platy biotite and chlorite (which encloses elongate crystals of magnetite). The plagioclase porphyroblasts have common oriented (but rotated) inclusions of amphibole, chlorite and biotite.

Several coarse-grained (0.3 - 2 mm) elongate pods of quartz are oriented parallel to the foliation. One relatively amphibole-rich band still contains plagioclase porphyroblasts and some fractured pale-pink porphyroblasts of garnet (0.3 - 0.7 mm). Some of the garnets exhibit chlorite rims and there is also clear evidence of retrogression of biotite to chlorite plus magnetite, and amphibole to very fine-grained chlorite plus magnetite aggregates.

Genetic interpretation: this sample exhibits the best examples of prograde and retrogressive assemblages. Peak metamorphic conditions appear to have produced a garnet amphibolite assemblage which has experienced minor to extensive retrogression to a chlorite-plagioclase (greenschist) assemblage. The more extensive retrogression may have occurred along very localised shear planes accounting for the considerable variability over short intervals of core and within the scale of this section, although the mineralogical differences may also partly reflect original compositional differences.

The precursor to this rock probably represents a mixed mafic tuff/psammitic sediment, although the former appears to be the dominant component in this sample.

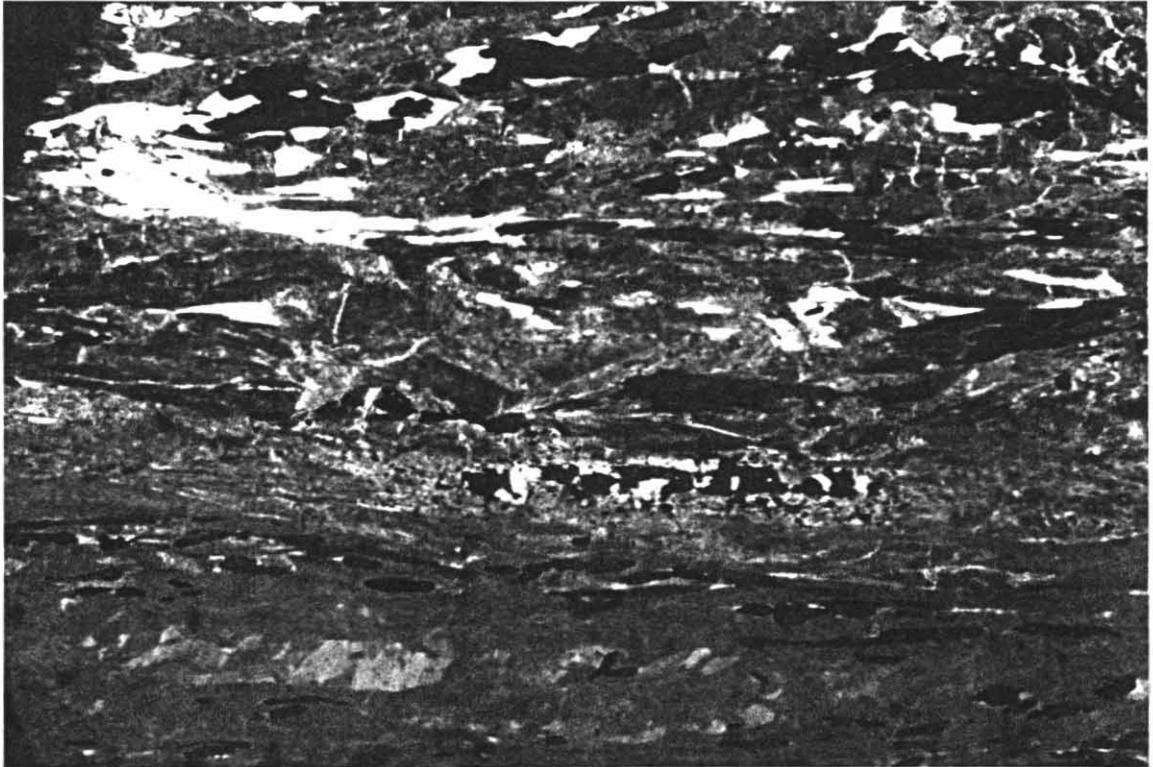


Fig. 14. Transition from chlorite-rich layer containing stringers of magnetite and plagioclase porphyroblasts, to a band rich in amphibole, biotite and magnetite. This same section also contains garnet, amphibole and plagioclase together with minor retrogressive chlorite. The chlorite-rich layer is interpreted as a thoroughly retrogressed equivalent of the amphibole-biotite-garnet assemblage. Sample AP2 82. Magnification x50, PPL.