APPENDIX 1

Four Petrology Reports

(See Digital File EL20_2003_200505_ 03_ Appendix1.pdf)

1. Sulphide Mineragraphy DDH NCT002
   By McArthur Ore Deposit Assessments Pty Ltd – Nov 2004

2. Petrographic Descriptions for twelve drill core rock samples from drill holes NCT001 & NCT002 (Mr Read Volcanics, Tasmania)
   By Mason Geoscience Pty Ltd – July 2004

3. Petrographic Descriptions for one grab rock sample from the Mt Read Volcanics (Tasmania).
   By Mason Geoscience Pty Ltd – January 2005

4. Petrographic Descriptions for five rock samples from Drill Hole NCT003 (Mt Read Volcanics, Queenstown Region, Tasmania)
   By Mason Geoscience Pty Ltd – February 2005

NEWCREST EXPLORATION

SULPHIDE MINERAGRAPHY
DDH NCT002

November 2004

McArthur Ore Deposit Assessments Pty Ltd

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NEWCREST EXPLORATION

DDH NCT002 SULPHIDE MINERAGRAPHY
November 2004

Introduction

5 polished thin sections from drillhole NCT002 (depths 199.1m, 202.5m, 204.2m, 206.8m, 447.8m) were submitted by Ken Morrison (on behalf of Newcrest Exploration) for assessment of sulphide mineralogy by MODA. Petrology had been previously undertaken on these slides by Pontifex and Associates (Adelaide). The non-polished thin sections included were not examined by MODA.

Method

Any sulphides (and gold) found on the slides were texturally described and several photomicrographs taken. Different textural styles of the same mineral are named with a numerical suffix according to predominance - NOT paragenetic sequence. For each sample, two images were selected to be presented in the standard MODA format as a one-page descriptive mineragraphy report. All 25 images were collated into a PowerPoint slideshow (on CD) which should ideally be viewed whilst reading the descriptions.

General Comments

Although the mineralogist has had no briefing on the field relationships of these samples, a few conclusions can be reached about this mineralisation, based solely on the micro-textural relationships observed.

- All the samples are strongly cleaved altered volcanics. The dominant alteration mineral is sericite, with minor quartz, chlorite and carbonate.
- All except the last sample (447.8m) contain ubiquitous disseminated fine-grained pyrite (5-50μm) and minor ultrafine-grained sphalerite that is associated with the sericitic alteration episode.
- The only evidence of early cross-cutting sulphide mineralisation was found in sample 206.8m.
- In all except the last sample (447.8m), the vast majority of the sphalerite-galena-chalcopyrite-tetrahedrite mineralisation appears to have been remobilised into its current textural location during, or after the Devonian deformation episode.
- In many cases, the non-pyrite sulphides appear to have been deposited late, into existing voids following earlier crustiform quartz and sparry carbonate deposition. There is very little evidence of replacement.
- Remobilisation of sphalerite, chalcopyrite, galena and tetrahedrite (along with quartz, chlorite and carbonate) into low pressure shadow zones parallel to

cleavage, around the non-ductile quartz and pyrite aggregates is quite common.

- 11 small grains of gold (up to 20µm) were found in sample 204.2m, hosted in annealed pyrite aggregates at grain boundaries, or in adjacent remobilised sphalerite. It appears the gold has been originally “sweated” out of the pyrite – a common feature in all Tasmanian auriferous base metal deposits.
- No unequivocal clastic base metal sulphides were observed, apart from one lone example of a highly stretched galena lens 650µm long in sample 204.2m.
- The common, but minor occurrence of sphalerite in fine-grained contorted clusters hosted in quartz, often associated with annular crustiform pyrite is unusual and not familiar to the author.
- The last sample (447.8m) contains virtually no pyrite, but late sphalerite-galena-chalcopyrite infills the core of a late cross-cutting carbonate-quartz veinlet, a probable Devonian feature.

G.J.McArthur PhD FAusIMM MMICA MSEG
Principal Geologist

NCT002 199.1m
Sulphide Mineralisation

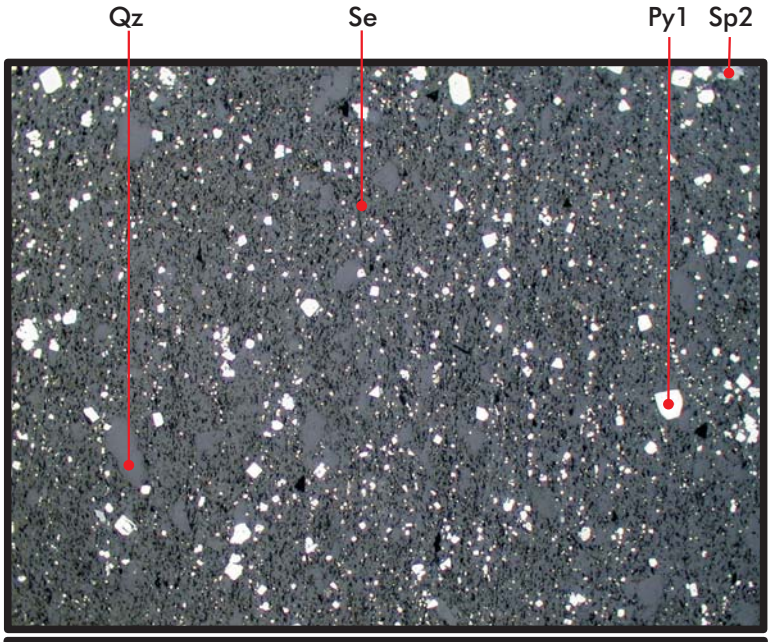

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Photo Scale: 1cm = 130μm

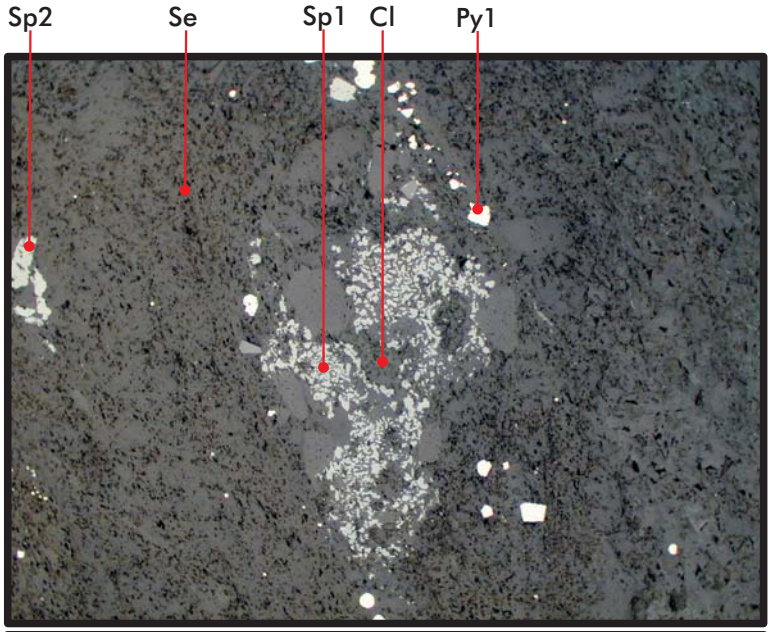

Photo: 7040, Digital image, Objective: 10X, Light: Reflected, Nicols: Uncrossed
Photo Scale: 1cm = 130μm

Microscopic description

Sulphide mineralisation only.

Pyrite (Py) (estimated 0.5-1.0 vol%) Dominantly occurring as disseminated (maximum 10% by volume) fine-grained euhedra 5-50μm (Py1) hosted by strongly cleaved and laminated ultrafine-grained sericite bands. The coarser grains often show recrystallised sericite shadow beards. Less common as isolated trains of coarser euhedra mainly up to 200μm, and rarely to 600μm (Py2) hosted by narrow cleaved bands of chlorite. No strong association with sphalerite.

Sphalerite (Sp) (trace) Mainly scattered throughout as occasionally contorted, lensoid clusters <400μm across, of very pale (low Fe) sphalerite grains (Sp1), hosted in sericite/chlorite and carbonate. Individual grains within these clusters are generally <50μm. Less common as scattered, irregular grains, mainly <5μm, but occasionally up to 70μm (with galena) hosted by the fine-grained sericite-pyrite units (Sp2).

Galena (Gn) (extremely rare) One occurrence found, as a 45μm inclusion in sphalerite.

See photomicrographs: NCT002-1991(a-c).

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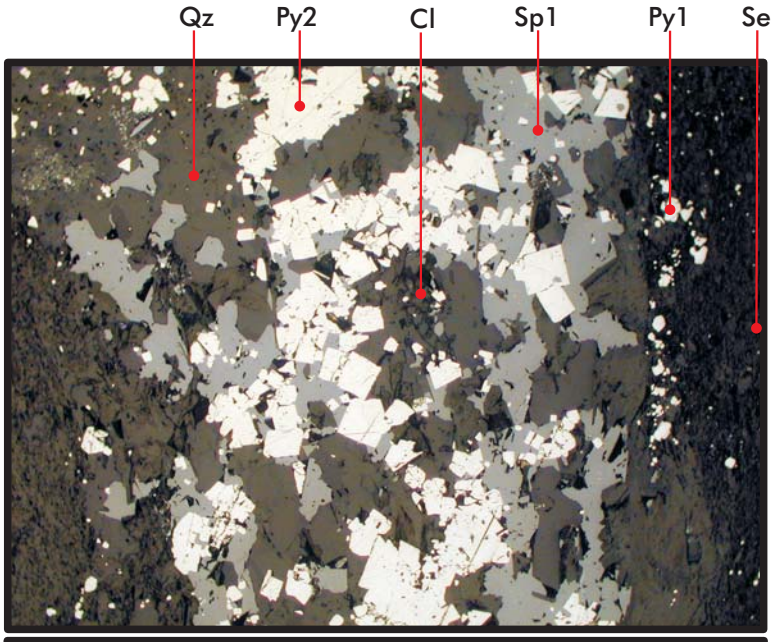
NCT002 202.5m
Sulphide Mineralisation



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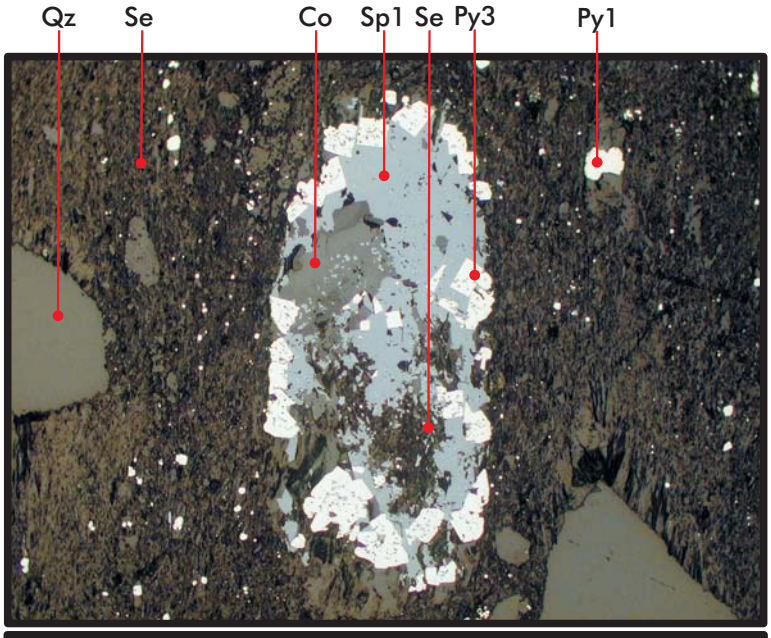

Photo: 7043, Digital image, Objective: 10X, Light: Reflected, Nicols: Uncrossed
Photo Scale: 1cm = 130μm

Microscopic description

Sulphide mineralisation only.

Pyrite (Py) (estimated 2 vol%) Dominantly occurring as disseminated (maximum 15% by volume) fine-grained euhedra 5-50μm (Py1) hosted by strongly cleaved massive sericite. In some areas these fine-grained euhedra are concentrated into augen-shaped clusters, possibly reflecting original primary clasts. Also as aggregates up to 500μm (Py2) strongly associated with chalcopyrite-diseased sphalerite that are hosted by siliceous bodies up to 3mm x 1mm in size, that could be clasts or boudinaged veins. Pyrite is also seen to occasionally form crusts <100μm wide (Py3), rimming ovoid sphalerite bodies, but in this form the pyrite is full of sphalerite inclusions.

Sphalerite (Sp) (estimated 0.5 vol%) Dominant as chalcopyrite-diseased irregular masses or ovoid bodies <1.5mm (Sp1) of medium-Fe (2-5%Fe) sphalerite associated with pyrite aggregates and crusts, and hosted by variable grainsize quartz and recrystallised sericite. Galena inclusions are extremely rare, but small rutile inclusions are fairly common in the ovoid bodies with Py crusts. Less common scattered throughout as ovoid/lensoid clusters <500μm across of very pale (low Fe) sphalerite grains (Sp2), hosted in sericite or carbonate. Individual grains within these clusters are generally <70μm. Volumetrically insignificant, but common as scattered, irregular grains, mainly <20μm (Sp3) hosted by the fine-grained sericite-pyrite.

Chalcopyrite (Cp) (trace) Mainly as classic chalcopyrite-disease in sphalerite with most blebs <2μm, and rarely up to 30μm (Cp1). Also as rare irregular grains <45μm hosted by carbonate (Cp2), with galena.

Galena (Gn) (trace) Mainly as irregular grains <50μm hosted by carbonate "clasts" (Gn1), accompanied by chalcopyrite. Rather rare as isolated inclusions <35μm hosted by sphalerite (Gn2).

See photomicrographs: NCT002-2025(a-g).

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NCT002 204.2m
Sulphide Mineralisation

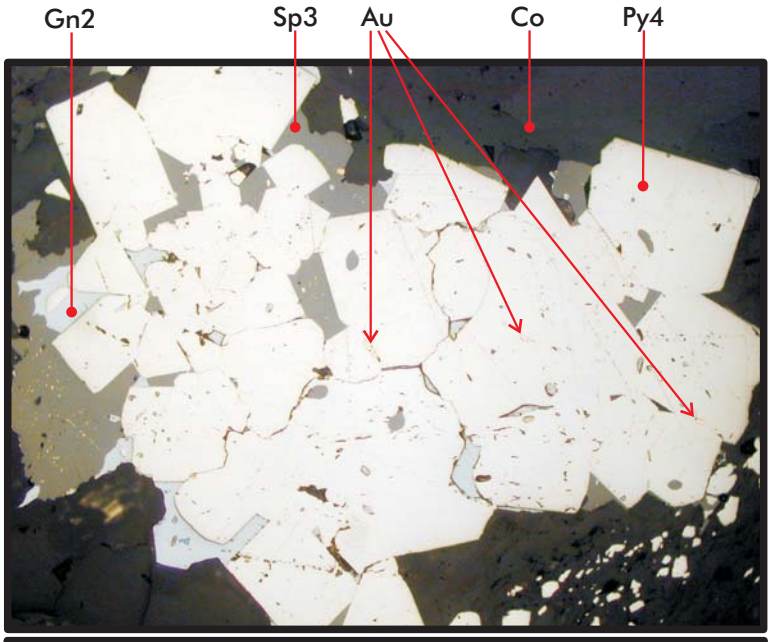

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Photo Scale: 1cm = 66μm

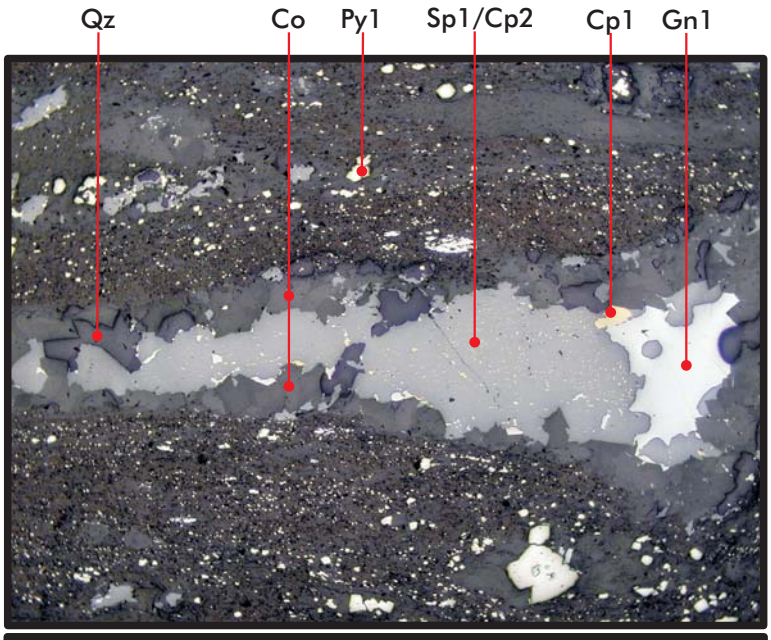

Photo: 7054, Digital image, Objective: 5X, Light: Reflected, Nicols: Uncrossed

Photo Scale: 1cm = 260μm

Microscopic description

Sulphide mineralisation only.

Pyrite (Py) (estimated 2 vol%) Dominantly occurring as disseminated (maximum 10% by volume) fine-grained euhedra 5-50μm (some to 200μm, Py1) hosted by strongly cleaved ultrafine-grained sericite (±quartz/chlorite). The coarser grains often show well-developed shadow beards of chlorite/quartz/carbonate. Less common as scattered aggregates up to 600μm (Py2) hosted by irregular siliceous patches that often show pull-aparts filled by carbonate or chlorite. One occurrence of a lensoid body 6mm x 1mm of semi-massive pyrite (Py3) with interstitial sericite/chlorite and minor sphalerite. Also as coarse-grained aggregates <600μm (Py4) associated with sphalerite+galena±gold, hosted by carbonate.

Sphalerite (Sp) (estimated 0.5 vol%) Mainly as unstrained bodies of chalcopyrite-diseased sphalerite (Sp1), up to 2mm x 500μm with associated galena+chalcopyrite±tetrahedrite±pyrite, as late infillings of variably-shaped cavities, that are partially lined with drusy carbonate and lesser quartz. In some areas the sphalerite+galena appears to partially replace the infilling carbonate. Of interest is the unusual purple colouration in transmitted light, which the author has only seen before in samples from MSV deposits in the Kimberleys. Also as scattered elongate grains <400μm (Sp2) with minor galena±pyrite inclusions and remobilized as shadow beards (Sp3) with rare gold inclusions, growing on larger pyrite or quartz grains. Less common as scattered, irregular grains (Sp4), mainly <20μm, hosted by the fine-grained sericite+quartz+pyrite units.

Galena (Gn) (estimated <0.5 vol%) Predominantly as irregular remobilized masses up to 800μm (Gn1) interstitial to, and partly replacing carbonate. Strongly associated with sphalerite, chalcopyrite and tetrahedrite, but paragenetically the latest deposited (with tetrahedrite). Uncommon with sphalerite forming shadow beards (Gn2) growing on pyrite or quartz. Reasonably common as small inclusions <30μm (Gn3) in euhedral pyrite. One occurrence of a highly strained, monominerallic lens 650μm x 100μm (Gn4).

Chalcopyrite (Cp) (estimated <0.5% vol%) Very predominant as irregular masses <600μm (Cp1), strongly associated with the remobilized infilling galena±sphalerite±tetrahedrite. Common, but volumetrically minor, as well-developed disease in sphalerite (Cp2). Disease blebs are 1-20μm.

Tetrahedrite (Te) (trace) Common as shadow beard growths <100μm (Te1), intimately associated with galena. Also as irregular grains <50μm (Te2) hosted by the remobilized, infilling galena. Very rare as inclusions <50μm (Te3) in euhedral pyrite.

Gold (Au) (trace) 11 small grains were found. 6 grains (2μm, 6μm, 6μm, 7μm, 10μm, 20μm) were found in one annealed pyrite aggregate, mainly on grain boundaries. Two 7μm grains were found hosted in nearby pyrite. 1μm, 6μm and 11μm grains are hosted in adjacent sphalerite shadow beards.

See photomicrographs: NCT002-2042(a-h).

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NCT002 206.8m
Sulphide Mineralisation

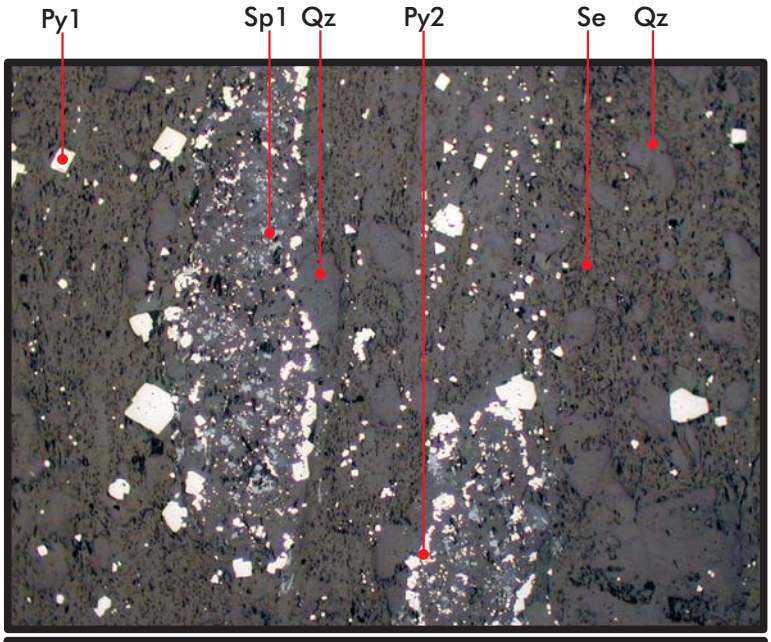

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Photo Scale: 1cm = 130μm

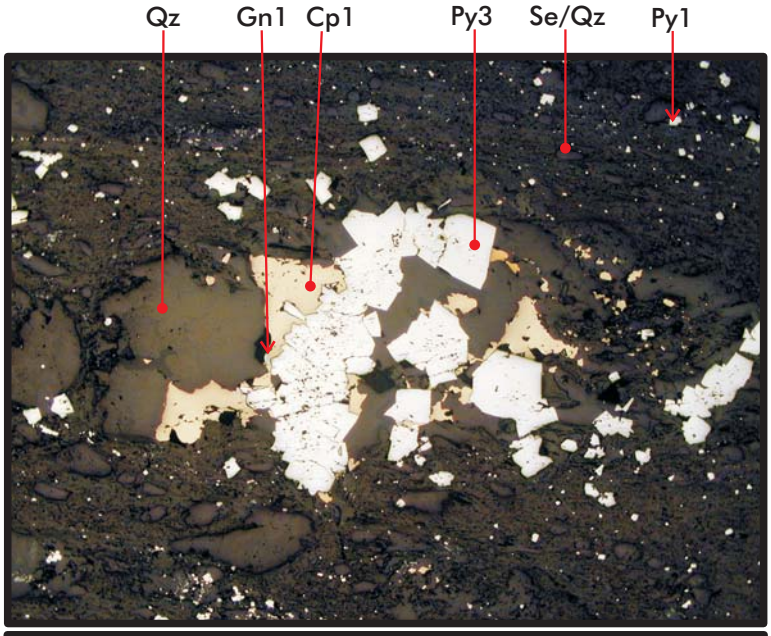

Photo: 7059, Digital image, Objective: 5X, Light: Reflected, Nicols: Uncrossed
Photo Scale: 1cm = 260μm

Microscopic description

Sulphide mineralisation only.

Pyrite (Py) (estimated 1 vol%) Dominantly occurring as disseminated (maximum 10% by volume) fine-grained euhedra 5-50μm (some to 500μm, Py1) hosted by strongly cleaved, ultrafine-grained laminated sericite (±quartz/chlorite). The more massive sericite and siliceous areas of the slide are noticeably sulphide-deficient. The coarser grains sometimes show shadow beards of sericite/chlorite/quartz. Also common as discontinuous, annular rings up to 30μm wide and 400μm diameter (Py2), hosted by irregular siliceous areas that generally have patchy, inner sphalerite. Also as coarse-grained aggregates up to 1mm (Py3) associated with coarse-grained chalcopyrite and quartz. A few large grains have extremely porous cores, suggesting a primitive, melnikovite precursor. One or two remnant, discontinuous pyrite veinlets (Py4) cut across the cleavage.

Chalcopyrite (Cp) (estimated <0.5% vol%) Predominant as irregular remobilized areas <400μm (Cp1), associated with coarser pyrite aggregates and quartz. Also as irregular disseminated grains up to 350μm (Cp2) with no associated pyrite, hosted in siliceous patches.

Sphalerite (Sp) (trace) Mainly scattered throughout as ovoid clusters <400μm across of sphalerite grains (Sp1) surrounded by a discontinuous pyrite annulus, hosted in quartz. Individual grains within these clusters are generally 10-100μm. Less common as scattered, irregular grains, mainly <10μm (Sp2), hosted by the fine-grained sericite-pyrite units.

Galena (Gn) (trace) Only as rare grains <50μm in remobilized chalcopyrite (Gn1) and as blebs <30μm hosted by euhedral pyrite (Gn2).

See photomicrographs: NCT002-2068(a-d).

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Ore Microscopy - Mine Geology - Resource Evaluations - Data Analysis

NCT002 447.8m
Sulphide Mineralisation

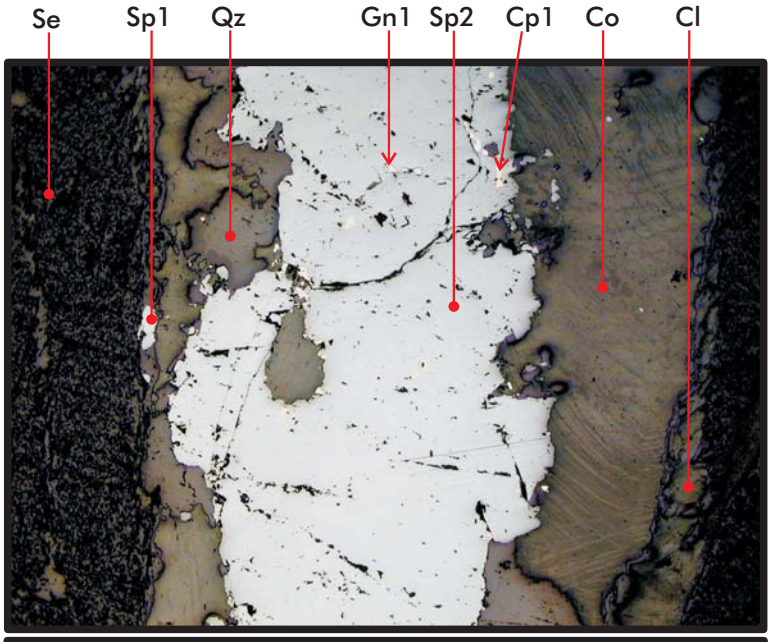

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Photo Scale: 1cm = 260μm

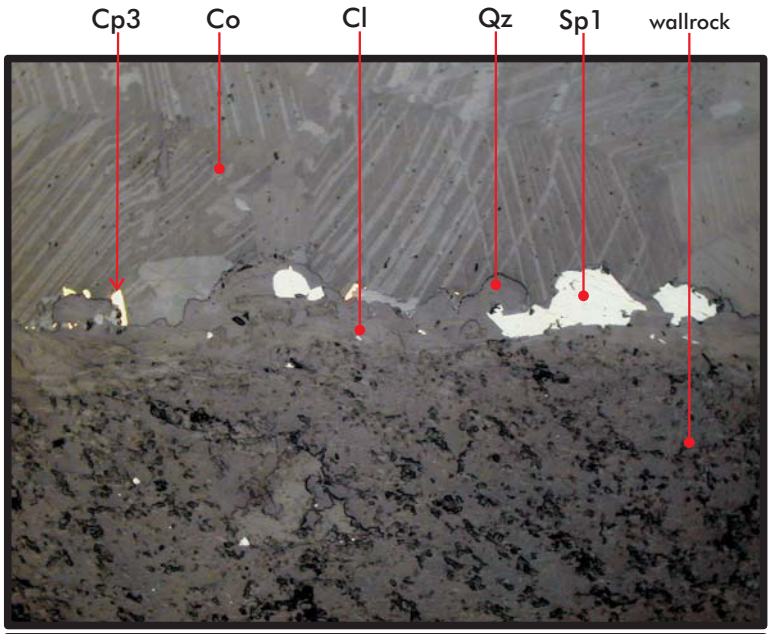

Photo: 7110, Digital image, Objective: 20X, Light: Reflected, Nicols: Uncrossed
Photo Scale: 1cm = 66μm

Microscopic description

Sulphide mineralisation only - all restricted to one 2mm wide carbonate-quartz veinlet.

Sphalerite (Py) (estimated 0.5 vol%) A minor amount of early inclusion-free sphalerite occurs as 50-150μm grains (Sp1) hosted by a thin quartz selvedge that coats the earliest, patchy chlorite-sericite selvedge. The dominant occurrence is as a single coarse-grained slug 4mm x 1mm of chalcopyrite-diseased sphalerite (Sp2) filling the centre of the veinlet, hosted by sparry carbonate. This later sphalerite contains scattered blebs of galena and chalcopyrite throughout, and rare pyrite on the margins.

Galena (Gn) (trace) Mainly as scattered, irregular blebs <75μm (Gn1) with associated chalcopyrite, hosted by the late sphalerite slug. Also as irregular grains <100μm hosted by narrow carbonate-filled cracks in the vein quartz (Gn2).

Chalcopyrite (Cp) (trace) Dominantly as scattered blebs <60μm (Cp1) with galena, hosted by the late sphalerite slug. Also scattered throughout the sphalerite slug as weakly developed, elongate disease blebs <1μm wide, but up to 35μm long (Cp2). Rare as scattered grains <35μm hosted by carbonate immediately inner from the quartz selvedge (Cp3).

Pyrite (Py) (trace) Extremely rare, a few euhedral grains <30μm occur either on the margin of the sphalerite slug, or in the close by carbonate.

See photomicrographs: NCT002-4478(a-b).

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Ore Microscopy - Mine Geology - Resource Evaluations - Data Analysis

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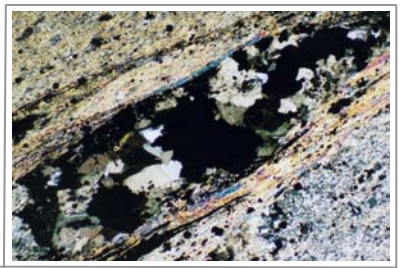
Petrographic Descriptions for Twelve Drill Core Rock Samples from Drill Holes NCT001 and NCT002 (Mt Read Volcanics, Tasmania)

REPORT #	**2993**
CLIENT	**Newcrest Mining Limited – SE Australia Exploration**
ORDER NO	**NML E 13163**
CONTACT	**Mr Ian Tedder**
REPORT BY	**Dr Douglas R Mason**
SIGNED	
	for Mason Geoscience Pty Ltd
DATE	**23 July 2004**



Petrographic Descriptions for Twelve Drill Core Rock Samples from Drill Holes NCT001 and NCT002 (Mt Read Volcanics, Tasmania)

SUMMARY

1. Rock Samples

- A suite of 12 drill core rock samples from drill holes NCT001 and NCT002, located in the Mt Read Volcanics south of Queenstown, Tasmania, has been studied using petrographic optical microscopy, supplemented by mineragraphic observations for selected samples.

2. Brief Results

- *A summary of rock names and mineralogy* is provided in TABLE 1.

- *Primary rock types*

  – **Fragmental volcanogenic rocks** formed the precursor rocks for the three shallower samples in NCT001 (10.9, 68.1, 106.0), and all of the samples in NCT002 (199.1, 202.5, 204.2, 206.8, 248.4, 417.1, 447.8). They are considered to have formed as crystal-lithic tuffs and crystal tuffs, composed of variable abundances of volcanogenic crystal fragments (quartz, plagioclase, minor ferromagnesians, Fe-Ti oxide, apatite, zircon) and lithic fragments (felsic volcanogenic rocks including rhyolitic ?fiammé and massive devitrified ?rhyolite), in a matrix of comminuted felsic materials including possible glass shards in NCT002, 447.8.

  – **Massive felsic rhyolitic rock** formed a coherent massive body of possible shallow intrusive origin. It formed the primary rock in the deeper two samples in NCT001 (463.5, 486.6), and also occurs as lithic fragments in the shallower 3 samples of NCT001 and a number of samples from NCT002.

- *Metamorphism and alteration*

  – **Magnetite-garnet skarn-type veins** are identified in the large meta-rhyolite fragment of NCT001, 68.1m. They are considered to have formed in response to invasion of the rhyolitic body by relatively high-temperature hydrothermal fluid. Absence of such veins from enclosing fragmental rock suggests that the veining event occurred prior to deposition of the fragmental volcanogenic sequence, and prior to the overprinting metamorphic event (see next).

  – **Low-grade regional metamorphism** in the lower greenschist facies has affected all samples. This generated variably foliated assemblages dominated by sericite, quartz, and albite, with minor chlorite, calcite, zoisite, opaques (?ilmenite) and Ti-phase (sphene, rutile). A more strongly foliated zone in drill hole NCT002 (202.5, 204.2, 206.8) has accepted a higher degree of strain, with associated development of moderately abundant pyrite and minor sphalerite, galena and chalcopyrite. Dissemination of pyrite pervasively throughout the rock, with concentrations in selected lithic fragment sites, supports the interpretation that the pyrite formed mainly by introduction in synmetamorphic hydrothermal fluid. Traces of sphalerite, galena and chalcopyrite are sparsely distributed through the rock, and may also have been introduced at this time. Mobility of base-metal sulphides during the metamorphic event is supported by the presence of thin sulphide-bearing veinlets (calcite + quartz + sphalerite + chlorite + galena + chalcopyrite) in sample NCT002, 447.8m. However, granular aggregates of sphalerite + galena ± chalcopyrite ± quartz ± calcite in NCT002 (202.5, 204.2, 206.8) are comparable in size and shape with deformed lithic fragments, and possibly formed as primary sulphidic fragments in the original volcanogenic deposit.

TABLE 1: SUMMARY OF ROCK NAMES AND MINERALOGY

SAMPLE	ROCK NAME	MINERALOGY*			
		Primary**	**Alteration**	**Veins**	**Weathering**
NCT001, 10.9m	Meta-crystal-lithic tuff	Qtz, pla, opq(?ilm), zir	Ser, qtz, cal, chl, zoi	Cal, ser, zoi	-
NCT001, 68.1m	Meta-crystal tuff	Qtz	Ser, alb, cal, zoi, leu(?rut)	-	-
	Magnetite-garnet veined, meta-felsic rock (lithic fragment)	-	Alb, qtz, ser, chl	Opq(mt), gar	-
NCT001, 106.0m	Meta-crystal-lithic tuff	Qtz, pla, opq(?ilm), zir	Ser, qtz, cal, alb, chl, zoi	-	-
NCT001, 463.5m	Meta-acid igneous rock (rhyolite)	Qtz, zir	Ser, cal, chl, rut	-	-
NCT001, 486.6m	Meta-acid igneous rock (rhyolite)	Qtz, zir	Ser, qtz, cal, chl, alb, opq, ?rut/?spn	-	-
NCT002, 199.1m	Foliated meta-sedimentary breccia	Qtz, zir	Ser, qtz, chl, dol, py, rut, sph, gal	Dol, py, sph, gal	-
NCT002, 202.5m	Foliated high-intensity sericite-sulphide altered meta-fragmental rock	Qtz, zir	Ser, py, qtz, rut, sph, gal, cpy	-	-
NCT002, 204.2m	Foliated sericite-sulphide altered meta-fragmental rock	Qtz	Ser, qtz, py, chl, dol, sph, gal, cpy, gld	-	-
NCT002, 206.8m	Foliated meta-fragmental rock (darker host rock)	Qtz, zir	Ser, py, dol, chl, sph, cpy, gal, rut, ilm	-	-
	Foliated meta-felsic rock (?volcanogenic lithic fragment)	Qtz	Ser, qtz, chl, py, rut, cpy, gal	-	-
NCT002, 248.4m	Weakly foliated meta-lithic-crystal tuff	Qtz, zir	Ser, qtz, chl, cal, opq(?py,?ilm), ?spn	-	-
NCT002, 417.1m	Foliated meta-crystal tuff	Qtz, apa, zir	Ser, qtz, chl, cal, Kf, opq(?ilm), spn	-	-
NCT002, 447.8m	Calcite-quartz-sulphide veined, weakly foliated meta-crystal tuff	Qtz, zir	Ser, qtz, chl, opq(?ilm)	Cal, qtz, chl, sph, gal, cpy	-

NOTES:
*: Minerals are listed in each paragenesis according to approximate decreasing abundance.
**: Only primary minerals currently present in the rock are listed. Others may have been present, but are altered.

Mineral abbreviations:
Alb = albite; apa = apatite; cal = calcite; chl = chlorite; cpy = chalcopyrite; dol = dolomite; gal = galena; gar = garnet; gld = native gold; ilm = ilmenite; Kf = K-feldspar; leu = leucoxene (indeterminate Ti-phase); mt = magnetite; opq = undifferentiated opaques (possible mineral in brackets); pla = plagioclase; py = pyrite; qtz = quartz; rut = rutile; ser = sericite; sph = sphalerite; spn = sphene; zir = zircon; zoi = zoisite; ?min = uncertain mineral identification.

1 INTRODUCTION

A suite of 12 drill core rock samples was received from Mr Ian Tedder (Newcrest Mining Limited – SE Australia Exploration, c/- Cadia Project, via Orange, NSW) on 24 June 2004.

It was indicated that the samples originate from the Mt Read Volcanics at a location south of Queenstown in Tasmania. Particular requests were:

i) To prepare a thin section for each sample, except for samples NCT002-199.1, 202.5, 204.2, 206.8m which come from a mineralised structure and therefore require a polished thin section.

ii) To provide a petrographic description including mineralogy, alteration and paragenesis.

iii) To respond to particular queries for some of the samples.

Excerpts from this report were provided by email to Mr Tedder on 20 July 2004. This report contains the full results of this work.

2 METHODS

The samples were examined in hand specimen and marked for thin section preparation.

At Mason Geoscience Pty Ltd conventional transmitted polarised light microscopy was used to prepare the routine petrographic descriptions. Additional mineragraphic observations are provided where a polished thin section is available.

Photomicrographs have been included for some samples to illustrate particular aspects of the rocks, including the nature of the fragments and overprinting effects.

3 PETROGRAPHIC DESCRIPTIONS

The petrographic descriptions are provided in the following pages. A combined petrographic and mineragraphic description is provided where a polished thin section is available.

SAMPLE : NCT001, 10.9m (Mt Read Volcanics, Tasmania)

SECTION NO : NCT001, 10.9

HAND SPECIMEN : The drill core sample represents a fine-grained pale grey rock through which are distributed small equant dull waxy quartz grains. Dark green small patches and larger bands or veins appear to be dominated by chlorite.

ROCK NAME : Meta-crystal-lithic tuff

PETROGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

Mineral	Vol %	Origin
Quartz	10	Primary crystals
Plagioclase	1	Relict primary crystals
Opaques (?ilmenite)	Tr	Relict primary crystals
Zircon	Tr	Primary crystals
Sericite	68	Metamorphic / fracture fillings
Quartz	10	Metamorphic
Calcite	5	Metamorphic / fracture fillings
Chlorite	5	Metamorphic
Zoisite	Tr	Metamorphic / fracture filling

In thin section, this sample displays a partly-preserved primary fragmental texture, modified by metamorphic recrystallisation and mild deformation.

Quartz occurs in minor amount in two forms:

i) Some occurs as clear equant euhedral to angular anhedral grains ranging in size from ~0.2 mm up to ~1.5 mm. Many display severe magmatic corrosion which, together with their equant crystal shapes, confirm a volcanogenic origin.

ii) Some quartz occurs as equant but anhedral patches ~0.2-0.4 mm in size which occupy local patches up to several millimetres in size. These appear to represent areas of incipient devitrification in the precursor rock.

Fine-grained sericite is abundant, and occurs in different sites:

i) Most occurs as an oriented mat that pervades most of the rock. This appears to represent replaced precursor compositionally uniform (glassy) matrix.

ii) Better-crystallised sericite forms slightly larger flakes concentrated along irregularly oriented thin veinlets through the rock. Local fractures also contain selvedges of better-crystallised sericite.

iii) Fine-grained mats of randomly oriented sericite flecks have densely replaced precursor plagioclase prisms and crystal fragments. Some of these retain some primary clear plagioclase.

Chlorite occurs in minor amount as fine-grained, poorly-crystallised, drab green aggregates that tend to occur mainly in the sericite-altered plagioclase crystal sites.

Calcite occurs in minor amount as ragged clear grains concentrated along some fractures with sericite, and also located in some of the altered crystal sites.

Zoisite is present in trace amount as tiny stumpy prismatic crystals that occur along fractures with associated sericite, and also in some of the altered crystal sites.

Opaques occur in minor amount as blocky crystals irregularly sprinkled through the rock. Most have suffered partial to complete replacement by cryptocrystalline turbid Ti-phase material ('leucoxene').

Zircon occurs in trace amount as small stumpy prismatic crystals with typical high relief and strong birefringence. Some of these crystals occur in sericite-chlorite-altered crystal sites that may have been of ferromagnesian origin (eg ?biotite), but some occur sparsely scattered through the sericite-quartz altered ?glassy matrix.

Scattered through the rock are uncommon ovoid to irregularly shaped patches (lithic fragments) composed of small anhedral quartz grains in a sericitic matrix.

INTERPRETATION :

This sample is considered to have formed as a felsic tuffaceous volcanogenic rock, originally composed of scattered crystals (quartz, plagioclase, minor ferromagnesians, ?ilmenite, zircon) and minor lithic fragments in a fine matrix of probable glassy ash nature.

Low-grade regional metamorphism has affected the rock, generating the new replacement assemblage of sericite + quartz + chlorite + calcite + leucoxene + zoisite. Variably oriented fractures were sealed by calcite + sericite ± zoisite, and slightly coarser sericite developed in selvedges marginal to the fractures.

SAMPLE : NCT001, 68.1m (Mt Read Volcanics, Tasmania)

SECTION NO : NCT001, 68.1

HAND SPECIMEN : The drill core sample has captured the contact between medium grey fine-grained fragmental rock and darker greenish grey altered rock cut by irregularly oriented thin fracture fillings of dark brownish black altered magnetite (strong positive response to the hand magnet) and white calcite.

ROCK NAME : Meta-crystal tuff

Magnetite-garnet veined, meta-felsic rock (lithic fragment)

PETROGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

Mineral	Vol %	Origin
Meta-crystal tuff		
Quartz	10	Primary crystals
Sericite	76	Metamorphic
Albite	10	Metamorphic
Calcite	3	Metamorphic
Zoisite	Tr	Metamorphic
Leucoxene (?rutile)	<1	Metamorphic
Magnetite-garnet veined, meta-felsic rock		
Albite	67	Devitrification / metamorphic
Quartz	10	Devitrification / metamorphic
Sericite	15	Metamorphic
Chlorite	5	Metamorphic
Opaques (mainly ?magnetite)	2	Vein and fracture fillings
Garnet	<1	Selvedges of veins and fracture fillings

In thin section, this sample displays different textures in two different parts of the rock.

Meta-crystal tuff retains its primary fragmental texture. Quartz occurs as scattered equant crystals and angular crystal fragments ~0.2-2.0 mm in size. Most display strong magmatic resorption, supporting a volcanogenic origin. Plagioclase formed prismatic crystals and crystal fragments comparable in size with the quartz, but all have suffered complete replacement by optically continuous albite and dense mats of sericite.

Sericite is particularly abundant throughout the matrix, where it forms a dense mat with preferred orientation.

Calcite occurs in minor amount as small ragged grains in aggregates, commonly in pressure shadows at ends of quartz and plagioclase crystal sites.

Zoisite is present in minor amount as small turbid granules that tend to be loosely concentrated in diffuse patches.

Leucoxene (possibly better-crystallised ?rutile) occurs as optically continuous dull replacements of precursor opaque crystals (probably ?ilmenite).

Magnetite-garnet veined, meta-felsic rock is composed mostly of albite and quartz. The quartz forms small anhedral grains that tend to form intergrowth textures with anhedral enclosing albite grains. Together the quartz and albite appear to represent a relict devitrification texture in a felsic volcanogenic rock.

Sericite is moderately abundant, forming tiny flecks concentrated in wisps and discontinuous patches whose preferred orientation contributes to a foliation through the rock, parallel to the preferred alignment of sericite in the associated meta-crystal tuff. At the contact between the two rock type, sericite wisps continue across the contact, confirming that metamorphism has overprinted both rock types.

Chlorite occurs in minor amount as poorly crystallised fine-grained patches associated with the sericite wisps, and some chlorite also tends to occur at margins of the veins (see next).

Cutting the rock are brittle veins of variable thickness filled by opaque materials (mainly magnetite, as supported by magnetic response in hand sample). Small subhedral garnet grains are developed as a discontinuous selvedge along the margin of the opaque-filled veins. The garnet displays the typical optical properties of this phase: pale yellow-pink colour, high relief, isotropic optical behaviour. Most of the garnet grains have suffered cracking and partial replacement by calcite.

INTERPRETATION :

This sample is considered to have formed in different stages:

1. Felsic igneous rock, possibly of shallow intrusive mode of emplacement, suffered devitrification to form the assemblage albite + quartz.

2. Fracturing of the felsic igneous rock encouraged invasion by relatively high-temperature hydrothermal fluid, producing magnetite skarn veins composed of magnetite with garnet selvedges.

3. At a later time, felsic volcanism produced a tuffaceous deposit of crystals and ash with local large blocks of basement rock (ie skarn-veined devitrified felsic rock). The earlier origin of the felsic volcanic basement blocks is indicated by the restriction of the high-temperature skarn veins to that rock type.

4. Low-grade regional metamorphism affected the rock sequence, generating new weakly foliated assemblages of sericite + albite + quartz + calcite + minor chlorite + Ti-phase. The observations that sericite wisps overprint the contact between the large rock block and enclosing tuff confirms that metamorphism occurred after development of the earlier rock structures.

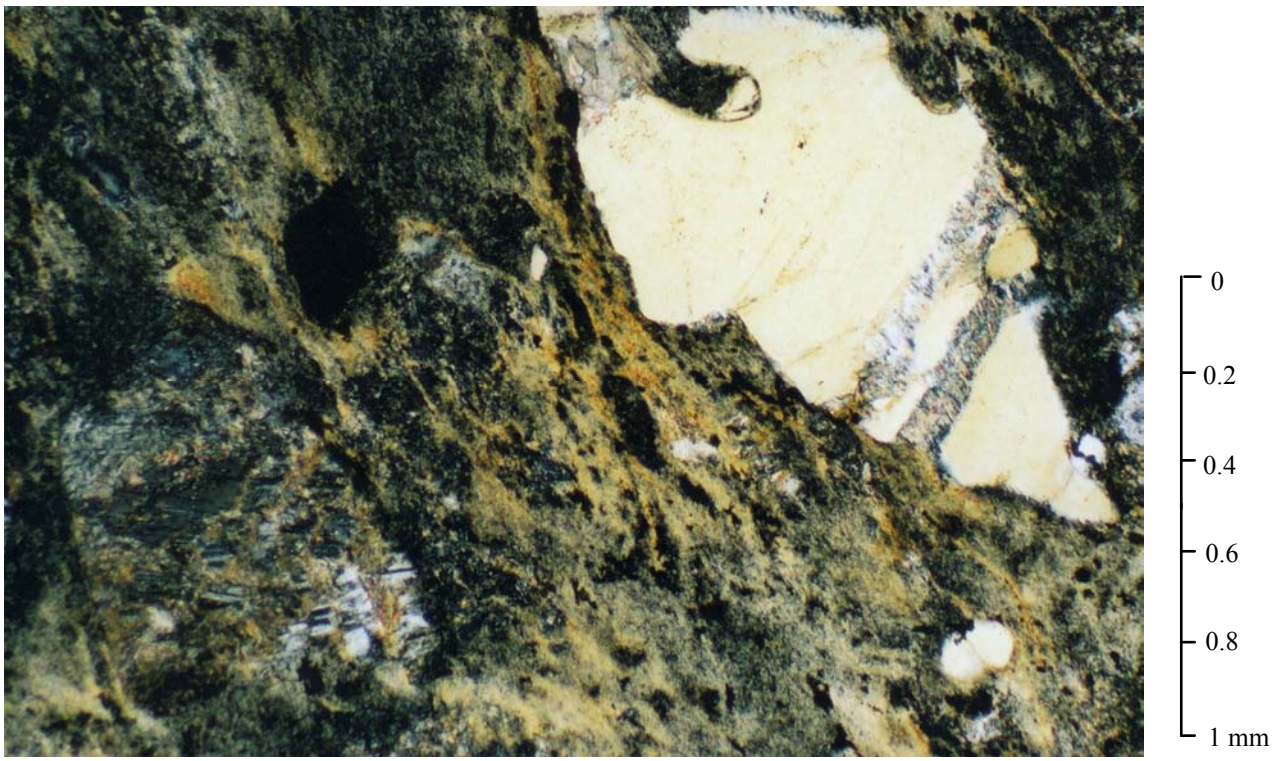


FIG. 1: SAMPLE NCT001, 68.1m (Transmitted light, crossed polarisers, x5, Film 1 / Frame 3)
This view illustrates the nature of the principal volcanogenically derived crystal fragments: a quartz fragment (yellowish white, top right) displays magmatic resorption, alignment within the foliation (NW-SE), but lack of ductile deformation except for pull-apart structure at its bottom right; a plagioclase fragment (bottom left) is partly sericitised.

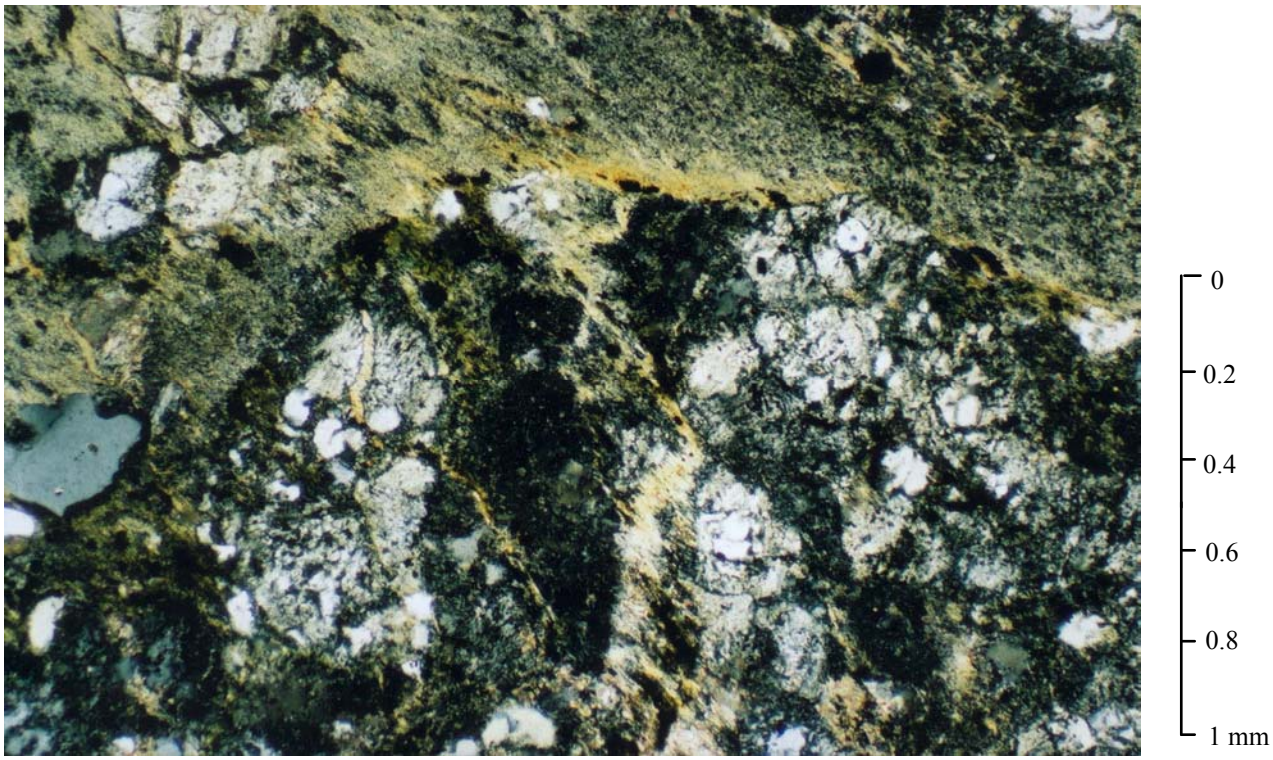


FIG. 2: SAMPLE NCT001, 68.1m (Transmitted light, crossed polarisers, x5, Film 1 / Frame 1)
This view captures the contact between a large fragment of meta-devitrified rhyolite (bottom, composed mainly of white to grey quartz and minor sericite) in foliated sericitic matrix (yellow to drab green). Note the consistent orientation of the foliated sericite (NW-SE) in both matrix and as an overprint of the lithic fragment.

FIG. 3: SAMPLE NCT001, 68.1m (Transmitted plane polarised light, x5, Film 1 / Frame 2)
This view was taken from within a meta-rhyolite fragment. It illustrates veins of opaques (mainly magnetite) and garnet (colourless high-relief grains at margins of the opaque veins). These veins cut only the meta-rhyolite fragment, and therefore formed prior to incorporation of the rhyolite into the fragmental deposit.

SAMPLE : NCT001, 106.0m (Mt Read Volcanics, Tasmania)

SECTION NO : NCT001, 106

HAND SPECIMEN : The drill core sample represents a drab grey rock through which are scattered small equant glassy quartz grains and local larger (up to ~1 cm) angular darker grey lithic fragments.

ROCK NAME : Meta-crystal-lithic tuff

PETROGRAPHY AND MINERAGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

Mineral	Vol %	Origin
Quartz	12	Primary crystals and fragments
Plagioclase	3	Relict primary crystals and fragments
Opaques (?Fe-Ti oxide, incl. leucoxene)	<1	Relict primary crystals (inc. alteration)
Zircon	Tr	Primary crystals
Lithics (albite, quartz; meta-acid volcanic)	5	Lithic fragments
Sericite	75	Metamorphic
Calcite	3	Metamorphic
Chlorite	1	Metamorphic
Zoisite	Tr	Metamorphic

In thin section, this sample displays a relatively well-preserved primary fragmental texture of volcanogenic origin, modified by selective metamorphic recrystallisation and mild deformation.

Sericite dominates the rock, occurring as a fine-grained optically continuous mat developed throughout the matrix. Although essentially optically continuous, the sericitic mat is characterised by elongated patches, lenses or bands that contribute to the structure (foliation) through the rock, and wrap around crystals and lithic fragments.

Quartz occurs as uniformly distributed blocky crystals and angular crystal fragments up to ~1 mm in size. Most display moderate to severe magmatic resorption, supporting a volcanic origin.

Opaques form scattered blocky crystals, some partly replaced by turbid Ti-phase material (leucoxene). The opaques most likely formed as primary Fe-Ti mineral (possibly magnetite but no reflected light observations are available for confirmation).

Zircon is rare, forming tiny terminated prismatic crystals some of which occur epitaxially on the opaque grains.

Plagioclase formed blocky subhedral prisms and angular crystal fragments up to ~1 mm long. Most have suffered partial replacement by sericite or by calcite, but most retain some of their primary plagioclase.

Calcite occurs in minor amount as small anhedral grains that tend to be concentrated in aggregates in pressure shadows marginal to crystals or in microcracks that cut the crystals.

Chlorite is present in minor amount as fine-grained drab green aggregates sparsely scattered through the rock. Some of these may have formed as primary ferromagnesian crystals, but their nature has been obscured.

Zoisite occurs in trace amount as small turbid grains sparsely scattered through the rock. In places they occur in the sericitic matrix, but elsewhere occur along irregularly oriented thin fractures and in altered ?ferromagnesian grain sites.

Angular lithic fragments up to centimetre size are sparsely scattered through the rock. All display an equant devitrification texture composed of equant anhedral albite grains intergrown with small quartz grains. Some of the equant albite grains contain small lath-like crystallites of precursor primary plagioclase: these textures confirm that the rock formed by devitrification of a coherent acid igneous rock (possibly rhyolitic lava).

INTERPRETATION :

This sample is considered to have formed as a tuffaceous deposit composed of crystals (quartz, plagioclase, opaques possibly ?magnetite, trace ferromagnesians and zircon) in a fine matrix of probable ashy nature. Angular lithic fragments of devitrified ?rhyolite were deposited with the primary tuffaceous materials. Whether the acid lithic fragments were cogenetic with the acid tuff, or belonged to an earlier basement lithology, remains unknown: note that similar devitrified felsic rock contained magnetite-garnet veins in sample NCT001, 68.1m, and therefore possibly is of basement origin.

The rock has suffered low-grade regional metamorphism, generating the weakly foliated assemblage of sericite + minor calcite + chlorite + zoisite. Recrystallisation of the felsic matrix to form a foliated sericitic mat suggests that the low-grade event was accompanied by a mild directed regional stress regime.

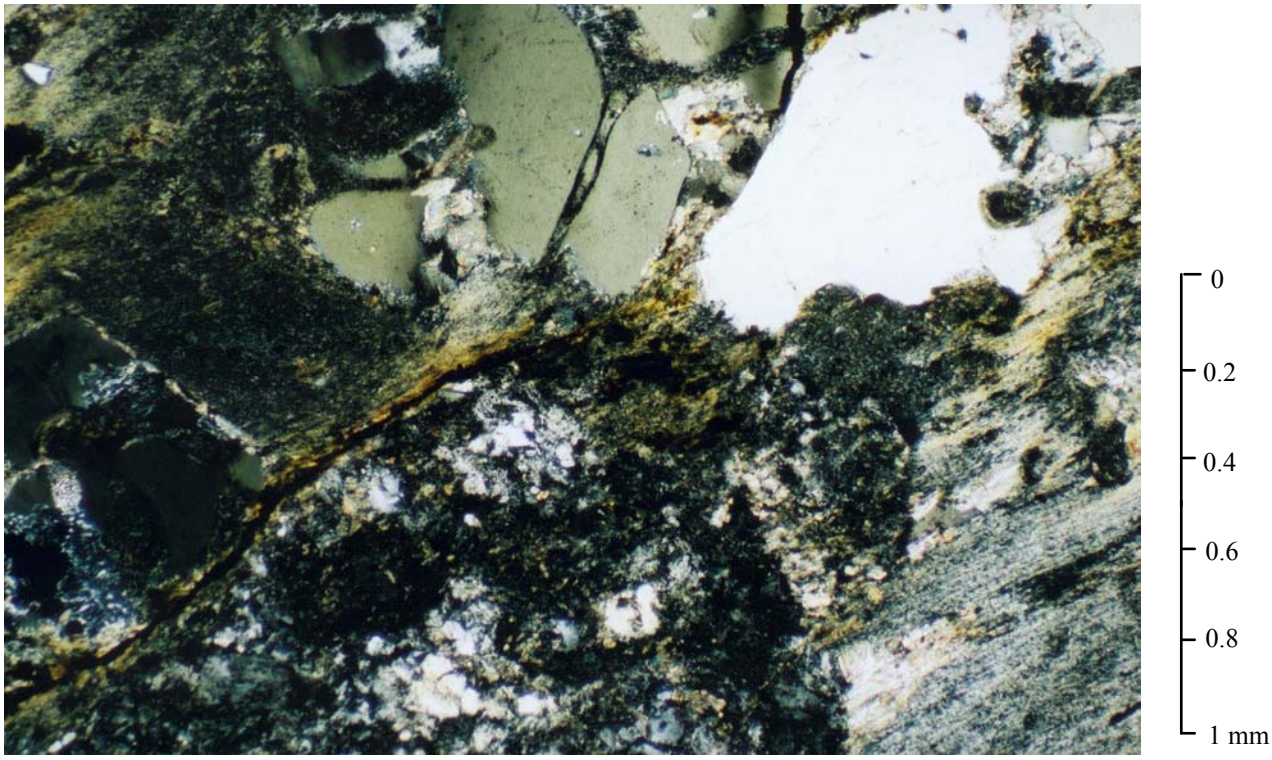


FIG. 4: SAMPLE NCT001, 106.0m (Transmitted light, crossed polarisers, x5, Film 1 / Frame 4)
This view illustrates the presence of different fragment types, including clear angular grains of volcanogenic quartz (white to pale grey, top centre, top right) and a fragment of devitrified rhyolite (bottom), in a variably foliated matrix dominated by sericite.

SAMPLE : NCT001, 463.5m (Mt Read Volcanics, Tasmania)

SECTION NO : NCT001, 463.5

HAND SPECIMEN : The drill core sample represents a fine-grained, massive, drab waxy greyish green rock, through which are scattered small darker green patches (?chlorite).

ROCK NAME : Meta-acid igneous rock (rhyolite)

PETROGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

Mineral	Vol %	Origin
Quartz	5	Igneous
Zircon	Tr	Igneous
Quartz	50	Devitrification
Sericite	40	Metamorphic alteration
Calcite	3	Metamorphic alteration
Chlorite	2	Metamorphic alteration
Rutile	Tr	Metamorphic alteration

In thin section, this sample displays a weakly preserved primary porphyritic igneous texture, modified by equigranular devitrification and overprinting metamorphic replacement.

Quartz dominates the rock, and two types are distinguished:

i) A small amount of quartz occurs as doubly terminated crystals up to ~1 mm long, and subrounded grains of similar size. These quartz crystals display forms consistent with a primary microphenocrystic igneous origin.

ii) Much quartz occurs as equant anhedral grains mostly ~0.4 mm in size. They form a more-or-less equigranular mosaic throughout the rock, considered to be of devitrification origin.

Sericite is the other principal phase. It occurs as fine-grained trails and mats distributed more-or-less uniformly through the rock. It appears to have formed by replacement of precursor materials (probably feldspar but none is preserved).

Calcite is present in minor amount as fine-grained ragged aggregates.

Chlorite occurs locally as small ragged fine-grained patches.

Rutile is present as small granules concentrated in loose small aggregates scattered through the rock: they may represent thoroughly altered precursor Fe-Ti oxide grains of primary origin.

INTERPRETATION :

This sample is considered to have formed as a massive coherent acid igneous rock of rhyolitic composition. It was originally composed of scattered small terminated quartz microphenocrysts in a glassy matrix. Other minerals might have been present in minor amount (eg ?Fe-Ti oxide grains). Whether the rock formed as a lava or a very shallow intrusive body remains unknown, but the lack of any type of flow banding in such a

highly viscous magma tends to support a shallow intrusive mode of emplacement rather than an extrusive (lava flow) mode of emplacement.

The rock has suffered replacement in response to a low-grade regional metamorphic event. This generated the moderately foliated assemblage of sericite + quartz + minor calcite + chlorite + rutile. The development of a preferred orientation in the sericite suggests that a directed regional stress regime accompanied the metamorphic event.

Note that a very similar rock type has been observed in NCT001, 68.1m and NCT001, 106.0m. In NCT001, 68.1m, the rock has suffered thin veining by magnetite + garnet, suggesting that the rock formed a basement rock modified by a skarn-type veining event and subsequent overprinting low-grade metamorphic event.

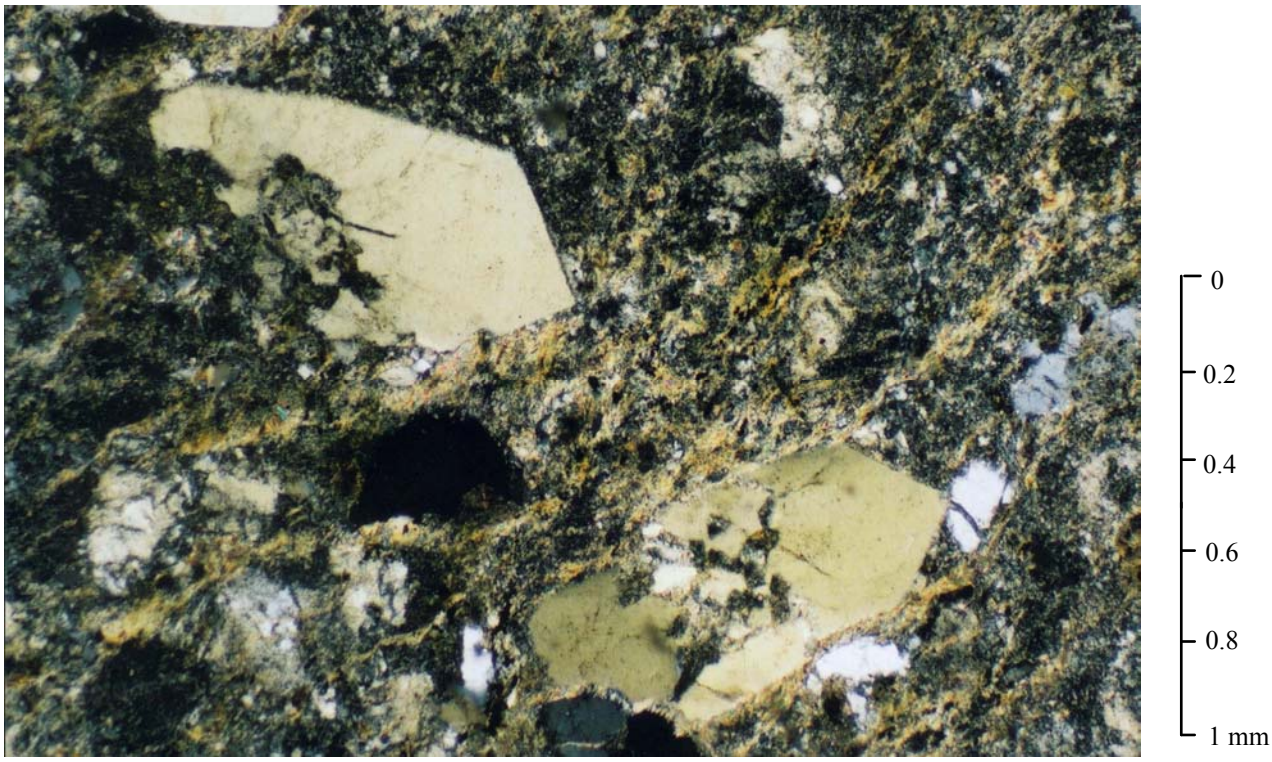


FIG. 5: SAMPLE NCT001, 463.5m (Transmitted light, crossed polarisers, x5, Film / Frame 6)
This view illustrates textural features of the meta-rhyolite. Euhedral terminated prismatic primary phenocrysts of quartz (pale yellow, upper left, lower right) are non-resorbed, which distinguishes them from the commonly resorbed volcanogenic crystals in most of the samples of this suite. The matrix suffered devitrification to form an equigranular mosaic of quartz-albite, prior to metamorphic overprinting which developed foliated flecks and trails of sericite (yellowish colour).

SAMPLE : NCT001, 486.6m (Mt Read Volcanics, Tasmania)

SECTION NO : NCT001, 486.6

HAND SPECIMEN : The rock slice represents a fine-grained, massive, drab greenish grey rock with scattered small ragged dark green (?chloritic) patches.

ROCK NAME : Meta-acid igneous rock (rhyolite)

PETROGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

Mineral	Vol %	Origin
Quartz	10	Igneous microphenocrysts
Zircon	Tr	Igneous
Quartz	30	Metamorphic
Sericite	43	Metamorphic
Calcite	15	Metamorphic
Chlorite	1	Metamorphic
Albite	Tr	Metamorphic (after plag. phenocrysts)
Opaques	Tr	Metamorphic
Ti-phase (?rutile, ?sphene)	Tr	Metamorphic

In thin section, this sample displays a partly-preserved microporphyritic primary igneous texture, modified by alteration effects including devitrification and metamorphic alteration.

Quartz is abundant and two textural types are distinguished:

i) A moderate amount occurs as small equant blocky crystals ~0.1-0.2 mm in size. They are distributed uniformly through the rock, and their size, shape and distribution support a primary igneous (microphenocrystic) origin.

ii) Much quartz forms equant anhedral grains ~0.4 mm in size. These quartz grains formed a more-or-less equigranular mosaic of probable devitrification origin, and tend to contain the smaller euhedral microphenocrysts of i) above as cores. The larger quartz grains therefore are readily interpreted as devitrification grains that formed with the precursor quartz microphenocrysts as nucleii.

Sericite is the other principal phase. It forms small flecks distributed throughout the rock. Some pervade the larger devitrification quartz grains of ii) above, rendering them somewhat turbid, but most sericite tends to form dense mats in a broad network developed around the quartz grains.

Calcite occurs in moderate amount as ragged clear grains in aggregates irregularly distributed through the rock.

Chlorite occurs in minor amount as tiny pleochroic green flakes that tend to be concentrated in small patches scattered through the rock. In places, some of these small patches display prismatic shapes of precursor crystals (probably primary ?plagioclase quench laths).

Albite is uncommon, occurring as optically continuous replacements of large prismatic crystals ~1 mm long. These represent altered plagioclase phenocrysts that were quite uncommon, scattered sparsely through the rock.

Opaques occur in trace amount as tiny equant crystals and small aggregates scattered through the rock. Their identification remains uncertain in the absence of reflected light observations.

A Ti-phase occurs in trace amount as small ragged grains with turbid appearance and weakly pleochroic character, and very high birefringence: it may be sphene or rutile but is too fine-grained for positive optical identification.

INTERPRETATION :

This sample is considered to have formed as an acid igneous rock, probably of rhyolitic composition. It originally contained small equant quartz crystals (microphenocrysts) and tiny ?plagioclase crystallites in a glassy groundmass. The complete absence of flow banding mitigates against a lava flow origin, and tends to support a shallow intrusive origin.

The rock has suffered pervasive modification in response to devitrification and metamorphic alteration. Devitrification generated a mosaic of equant anhedral quartz grains, and low-grade regional metamorphism generated sericite + calcite + chlorite + minor opaques + albite + trace Ti-phase (?sphene, ?rutile).

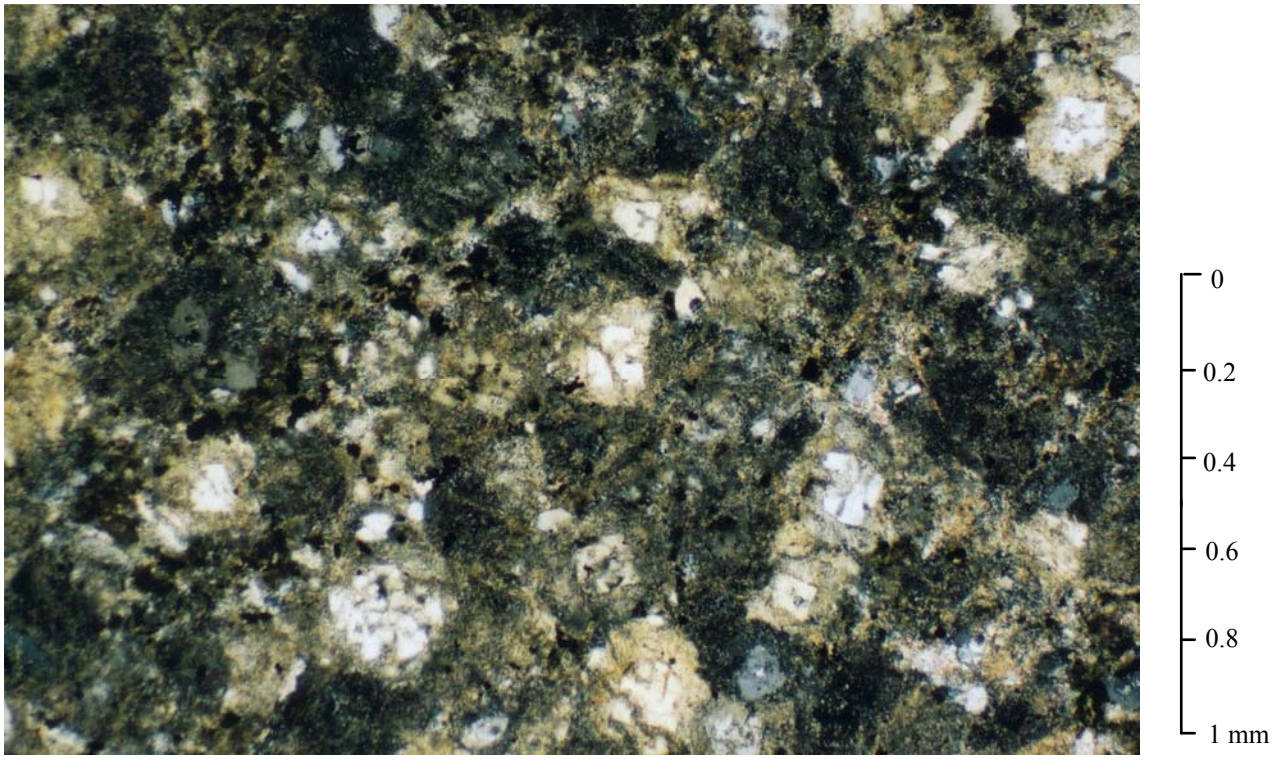


FIG. 6: SAMPLE NCT001, 486.6m (Transmitted light, crossed polarisers, x5, Film 1 / Frame 7)
This view of meta-rhyolite illustrates its massive texture where metamorphic strain has not been accepted. Tiny equant clear quartz grains (sparsely scattered) are primary in origin. Devitrification generated the equant anhedral grains of quartz + feldspar, which nucleated on the primary small quartz grains. Subsequent metamorphic overprint generated fine-grained pervasive sericite (pale yellowish to drab dark colour) by replacement of the feldspar.

SAMPLE : NCT002, 199.1m (Mt Read Volcanics, Tasmania)

SECTION NO : NCT002, 199.1

HAND SPECIMEN : The drill core rock slice represents a coarse fragmental rock composed of subparallel elongated fine-grained lithic fragments of various pale cream and medium green colours, in a fine-grained green matrix. A foliation is defined by alignment of the fragments and structure in the matrix. Tiny lustrous silvery sulphide grains (mainly ?pyrite) occur in fragments and matrix.

The sample fails to effervesce in reaction with dilute HCl, suggesting calcite is absent.

ROCK NAME : Foliated meta-sedimentary breccia

PETROGRAPHY AND MINERAGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

Mineral	Vol %	Origin
Quartz	15	Primary crystals and fragments
Zircon	Tr	Primary crystals
Sericite	53	Metamorphic
Quartz	20	Metamorphic / fracture fillings
Chlorite	5	Metamorphic
Carbonate (dolomite)	5	Metamorphic alteration / fracture fillings
Pyrite	Tr	Metamorphic alteration / fracture fillings
Rutile	Tr	Metamorphic
Sphalerite	Tr	Fracture fillings
Galena	Tr	Metamorphic

In polished thin section, this sample displays a partly-preserved coarse primary fragmental texture, modified by metamorphic deformation and replacement.

Quartz is moderately abundant and occurs in different forms:

i) Some occurs as equant blocky crystals up to ~1.5 mm in size that display magmatic resorption, and angular crystal fragments that range down to quite small size (~0.2 mm). Most retain their primary shapes, except for some which display incipient fragmentation and recrystallisation, and others that display partial grain shape modification by entrainment into the foliation.

ii) A significant amount of quartz occurs as tiny anhedral grains that form fine-grained equigranular mosaics pervasively through some lithic fragments. This is considered to represent metamorphic recrystallisation quartz

iii) A small amount of quartz occurs as equant anhedral grains ~0.2-0.4 mm in size, which form an equigranular mosaic in some lithic fragments inferred to represent devitrified and metamorphosed glassy acid igneous rock (rhyolite).

iv) A small amount of quartz occurs as tiny clear grains that partly fill some irregularly oriented thin fractures that locally cut the rock.

Sericite is abundant and occurs in different sites:

i) Much occurs as a strongly foliated mat which occupies the matrix areas between the lithic fragments. This is interpreted to represent recrystallised and deformed primary sedimentary argillaceous matrix.

ii) Much sericite occurs in modified lithic fragments, where it forms a fine-grained strongly foliated mat in meta-?argillite fragments, and fine-grained massive mats and mosaics in fine-grained altered meta-felsic rocks (?ash tuffs).

Chlorite occurs in moderate amount as fine-grained green flakes and patches that pervade modified lithic fragments. In some fragments the chlorite forms small sparsely scattered patches, in others it pervades the fragments in reticulated mat, and in a small number of fragments the chlorite forms a dense fine-grained foliated mat that occupies most of the elongated fragments. In the matrix, some chlorite tends to be concentrated in thin folia, locally enwrapping lithic fragments.

Carbonate occurs in moderate amount as anhedral grains to blocky (rhombic) crystals. Their shapes and quite strong double refraction support identification as dolomite. They tend to occur in aggregates, either in the matrix areas, in pull-apart structures in some lithic fragments, and as fillings in discontinuous thin fractures of variable orientation.

Pyrite is present in minor amount as small euhedral cubic crystals ranging from micron size up to ~0.4 mm. It is irregularly distributed, occurring in significant abundance pervasively through the meta-argillite lithic fragments and as larger crystals and aggregates in the matrix areas. A minor amount occurs associated with dolomite and quartz in local thin fracture fillings.

Rutile occurs in minor amount as small granules that tend to occur in small aggregates which possibly represent completely altered primary Fe-Ti oxide grains.

Sphalerite is rare, occurring as small ragged grains very sparsely and irregularly scattered through the rock.

Galena is rare, forming tiny inclusions within some larger pyrite crystals and also occurring as tiny ragged grains intergrown with sphalerite.

Zircon is rare, occuring as small terminated prismatic crystals in the matrix areas.

INTERPRETATION :

This sample is considered to have formed as a coarse fragmental rock. It was originally composed of abundant, closely packed lithic fragments (felsic volcanogenic rocks, some argillaceous sediments) in a fine-grained matrix of argillaceous nature with minor crystals and crystal fragments (quartz, minor others including ?Fe-Ti oxide and zircon). The fragmental materials were derived from a varied sedimentary and volcanogenic source, and their angular shapes suggest that they suffered only minor transport.

Low-grade regional metamorphism modified the rock. Acceptance of a significant amount of strain resulted in rotation of the lithic and crystal fragments into the trace of a moderately strong penetrative foliation. During deformation, recrystallisation and replacement of much of the primary rock components generated the new assemblage of sericite + quartz + chlorite + dolomite + minor pyrite + trace rutile + sphalerite + galena. The irregular distribution of the sulphides, particularly their occurrence dominantly in the matrix, suggests that most or all of the sulphide components were introduced into the rock in the metamorphic fluid. There is no textural evidence that the sulphides formed as primary components of the sedimentary breccia.

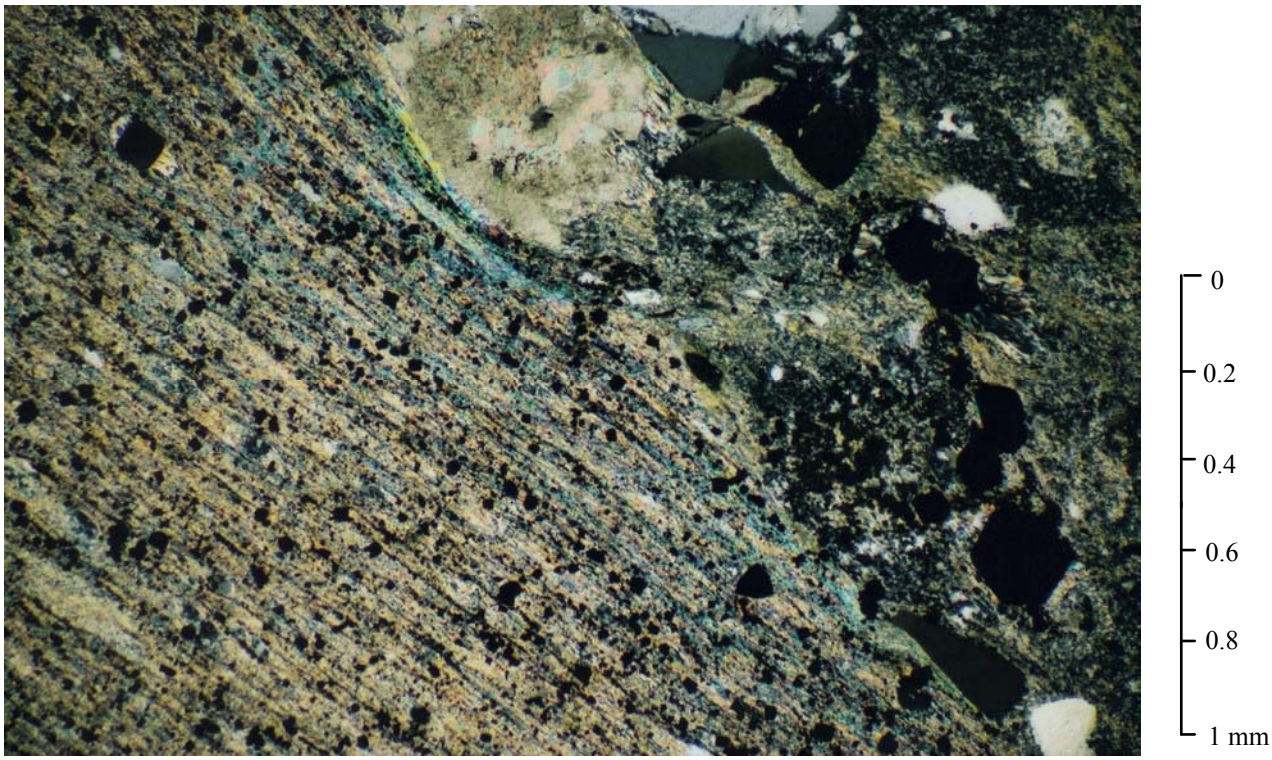


FIG. 7: SAMPLE NCT002, 199.1m (Transmitted light, crossed polarisers, x5, Film 1 / Frame 8)
This view illustrates the irregular distribution of opaques (pyrite, small black cubic crystals) which are sparsely disseminated throughout a foliated meta-argillite lithic fragment (left). Larger pyrite cubes occur in matrix at lower right.

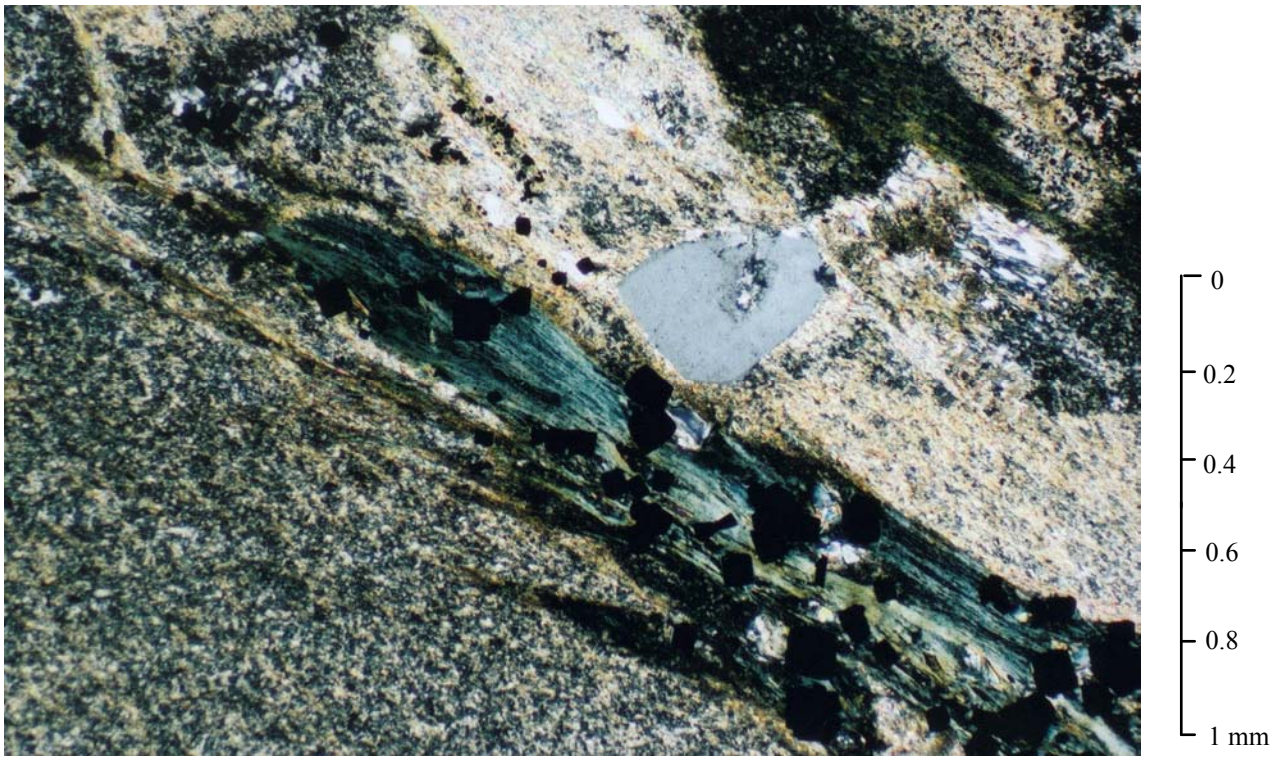


FIG. 8: SAMPLE NCT002, 199.1m (Transmitted light, crossed polarisers, x5, Film 1 / Frame 9)
This view illustrates the development of metamorphic pyrite (black cubic crystals) preferentially in a chlorite-altered lava fragment (?fiammé, anomalous green). The pyrite commonly favours high-strain zones such as margins of larger lithic fragments (eg large clast at lower left), where flow of metamorphic fluid was greater.

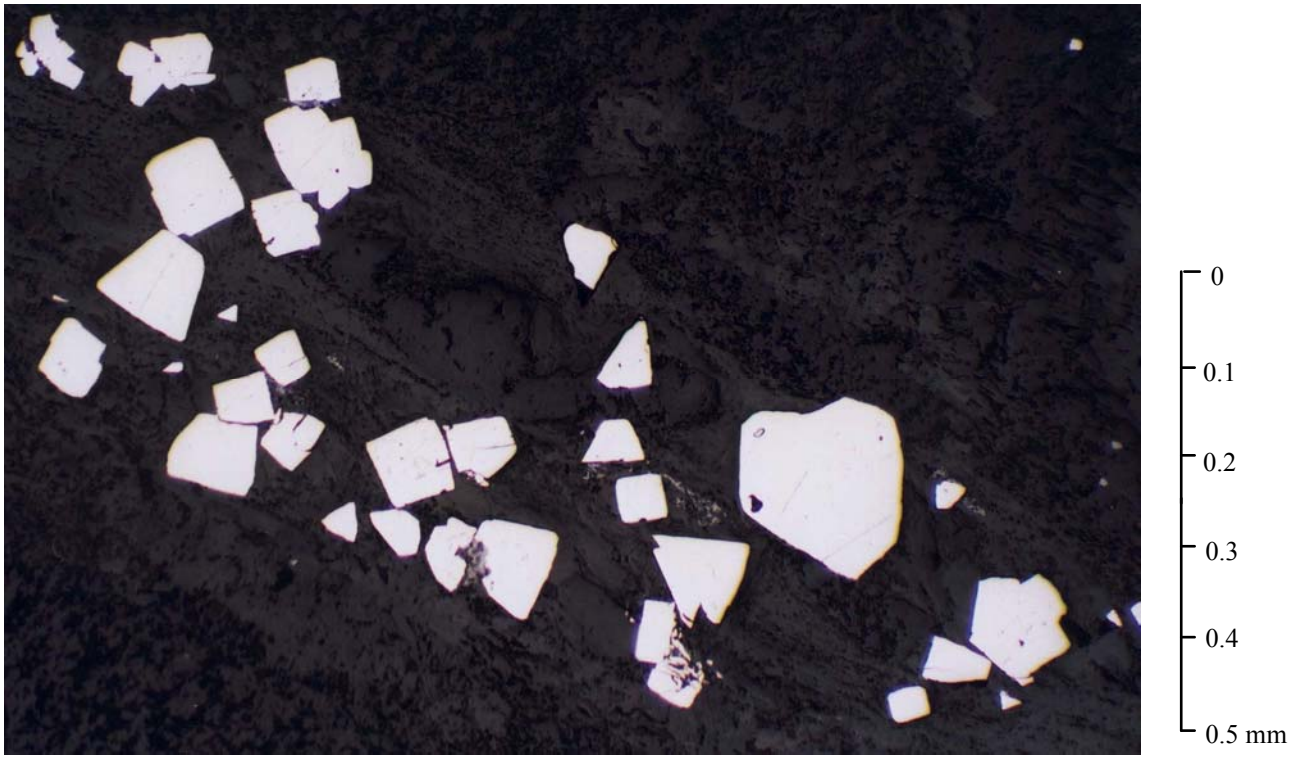


FIG. 9: SAMPLE NCT002, 199.1m (Reflected plane polarised light, x10, Film 1 / Frame 10)
This view was taken from a pyrite-altered lithic fragment, and illustrates the euhedral crystal form of the pyrite. Such forms suggest that the pyrite formed during a single event (ie the metamorphic overprinting event); there is no evidence that the pyrite experienced multiple events, or suffered deformation following pre-metamorphic formation.

SAMPLE : NCT002, 202.5m (Mt Read Volcanics, Tasmania)

SECTION NO : NCT002, 202.5

HAND SPECIMEN : The drill core rock slice represents a grey fragmental rock composed of angular lithic fragments (medium grey, pale grey, dark green) which are aligned in the trace of a strong foliation in a grey matrix. Small lustrous sulphide grains (mainly ?pyrite) are disseminated in significant amount throughout the rock.

ROCK NAME : Foliated high-intensity sericite-sulphide altered meta-fragmental rock

PETROGRAPHY AND MINERAGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

Mineral	Vol %	Origin
Quartz	2 (0-20)	Primary crystals and fragments
Zircon	Tr	Primary crystals and fragments
Sericite	90	Metamorphic ?alteration
Pyrite	5	Metamorphic alteration
Quartz	2	Metamorphic
Rutile	Tr	Metamorphic
Sphalerite	Tr	Metamorphic ?alteration
Galena	Tr	Metamorphic ?alteration
Chalcopyrite	Tr	Metamorphic ?alteration

In polished thin section, this sample displays a weakly preserved fragmental texture modified by metamorphic deformation and replacement.

Sericite dominates the rock and occurs in different forms:

i) Much occurs as a strongly foliated mat developed throughout the rock. This is considered to represent matrix that has accepted a significant degree of strain during metamorphic deformation.

ii) Much sericite also occurs pervasively through the rock as dense replacement mats within altered lithic fragments. None of these retain any primary textures, and the sericite displays varied textures from massive to foliated.

Quartz occurs in minor amount in two forms:

i) Some occurs as equant blocky crystals up to ~2 mm in size that display magmatic resorption, and angular crystal fragments, that are concentrated in a single band several millimetres wide at one end of the section. This is considered to represent primary layering in the fragmental rock.

ii) Some quartz forms equant anhedral grains that build a massive equigranular mosaic in minor angular lithic fragments of inferred meta-felsic volcanogenic origin.

Pyrite is moderately abundant. It occurs pervasively throughout the rock as small cubic crystals ranging from microns in size up to ~0.1 mm (mostly ~0.05-0.1 mm). The crystals are disseminated pervasively but somewhat irregularly throughout the matrix areas, and also are concentrated more densely in lensoidal bodies aligned in the trace of the foliation that possibly represent severely altered precursor lithic fragments. The

presence of small pyrite crystals in aggregates in fractures and alteration patches in quartz grains confirms that pyrite has formed by replacement (rather than by recrystallisation) in at least some areas of the rock.

Sphalerite is present in minor amount as anhedral grains concentrated in ovoid to ragged patches up to ~2 mm in size scattered irregularly through the rock. Intergrown with sphalerite in these patches are anhedral quartz grains, cubic pyrite crystals, minor small sericite flakes, and tiny grains of chalcopyrite mainly as inclusions in sphalerite. The origin of these sphalerite-rich patches remains obscure, but they possibly represent recrystallised primary sulphidic lithic fragments rather than replacement patches.

Rutile occurs in trace amount as tiny equant crystals locally concentrated in small aggregates (possibly altered Fe-Ti oxide grains), and as tiny crystals sprinkled through altered lithic fragment sites.

Zircon is rare, occurring as small terminated crystals and crystal fragments in the altered matrix.

INTERPRETATION :

This sample is considered to have formed as a primary fragmental rock but most primary minerals and textures have been destroyed. Angular lithic fragments were abundant, and may have been of fine-grained felsic volcanogenic origin (?lava, ?tuff). Crystals and crystal fragments (quartz, ?Fe-Ti oxide, trace zircon) were concentrated in minor thin horizons as part of primary depositional layering.

In response to low-grade regional metamorphism with associated directed stress regime, the rock suffered recrystallisation to form the moderately foliated assemblage of sericite + pyrite + quartz + trace rutile. Pyrite formed pervasively through the rock, and appears to have formed by replacement. In contrast, sphalerite, galena and chalcopyrite formed in small patches of similar size and shape to lithic fragments. It is possible that these small sulphidic patches formed as primary sulphidic fragments of precursor chemical sedimentary origin that were deposited together with the dominant lithic fragments. The alternative is that these particular sulphides formed by selective replacement of particular precursor lithic fragments, but this is considered unlikely.

Further difficulty in interpreting this sample arises from consideration of the timing of alteration: was the sample altered during the metamorphic event, or had alteration (eg hydrothermal alteration) affected the rock prior to metamorphism? There are no clear textures to aid either interpretation, except that the shapes of the pyrite crystals are quite clean and support only a single crystallisation event (ie synmetamorphic alteration). The pyrite does not appear to have suffered modification during the metamorphic event. It is suggested that the relatively high strain displayed by this sample would have encouraged fluid flow along the foliation, and this may be a reason for the relatively high intensity of alteration.

Client query [from email of 21 July 2004]: The deformed nature of the mineralised samples, particularly NCT002-202.5 led me to term them 'mylonite' in my summary logs. Is the deformation anywhere near that intense?

Response: No. None of the samples display mylonitisation. [*Definition of mylonitisation* – 'Deformation of a rock by extreme microbrecciation, due to mechanical forces applied in a definite direction, without noteworthy chemical reconstitution of granulated materials. Characteristically the mylonites thus produced have a flinty, banded, or streaked appearance, and contain undestroyed *[sic]* augen and lenses of the parent rock in a granulated matrix.' AGI Glossary of Geology, 2nd Edition, 1980.] In contrast, all of the rocks in this suite display mild ductile deformational effects, with stronger ductile deformation producing stronger foliation and elongation of lithic fragments in the samples NCT002-202.5, 204.2, 206.8.

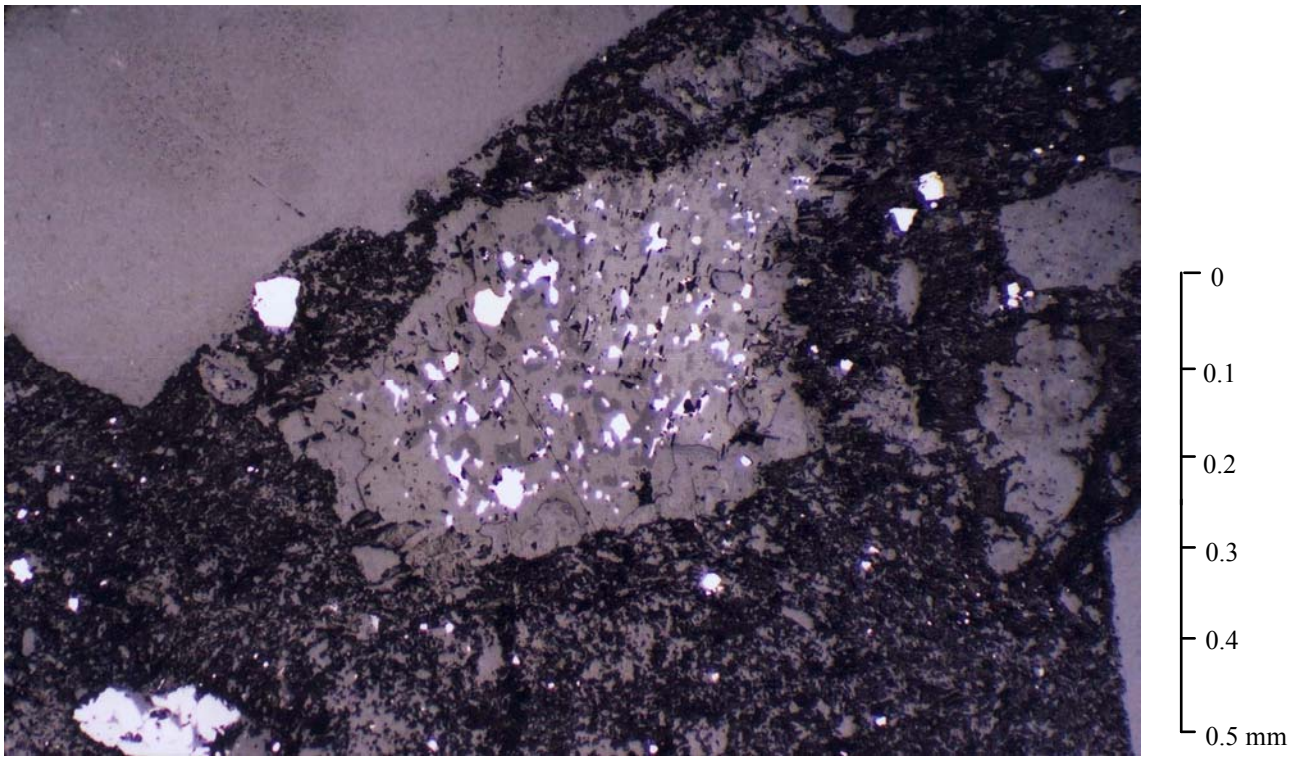


FIG. 10: SAMPLE NCT002, 202.5m (Reflected plane polarised light, x10, Film 1 / Frame 11)
This view captures an angular fragment (centre), considered to be a lithic fragment. It is composed of a more-or-less microgranular mosaic of calcite speckled by small ragged grains of galena (pale grey) and chalcopyrite (pale yellow). The fragment possibly represents a precursor sulphidic sediment of ?exhalative volcanogenic origin. A large volcanogenic quartz fragment occurs at top left.

FIG. 11: SAMPLE NCT002, 202.5m (Transmitted light, crossed polarisers, x5, Film 1 / Frame 12)
This view illustrates the development of abundant small opaque crystals (pyrite) preferentially in lithic fragments that are now elongated in the trace of the metamorphic foliation (NE-SW). Comparable small pyrite crystals are disseminated pervasively through the rock, suggesting that most of the pyrite formed as part of the metamorphic overprinting event.

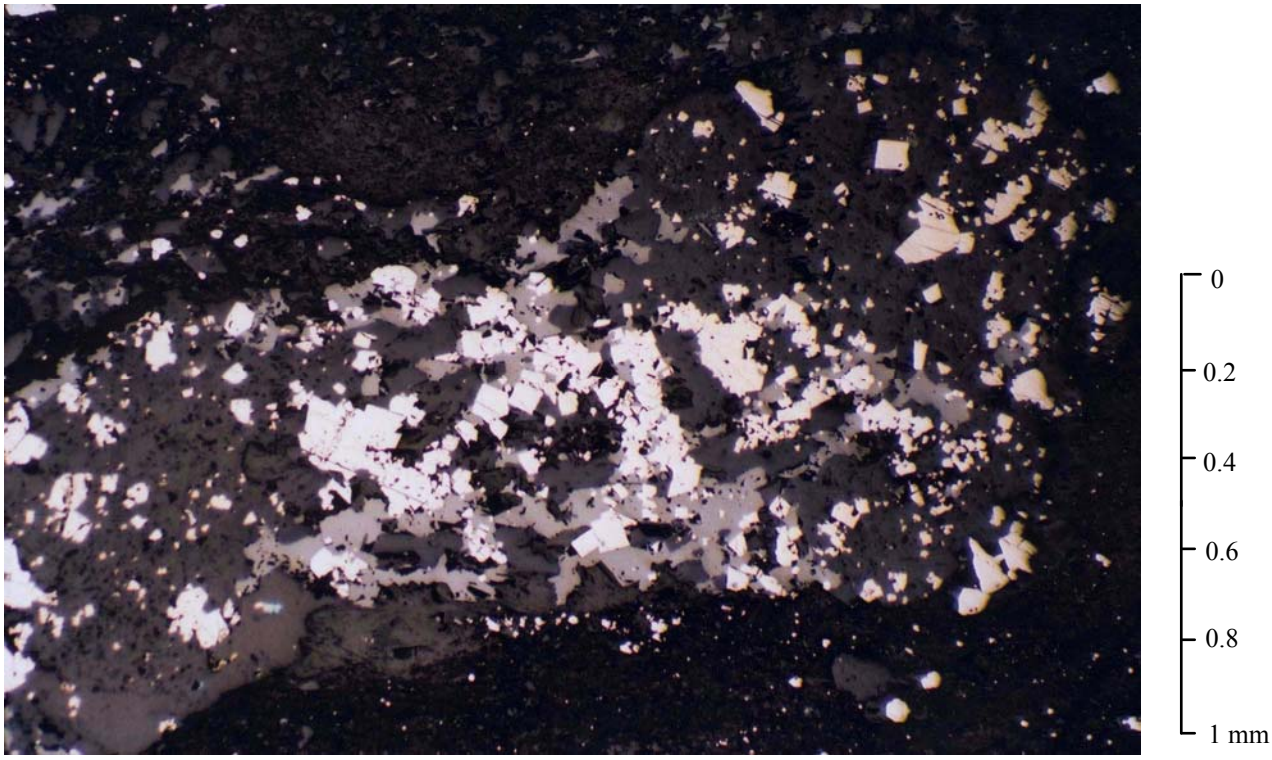


FIG. 12: SAMPLE NCT002, 202.5m (Reflected plane polarised light, x5, Film 1 / Frame 14)
This view captures a sulphidic patch, aligned in the trace of the foliation (NE-SW), composed of quartz, pyrite (white cubes), and sphalerite (ragged medium grey grains). It possibly represents a recrystallised fragment of sulphidic sediment.

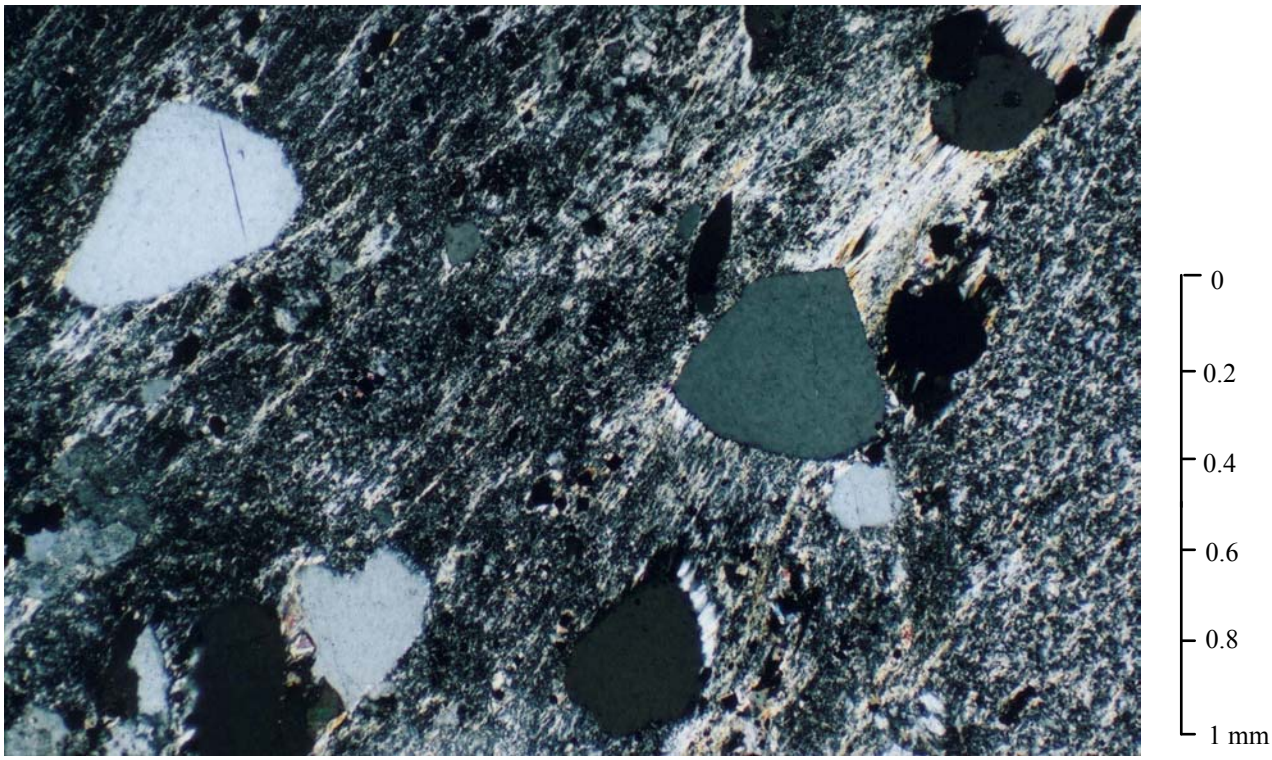


FIG. 13: SAMPLE NCT002, 202.5m (Transmitted light, crossed polarisers, x5, Film 1 / Frame 15)
This view illustrates the preserved primary shapes of volcanogenic quartz crystal fragments (white to grey), in a matrix of moderately strongly foliated sericite. The rock is inferred to have suffered slow strain (ie metamorphic ductile deformation), and has not suffered rapid strain (eg fault zone cataclasis). The slow strain was accepted pervasively by the sericite-altered matrix and lithic fragments, while the quartz crystal fragments remained rigid.

SAMPLE : NCT002, 204.2m (Mt Read Volcanics, Tasmania)

SECTION NO : NCT002, 204.2

HAND SPECIMEN : The drill core slice represents a grey rock in which elongate (stretched) lithic fragments with aspect ratios ~5:1 are aligned in a foliated grey matrix. Fine-grained lustrous sulphide (mainly pyrite) is disseminated throughout the rock.

The sample fails to effervesce in reaction with dilute HCl, suggesting calcite is absent.

ROCK NAME : Foliated sericite-sulphide altered meta-fragmental rock

PETROGRAPHY AND MINERAGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

Mineral	Vol %	Origin
Quartz	5	?Relict primary / metamorphic
Sericite	84	Metamorphic ?alteration
Pyrite	5	Metamorphic ?alteration
Chlorite	3	Metamorphic
Carbonate (dolomite)	2	Metamorphic ?alteration
Sphalerite	<1	Metamorphic ?alteration
Galena	Tr	Metamorphic ?alteration
Chalcopyrite	Tr	Metamorphic ?alteration
Native gold	Tr	Metamorphic ?alteration (inclus. in pyrite)

In polished thin section, this sample displays a partly preserved coarse fragmental texture, modified by strong deformation and associated metamorphic recrystallisation and alteration.

Sericite dominates the rock, and occurs in different forms:

i) Much sericite occurs in elongated (deformed) lithic fragments, where it forms a fine-grained uniform foliated replacement mat.

ii) Much sericite also occurs as a strongly foliated matrix which encloses the deformed lithic fragments. In places it is difficult to distinguish between matrix and fragments.

Quartz occurs in moderate amount. Some appear to represent relict primary crystal fragments, but elsewhere quartz is concentrated as granular mosaics in some lithic fragments of uncertain origin (?meta-sediments, ?meta-felsic volcanic).

Pyrite is moderately abundant, occurring as small euhedral to subhedral crystals that are disseminated somewhat irregularly throughout the rock. Some are present in the foliated sericite-rich matrix, and some occurs in sericite-rich lithic fragment sites. In places, small pyrite crystals are more densely concentrated in lenses which possibly represent severely altered lithic fragments.

Sulphides are locally concentrated in elongate to subangular patches up to several millimetres in size, composed of anhedral colourless sphalerite grains and patches, ragged chalcopyrite grains (which also occurs as tiny inclusions in sphalerite), small ragged galena grains, and euhedral pyrite crystals and aggregates. Sulphide ratios are variable, but most are sphalerite rich with sphalerite > galena = chalcopyrite. Many of

these patches also contain carbonate (dolomite) and clear quartz. At least some of the sulphidic patches have the appearance of recrystallised primary fragments rather than alteration patches.

Chlorite occurs in minor amount as fine-grained dense mats concentrated in elongated lenses aligned in the foliation, and appear to represent altered lithic fragments. Intergrown with the chlorite are small pyrite crystals and ragged sphalerite grains.

Carbonate (dolomite) occurs mainly as anhedral grains and rhombic crystals concentrated in sulphide-rich patches (recrystallised ?lithic fragments), and also as aggregates irregularly scattered elsewhere through the rock.

Native gold is rare, occurring as subhedral tiny crystals within pyrite cubes and within ragged sphalerite grains, within a lens composed of calcite + quartz + sulphides (pyrite > sphalerite > galena). Several grains of native gold are observed in this lens, but nowhere else in the section.

INTERPRETATION :

This sample formed as a primary fragmental deposit, originally composed of closely-packed lithic fragments of uncertain composition(s) in a fine-grained matrix. Dynamic regional metamorphism in the lower greenschist facies generated the foliated metamorphic assemblage of sericite + quartz + pyrite + chlorite + dolomite + minor sphalerite + galena + chalcopyrite + native gold.

The dissemination of sulphide (particularly pyrite) throughout the rock in both foliated matrix and in foliated elongated lithic fragments suggests that transport and deposition of sulphides occurred during the metamorphic event. Fluid flow through the rock would have been greatly assisted by the development of the strong penetrative structure (foliation) through the rock. However, occurrence of base metal sulphides (sphalerite > galena = chalcopyrite) confined mainly to angular to lensoidal aggregates comparable in size and shape to other deformed lithic fragments suggests that these possibly represent deformed and recrystallised sulphidic lithic fragments of possible primary chemical sedimentary origin. If so, this suggests that chemical sedimentary base-metal-rich mineralisation may have formed in response to seafloor exhalative deposition prior to redeposition in the clastic deposit. An alternative interpretation of the base-metal-sulphide-rich patches is that they formed by a replacement mechanism during the metamorphic event.

Client query [from email of 21 July 2004]: With respect to samples NCT002-199.1, 202.5 and 204.2 I interpret these rocks as having formed in a fault zone because of the context with surrounding rocks and the narrow nature of the intersection (maximum of 4 m down hole thickness – but drilled down the lithology, suggesting true thickness is much thinner). So what I thought was that a fault developed, possibly prior to metamorphism which was accompanied by strong deformation, the fault zone was foliated and even reactivated to give us specimens such as 199.1 where there are fragments of sericite-pyrite which presumably formed earlier. So I guess my question is – how sure are you that these specimens represent primary fragmentals – or can they have formed in a fault zone?

Response: Yes, a possible sequence of events for the sulphide-rich section is as proposed above: ie faulting and mineralisation of the fault, followed by subsequent metamorphic overprinting (ie deformation, recrystallisation, and some degree of remobilisation of particular components in the metamorphic fluid). However, it is considered more likely by the writer that mineralisation accompanied deformation (ie synmetamorphic timing). In this scenario, metamorphism with accompanying deformation affected the entire sequence, with enhanced deformation, fluid flow and mineralisation in a zone of higher strain. Observations to support this scenario include:

i) Consistency of fragment types

Most samples in NCT002 (199.1, 202.5, 204.2, 206.8, 248.4) contain closely packed, varied rock types and crystals as fragments. They are reasonably interpreted to have formed as primary, framework-supported

fragmental deposits. There is no need to appeal to a special mechanism (eg fault brecciation) to produce these textures.

ii) Consistency but varied intensity of strain

Higher strain is evident in 202.5, 204.2 and 206.8, as indicated by stronger foliation of sericite and larger aspect ratios of most (but not all) lithic fragments. The angular relationship between the structure in these samples and samples higher and lower in the hole is unknown to the writer, but if they are more-or-less subparallel then the simplest interpretation is that we are looking at a single (subparallel) foliation which developed at one time, not an earlier structure (in the proposed fault) that was overprinted by a later structure that was fortuitously subparallel in orientation.

iii) Coherent quartz crystals

Wherever they occur, quartz crystals and crystal fragments have retained their primary shapes (variably equant, partly magmatically resorbed, angular where fragmented). They have not suffered *in situ* deformation of any type, except for uncommon pull-apart structures in some grains. This confirms that the quartz crystals have experienced a relatively *low strain rate*, allowing almost all strain to be taken up by recrystallisation and reorientation of enclosing sericite flakes throughout the rock, including in the matrix and in appropriate lithic fragments. The quartz crystals did not experience a high strain rate, as would be expected in a fault zone, where the quartz crystals would have suffered strong brittle deformation effects.

iv) Coherent pyrite crystals

All pyrite grains display euhedral (cubic) crystal forms. Their euhedral shape suggests that they formed during a single event. They lack cores and overgrowths, they do not display brittle fracturing, or grain elongation in the trace of the foliation. Their shapes do not suggest that they experienced a multi-stage evolution (eg early crystallisation in a fault zone, followed by later metamorphic overprinting).

v) Pyritic lithic fragments

Yes, some lithic fragments in NCT002-199.1 are composed of foliated sericite peppered by tiny pyrite crystals. However, minor pyrite also occurs in the matrix immediately adjacent to these fragments, and pyrite also occurs disseminated elsewhere through the rock in the matrix and in other types of lithic fragments. All of the pyrite displays similar characteristics (size and shape), and all is considered to have formed more-or-less synchronously as part of the metamorphic event. This pyritisation of lithic fragments is more strongly developed in samples NCT002-202.5, 204.2 and 206.8.

vi) Synmetamorphic base-metal sulphide-bearing veinlets

Sample NCT002-447.8m captures a set of thin calcite-quartz-chlorite veinlets which contain base-metal sulphides (sphalerite >> galena > chalcopyrite). The veinlets appear to lie subparallel to, but slightly discordant to, the principal foliation. The sphalerite is similar in colour in thin section (colourless to very pale buff, ie Fe-poor) to sphalerite that occurs in more strongly foliated and mineralised samples in this suite (ie NCT002-202.5, 204.2, 206.8). It is reasonable to infer, therefore, that these thin veinlets formed from the same or closely similar fluid that generated more abundant sulphides in the more strongly foliated zone. This suggests that the mineralising fluid was synmetamorphic, rather than pre-metamorphic.

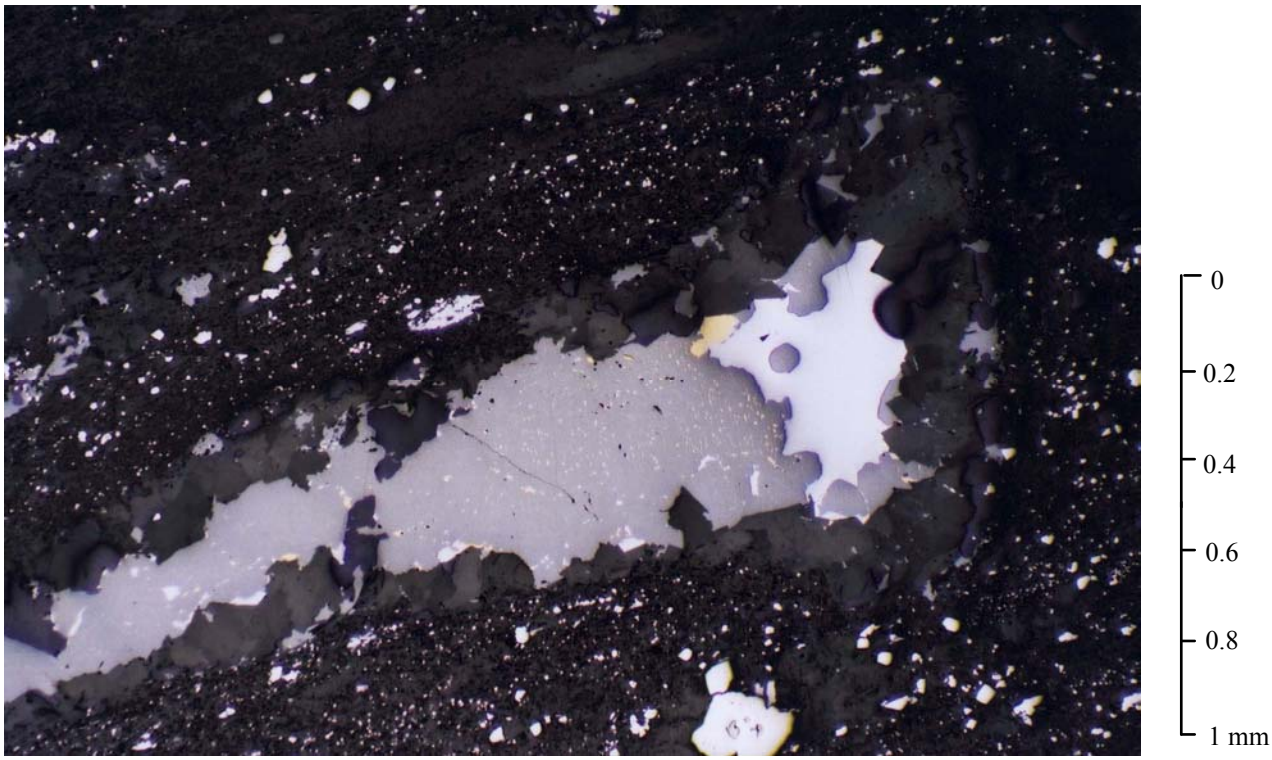


FIG. 14: SAMPLE NCT002, 204.2m (Reflected plane polarised light, x5, Film 1 / Frame 16)
This view illustrates a sulphide-rich patch, elongated in the trace of the foliation (NE-SW), composed of sphalerite (medium grey), galena (pale grey), chalcopyrite (yellow), and calcite (dark grey grains around margin). The patch is interpreted to represent a fragment of recrystallised sulphidic sediment, possibly of ?exhalative volcanogenic origin.

FIG. 15: SAMPLE NCT002, 204.2m (Transmitted light, crossed polarisers, x5, Film 1 / Frame 17)
This view captures a lens aligned in the trace of the foliation (NE-SW). The lens is composed of quartz (white to grey) and opaques (pyrite, sphalerite, galena; see FIG. 16), and possibly represents a recrystallised lithic fragment of primary quartz-sulphide sediment of ?exhalative volcanogenic origin.

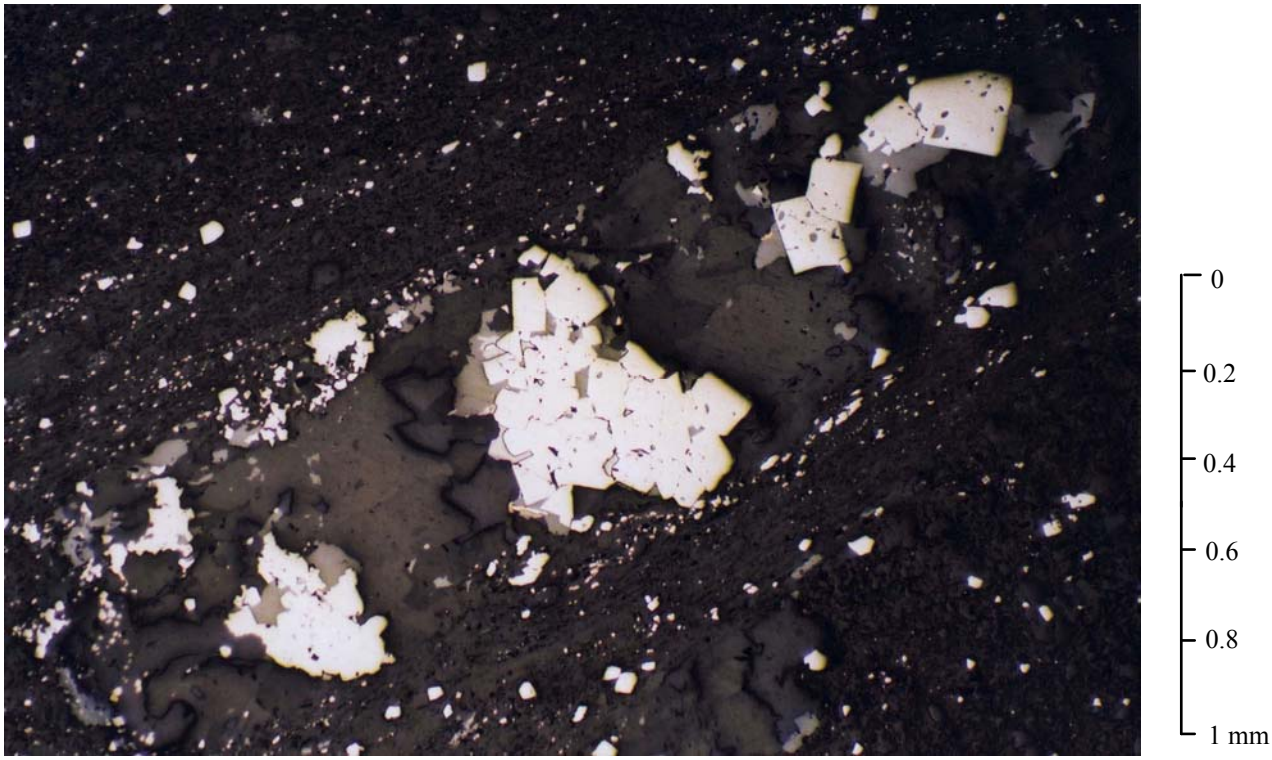


FIG. 16: SAMPLE NCT002, 204.2m (Reflected light, crossed polarisers, x5, Film 1 / Frame 18)
This is the same view as FIG. 15 above, and illustrates the sulphide minerals: pyrite (white), sphalerite (medium grey), galena (minor small pale grey grains).

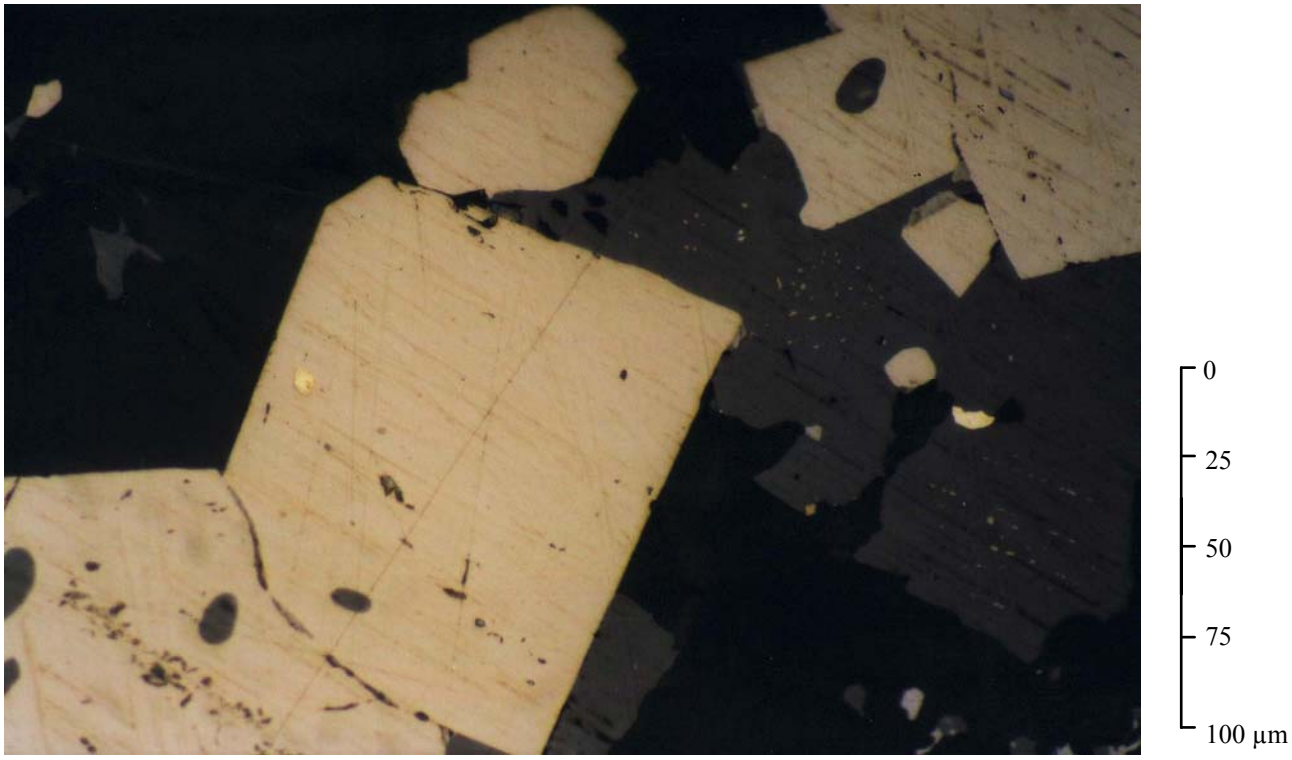


FIG. 17: SAMPLE NCT002, 204.2m (Reflected plane polarised light, x40, Film 1 / Frame 20)
This view was taken from a sulphide-bearing patch (possibly a sulphidic sedimentary lithic fragment) composed of calcite, quartz and sulphides (sphalerite > galena > chalcopyrite). In this view, two small grains of native gold (bright yellow) occur in a pyrite cube (cream, centre left) and in sphalerite (dark grey, centre right). A significant number of native gold grains occur in this lithic fragment, but were not observed elsewhere, suggesting the fragment was Au-rich.

FIG. 18: SAMPLE NCT002, 204.2m (Reflected plane polarised light, x5, Film 1 / Frame 22)
The angular patch in this view, considered to represent a sulphide-rich lithic fragment of possible ?exhalative volcanogenic origin, is composed of galena (pale grey), minor associated chalcopyrite (pale yellow) and sphalerite (small ragged medium grey grains) in a calcite matrix. Note the mineralogical and chemical lamination in the inferred fragment.

SAMPLE : NCT002, 206.8m (Mt Read Volcanics, Tasmania)

SECTION NO : NCT002, 206.8

HAND SPECIMEN : The drill core rock slice represents a foliated greenish grey rock in which indistinct elongated lithic fragment shapes are distinguishable in a grey matrix. The sample contains a large (centimetre-sized) paler patch, considered to represent a large lithic fragment, in contact with the darker greenish grey matrix: the thin section has captured part of the paler rock and adjacent darker rock.

ROCK NAMES : Foliated meta-fragmental rock (darker host rock)

Foliated meta-felsic rock (?volcanogenic lithic fragment)

PETROGRAPHY AND MINERAGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

Mineral	**Vol %**	**Origin**
Foliated meta-fragmental rock (darker host rock)		
Quartz	5 (Tr-10)	Primary crystals and fragments
Quartz	20	Primary quartz-rich lithic fragments
Zircon	Tr	Primary crystals and fragments
Sericite	64	Metamorphic / ?alteration
Pyrite	5	Metamorphic ?alteration
Carbonate (dolomite)	2	Metamorphic alteration
Chlorite	2	Metamorphic
Sphalerite	Tr	Metamorphic ?alteration
Chalcopyrite	Tr	Metamorphic ?alteration
Galena	Tr	Metamorphic ?alteration
Rutile	Tr	Metamorphic
Ilmenite	Tr	Metamorphic
Foliated meta-felsic rock (?volcanogenic lithic fragment)		
Quartz	20	?Relict primary / metamorphic
Sericite	74	Metamorphic alteration
Pyrite	3	Metamorphic alteration
Chlorite	2	Metamorphic alteration
Rutile	Tr	Metamorphic
Chalcopyrite	Tr	Metamorphic alteration
Galena	Tr	Metamorphic alteration

In polished thin section, this sample displays foliated metamorphic textures that overprint precursor textures in both the lithic fragment and enclosing host rock.

Foliated meta-fragmental rock (darker host rock) displays a partly-preserved coarse fragmental texture, modified by metamorphic recrystallisation and deformation. Quartz is moderately abundant, occurring as clear angular crystal fragments derived from magmatically resorbed volcanogenic crystals, and a significant amount of different quartz which forms anhedral subrounded grains and polycrystalline aggregates that represent quartz-rich lithic fragments (possibly silicified acid volcanic rock with tortuous internal structures defined by cryptocrystalline ?hematite trails). Sericite is abundant, forming fine-grained variably foliated

mats in strongly elongated lithic fragments, strongly foliated matrix enclosing the fragments, and foliated mats that anastomose through quartz-rich lithic fragments.

Other minerals occur in minor amounts. Carbonate (dolomite) forms local granular aggregates and discontinuous veinlets of varied orientation. Chlorite forms fine-grained pleochroic green aggregates in small patches and in some altered lithic fragments. Pyrite forms small crystals ranging from micron size up to ~0.2 mm in size, disseminated throughout the rock but locally concentrated in small lensoidal aggregates oriented in the trace of the foliation. Uncommon ragged grains of sphalerite and chalcopyrite occur in slightly coarser-grained patches with quartz and carbonate, elongated in the trace of the foliation. Ilmenite and closely associated rutile occur in small equant aggregates (possibly altered primary Fe-Ti oxide grains).

Foliated meta-felsic rock (?volcanogenic lithic fragment) displays a massive granular texture modified by metamorphic overprinting. Quartz is moderately abundant, forming equant anhedral grains in mosaic texture distributed uniformly through the rock: it possibly formed as part of alteration of a precursor felsic volcanogenic rock. Sericite is abundant, forming fine-grained dense mats that are variably massive to foliated, and anastomosed through the quartzose matrix. Chlorite occurs in minor amount as small fine-grained green patches scattered through the rock. Pyrite forms scattered cubic crystals, some with closely associated chalcopyrite and galena. Rutile occurs as tiny granules concentrated in small scattered grain sites (possibly primary Fe-Ti oxide grains) and along irregularly oriented thin trails.

INTERPRETATION :

This sample is considered to have formed as a fragmental rock composed of large altered felsic ?volcanogenic rock fragments, smaller quartz-rich fragments of possibly similar origin, and crystal fragments of volcanogenic origin. Dynamic regional metamorphism in the lower greenschist facies caused ductile deformation and produced the foliated assemblage of sericite + quartz + pyrite + chlorite + dolomite + trace chalcopyrite + galena + rutile. Notably, the orientation of the foliation continues without divergence across the contact between the large lithic fragment and enclosing rock.

Client query: Specimen NCT002-206.8 appears to show a contact relationship between the mineralised structure and host rock so a thin section of that contact would be good.

Response: The contact represents the boundary between a large lithic fragment and enclosing fragmental host rock. The moderately strong foliation developed in response to metamorphism discordantly cuts across the contact, confirming the later timing of the metamorphic structure with respect to the precursor fragmental texture.

Client query [from email of 21 July 2004]: With respect to NCT002-206.8, could you identify for me which part of the sample has the 'smaller quartz-rich fragments'. Again, with this specimen, I thought it possible that this contact represented a deformed fault contact between 'mineralised' (sericite here) fault material and tectonically brecciated wall rock.

Response: The 'smaller quartz-rich fragments' occur in the part of the sample that contains more abundant small white grains (quartz) in a dark greenish grey matrix. These smaller quartz fragments are quite distinct from the relict volcanogenic quartz grains. Elsewhere, the rock is paler greenish grey, contains more abundant volcanogenic quartz grains, and has a more 'normal' volcanogenic fragmental texture.

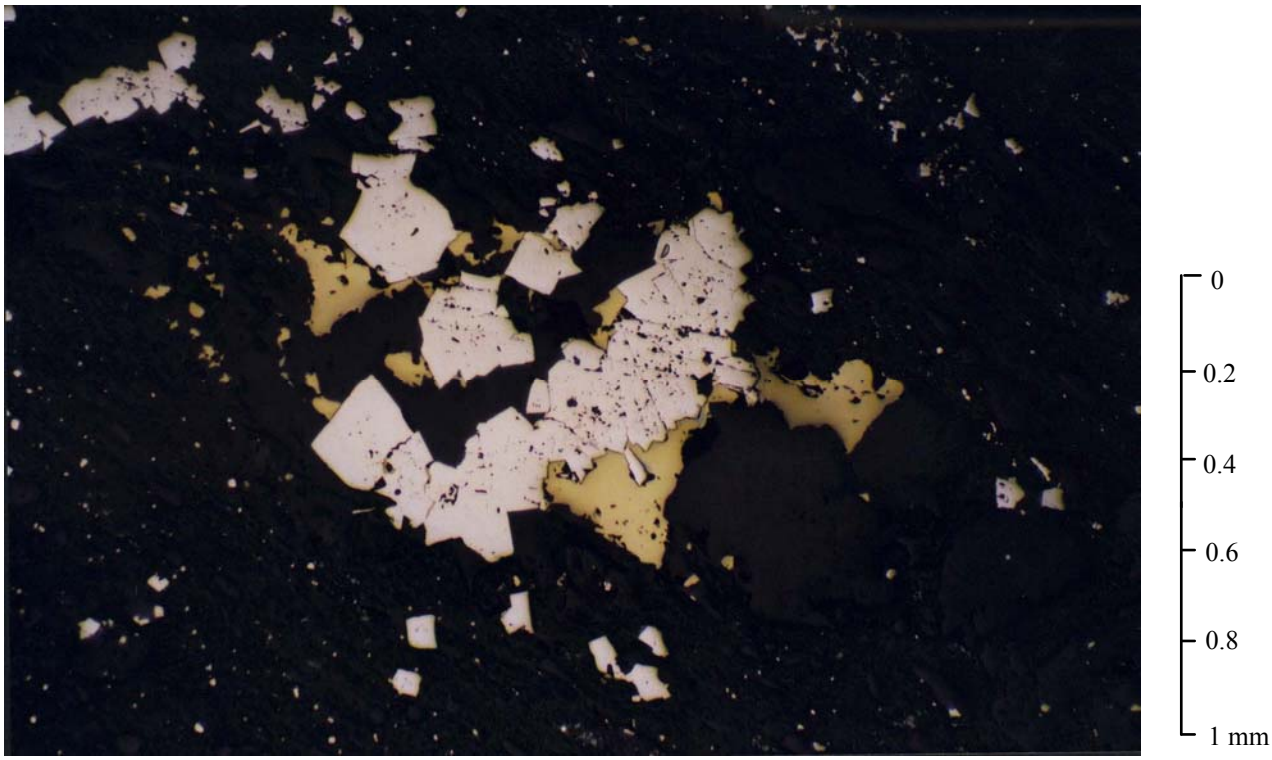


FIG. 19: SAMPLE NCT002, 206.8m (Reflected plane polarised light, x5, Film 1 / Frame 21)
This view illustrates a patch composed of pyrite (white), chalcopyrite (yellow), and non-opaque minerals (quartz, minor sericite). It possibly represents a recrystallised sulphidic sedimentary lithic fragment.

SAMPLE : NCT002, 248.4m (Mt Read Volcanics, Tasmania)

SECTION NO : NCT002, 248.4

HAND SPECIMEN : The drill core rock slice represents a coarse fragmental rock composed of angular to subrounded grey lithic fragments, and minor angular elongated dark green fragments, in a finer-grained matrix that is weakly foliated.

The sample effervesces strongly in reaction with dilute HCl, indicating minor calcite occurs in small patches scattered sparsely through the rock.

ROCK NAME : Weakly foliated meta-lithic-crystal tuff

PETROGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

Mineral	Vol %	Origin
Quartz	15	Primary crystals and fragments
Zircon	Tr	Primary crystals
Sericite	48	Metamorphic
Quartz	20	Metamorphic
Chlorite	15	Metamorphic
Carbonate (calcite)	1	Metamorphic alteration
Opaques (?pyrite, ?ilmenite)	Tr	Metamorphic / alteration
Ti-phase (?sphene)	Tr	Metamorphic

In thin section, this sample displays a primary coarse fragmental texture modified by metamorphic recrystallisation and weak to moderate foliation.

Sericite is abundant, and occurs in different sites:

i) A significant amount occurs as a fine-grained foliated mat occupying elongate patches identified as lithic fragments. Smaller ones are composed entirely of sericite, but larger ones locally contain equant phenocrysts of magmatically resorbed quartz. These lithic fragments are interpreted to represent primary rhyolitic lava fragments.

ii) Much sericite occurs in the matrix areas as wispy diffuse foliated patches aligned in the trace of the foliation.

Chlorite is moderately abundant. It occurs as very fine-grained pleochroic dark to very pale green flakes that tend to be concentrated in local elongated patches (lithic fragments of rhyolitic lava origin, some containing quartz phenocrysts).

Quartz occurs in different sites:

i) A significant amount occurs as equant crystals that display partial magmatic resorption, and angular crystal fragments, that range from ~0.2 mm up to ~2.0 mm in size. They clearly represent volcanogenic quartz crystals, some of which are observed in their primary occurrence in the sericite-chlorite altered meta-rhyolite lithic fragments.

ii) A moderate amount of quartz occurs as very fine-grained microgranular mosaics that occur in the recrystallised matrix areas.

iii) Some quartz occurs in angular to subrounded large blocky lithic fragments several millimetres in size, where the quartz forms equant anhedral grains pervaded by fine-grained sericite.

Carbonate (calcite) occurs in minor amount as clear anhedral grains that tend to be concentrated in lineated aggregates in pull-apart structures in some of the large quartz crystals.

Opaques are present in trace amount in two forms: as small cubic crystals (probably ?pyrite) that tend to be locally concentrated in small trails or aggregates aligned in the trace of the foliation, and tiny opaque granules concentrated in small aggregates in altered ?Fe-Ti oxide grain sites.

Ti-phase (possibly ?sphene) forms small blocky grains and aggregates with typical weak turbid pleochroism and very high birefringence, in the altered ?Fe-Ti oxide grain sites.

Zircon is rare, forming small terminated crystals in some of the elongated (meta-?rhyolite) lithic fragments.

INTERPRETATION :

This sample is considered to have formed as a felsic tuffaceous deposit composed of moderately abundant rhyolitic lithic fragments, and minor coherent blocky siliceous lithic fragments (possibly also of felsic volcanogenic origin), with moderately abundant crystals in a fine matrix of comminuted volcanogenic materials. Note that some of the lithic fragments, particularly the quartz-phyric rhyolitic fragments, may have formed as fiammé (ie flattened pumiceous primary lava fragments). This is supported by the wispy terminations of some of these fragments, particularly one larger fragment ~2 cm long.

The rock has suffered mild deformation during a low-grade regional metamorphic event in the lower greenschist facies. This caused elongation of some lithic fragments, and pull-aparts developed in some of the larger quartz crystals. Metamorphic recrystallisation generated the new assemblage of sericite + quartz + chlorite + minor calcite + trace opaques + Ti-phase (?sphene).

Client query: I wish to know if the dark cuspate shaped fragments are/were pumice.

Response: Yes, they were. These fragments formed as primary rhyolitic lava fragments composed of minor quartz phenocrysts and trace other crystals including Fe-Ti oxide and zircon, in a groundmass probably of glassy nature. Flattening of these fragments most likely occurred during deposition, and this primary structure was enhanced during subsequent metamorphic deformation. The smaller fragments have suffered complete replacement by chlorite, but one larger fragment is composed almost entirely of sericite with minor chlorite.

FIG. 20: SAMPLE NCT002, 248.4m (Transmitted light, crossed polarisers, x5, Film 1 / Frame 23)
This view was taken from a large lithic fragment considered to represent a fiammé (squashed rhyolite lava). It contains a magmatically corroded quartz phenocryst (white) and minor small altered Fe-Ti oxide grains (centre right) in a foliated matrix of sericite (yellow to drab green).

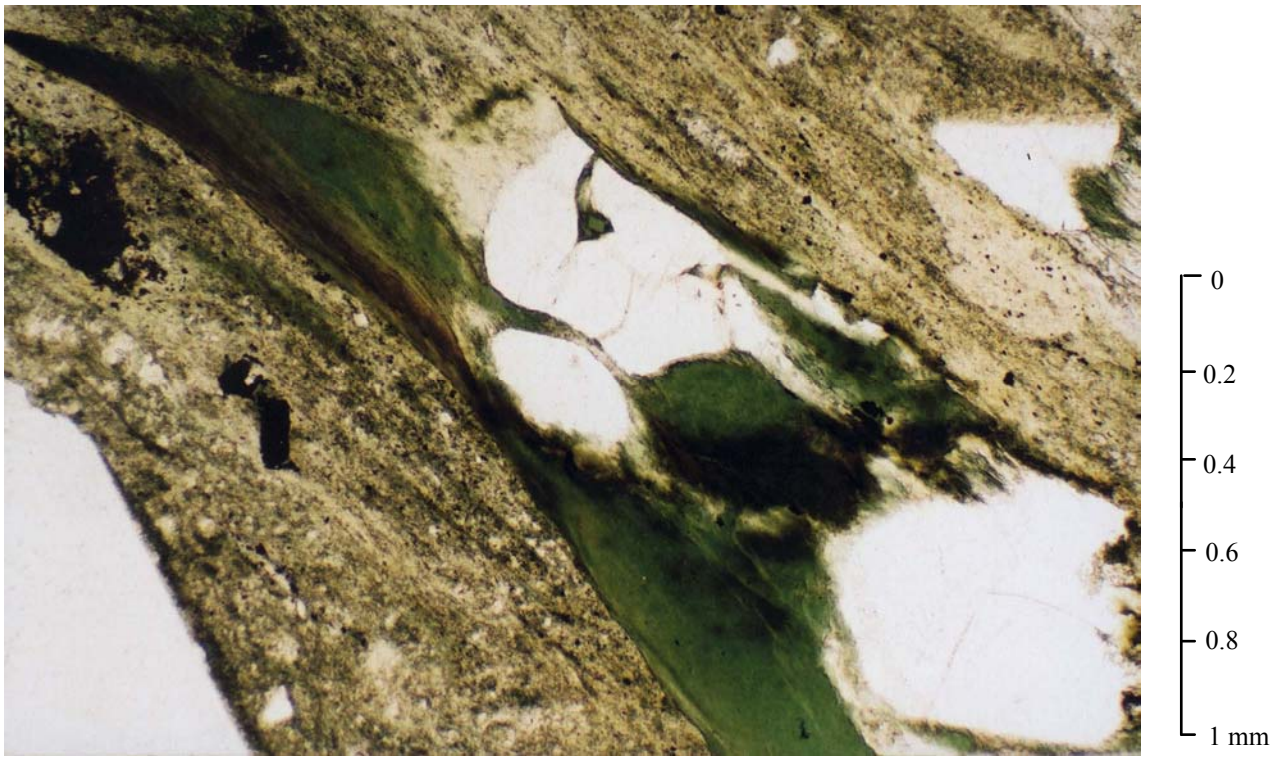


FIG. 21: SAMPLE NCT002, 248.4m (Transmitted plane polarised light, x5, Film 1 / Frame 24)
This view captures a strongly elongated lithic fragment (probably a fiammé) replaced by chlorite (dark green) but containing relict primary equant quartz phenocrysts (colourless, centre, bottom right).

SAMPLE : NCT002, 417.1m (Mt Read Volcanics, Tasmania)

SECTION NO : NCT002, 417.1

HAND SPECIMEN : The drill core rock slice represents a fine-grained medium green rock in which small grains of primary origin are faintly distinguishable.

ROCK NAME : Foliated meta-crystal tuff

PETROGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

Mineral	Vol %	Origin
Quartz	5	Primary crystals and fragments
Apatite	Tr	Primary crystals and fragments
Zircon	Tr	Primary crystals and fragments
Sericite	42	Metamorphic
Quartz	40	Metamorphic
Chlorite	10	Metamorphic
Carbonate (calcite)	<1	Metamorphic
K-feldspar	Tr	Metamorphic (in lithic fragment)
Opaques (mainly ?ilmenite)	<1	Metamorphic
Sphene	Tr	Metamorphic

In thin section, this sample displays a partly preserved primary matrix-supported fragmental texture, modified by metamorphic deformation and recrystallisation.

Sericite is abundant, and occurs in different sites:

i) Much of the sericite occurs as fine-grained dense mats that occur in blocky prismatic to wispy elongate patches ~1-2 mm in size aligned in the trace of a foliation. Some of these patches are inferred to represent sericite-altered precursor crystals (probably plagioclase but none is preserved). Others may have formed as lithic fragments (eg rhyolitic lava) but there are no supporting textures for this interpretation.

ii) A minor amount of sericite occurs as tiny flecks distributed through the matrix areas.

Quartz is the other principal phase, and occurs in different forms:

i) Much occurs as tiny anhedral grains that form a fine-grained mosaic throughout the matrix areas.

ii) A minor amount of quartz occurs as equant blocky crystals, magmatically resorbed crystals, and angular crystal fragments that are scattered more-or-less uniformly through the rock. These crystals clearly are of volcanogenic origin.

Chlorite occurs in moderate amount as tiny flecks scattered through the fine-grained quartz-sericite matrix areas, and locally is more strongly concentrated in wispy small patches aligned in the trace of the foliation.

Carbonate (calcite) occurs in minor amount as small clear grains that tend to form lineated aggregates in the pressure shadows marginal to quartz crystals.

K-feldspar is uncommon. It occurs only in a single subrounded lithic fragment captured in the centre of the section. The K-feldspar occurs as a fine-grained microgranular mosaic with possible relict devitrification texture, and also as replacements of precursor feldspar crystals and crystal fragments. The precursor rock may have been a felsic crystal tuff.

Opaques occur in minor amount as cryptocrystalline dense aggregates that appear to have replaced precursor blocky crystals (probably primary Fe-Ti oxide). A small amount of sphene occurs as small blocky turbid grains with typical high birefringence, in close association with the opaques.

Apatite occurs as small stumpy prismatic crystals and crystal fragments of primary origin. Rare small terminated prisms of zircon locally occur in close association with the apatite crystals and the altered Fe-Ti oxide crystals.

INTERPRETATION :

This sample is considered to have formed as a tuffaceous deposit composed of fragments (crystals >> lithics) in a fine felsic matrix of comminuted volcanogenic materials. The rock has been modified in response to low-grade regional metamorphism in the lower greenschist facies, generating a moderately foliated assemblage of sericite + quartz + chlorite + trace calcite + opaques (?ilmenite) + sphene.

Client query: NCT002-417.1 has a small pinkish clast on which I would like the thin section focused on.

Response: The small pinkish clast is composed mostly of K-feldspar, which occurs in a fine-grained microgranular mosaic as a matrix through which are scattered K-feldspar-altered feldspar crystals and minor fine-grained opaques (?ilmenite) after primary Fe-Ti oxide grains. The primary rock is considered to have initially formed as a felsic crystal tuff.

SAMPLE : NCT002, 447.8m (Mt Read Volcanics, Tasmania)

SECTION NO : NCT002, 447.8

HAND SPECIMEN : The drill core rock slice represents a fine-grained green rock in which a moderate foliation is defined by subparallel thin small dark green wisps that are sparsely distributed through the rock.

Cutting the rock is a thin vein ~2 mm wide, filled by white carbonate and translucent grey quartz. Strong effervescence in patches in reaction to dilute HCl indicates that calcite occurs in moderate amount in the vein.

ROCK NAME : Calcite-quartz-sulphide veined, weakly foliated meta-crystal tuff

PETROGRAPHY AND MINERAGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

Mineral	Vol %	Origin
Meta-crystal tuff		
Quartz	5	Primary crystals and fragments
Zircon	Tr	Primary crystals and fragments
Sericite	54	Metamorphic
Quartz	30	Metamorphic
Chlorite	10	Metamorphic
Opaques (?ilmenite)	<1	Metamorphic
Calcite-quartz-sulphide vein		
Calcite	57	Vein filling
Quartz	40	Vein filling
Chlorite	1	Vein filling
Sphalerite	1	Vein filling
Galena	Tr	Vein filling
Chalcopyrite	Tr	Vein filling

In polished thin section, this sample displays a partly-preserved primary fragmental texture modified by weakly foliated metamorphic overprint, and a massive space-filling granular texture in the vein.

Meta-crystal tuff retains its primary matrix-supported primary fragmental texture.

Sericite is abundant, occurring both as fine-grained massive replacements of blocky ?crystals (possibly ?plagioclase) and wispy ?lithics (possibly ?lava) that are aligned in the trace of a moderate foliation, and also as a fine-grained foliated mat developed throughout the matrix areas.

Quartz is the other principal phase and occurs in different forms:

i) Most occurs as tiny anhedral grains that form a fine-grained microgranular mosaic distributed throughout the matrix. It is more abundant in some horizons than in others.

ii) A small amount of quartz occurs as equant grains ~0.2-1.0 mm in size, some of which display magmatic resorption. They clearly are of volcanogenic origin.

iii) A minor amount of quartz occurs as equant anhedral grains concentrated in granular mosaic texture in uncommon lithic fragments up to several millimetres in size. These lithics display textures reminiscent of devitrified acid volcanic rock.

Chlorite is present in moderate amount as tiny pleochroic green flecks that are concentrated in small elongate patches whose shapes are independent of the foliation. They possibly represent preferentially chloritised ?shards in the primary fragmental matrix. Chlorite also occurs in higher concentrations in thin shears or fractures.

Opaques occur in minor amount as tiny grains that are concentrated in small aggregates ~0.2-0.4 mm in size that appear to represent thoroughly altered primary Fe-Ti oxide grains (probably primary ?ilmenite).

Zircon is rare, forming small terminated crystals and crystal fragments in the matrix areas.

Calcite-quartz-sulphide vein is composed mostly of anhedral large calcite grains, and similarly large anhedral calcite grains. Chlorite occurs in minor amount as small pleochroic green flakes that are concentrated in small aggregates mostly near the margins of the vein. Sphalerite occurs in minor amount as local large anhedral grains up to ~2 mm in size, and local small grains. The sphalerite is pale yellow, suggesting a low Fe content (and therefore relatively low temperature of formation). Galena forms small inclusions in sphalerite, and also forms local discrete grains at quartz grain boundaries. Chalcopyrite is uncommon, forming small ragged grains in the larger sphalerite grains and also forming local discrete tiny grains.

INTERPRETATION :

This sample is considered to have formed as a felsic tuffaceous deposit composed of a moderate proportion of crystals (quartz, ?feldspar, minor Fe-Ti oxide, zircon) and minor lithic fragments (?pumice, ?devitrified rhyolite) in a fine matrix that may have been dominated by glass shards. Low-grade regional metamorphism in the lower greenschist facies generated the new assemblage of sericite + quartz + chlorite + trace opaques (?ilmenite). The matrix was replaced by the foliated assemblage of sericite + quartz + chlorite, ?plagioclase and ?lithic fragments were replaced by sericite, chlorite replaced small ?shards in the matrix, and fine-grained ?ilmenite replaced the primary Fe-Ti oxide crystals.

During the metamorphic event, thin veinlets were filled by calcite + quartz + minor sulphides (sphalerite >> galena > chalcopyrite).

Client query: NCT002-447.8m has some sphalerite(?) within a thin carbonate vein. Could you please confirm that it is sphalerite.

Response: Yes, minor sphalerite occurs in the thin vein. The sphalerite is pale yellow, suggesting a relatively low Fe content and therefore relatively low temperature of crystallisation. This is consistent with the inferred lower greenschist facies P-T conditions.

Client query [from email of 20 July 2004]: ...The first three samples of NCT001 (10.9, 68.1 and 106.0) are thought to be part of a cover sequence (Tyndall Group?) while the other two NCT001 samples are interpreted to be part of the Central Volcanic Complex (ie basement!). We are far less certain of NCT002 – whether there is 'basement' there or not so would be interested in your comments about similarity of NCT002-417.1/447.8 with the last two samples in NCT001 and how the other NCT002 samples compare with the cover sequence samples of NCT001.

Response: In NCT001, the deeper two samples (463.5 and 486.6) differ significantly from the shallower three samples (10.9, 68.1, 106.0). The deeper samples represent massive rhyolitic igneous rock, possibly of shallow intrusive mode of emplacement, that has suffered devitrification and subsequent metamorphism. Comparable rock occurs as lithic fragments in the shallower samples, particularly as a large fragment in NCT001, 68.1m where veins of magnetite + garnet occur in the meta-rhyolite fragment and not in the

associated meta-fragmental rock. These observations suggest that the deeper meta-rhyolite also suffered veining by relatively high-temperature hydrothermal fluid prior to deposition of the fragmental rocks and subsequent metamorphism.

In NCT002, devitrified massive rhyolitic rock is not observed as entire samples. All of the samples represent fragmental precursor rocks. However, fragments of the massive rhyolitic rock are observed in samples NCT002, 199.1, 204.2, 206.8, and 248.4, as observed in the upper 3 samples of NCT001. It appears, therefore, that all of the samples in NCT002 are broadly comparable with the upper samples of NCT001 (ie Tyndall Group?), and that massive rhyolitic rock is absent from NCT002.

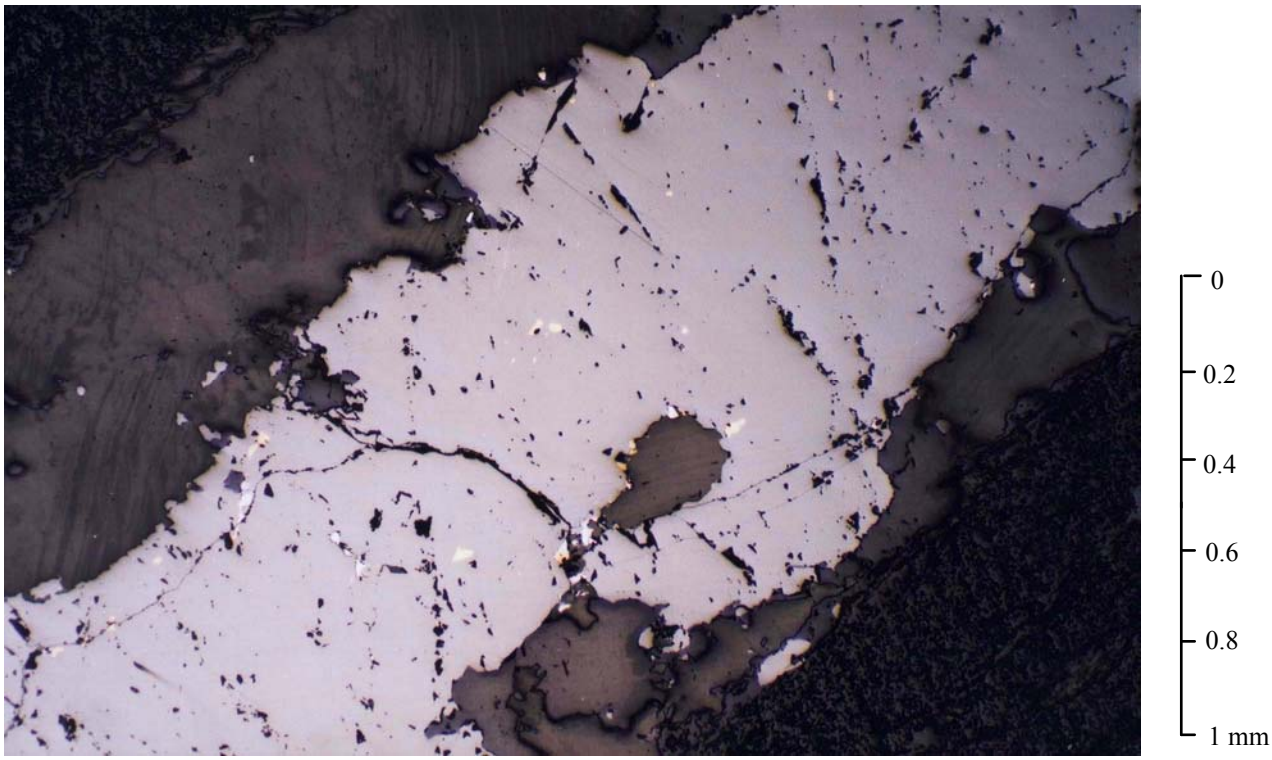


FIG. 22: SAMPLE NCT002, 447.8m (Reflected plane polarised light, x5, Film 1 / Frame 25)
This view was taken from a calcite-quartz-chlorite-sulphide vein (oriented NE-SW). Sphalerite (medium grey) forms large ragged grains, and is closely associated with small ragged grains of galena (pale grey) and chalcopyrite (pale yellow). The presence of these base-metal sulphide veins confirms that small amounts of base metals were mobilised and redeposited during the metamorphic event.

Mason Geoscience Pty Ltd

Petrological Services for the
Minerals Exploration and Mining Industry

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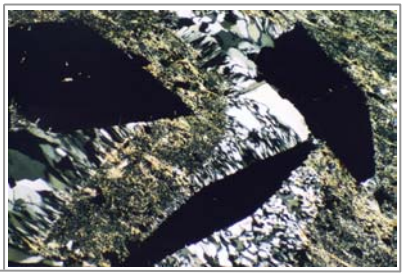
Petrographic Descriptions for One Grab Rock Sample from the Mt Read Volcanics (Tasmania) and Four Drill Core Samples from the Cadia Area (NSW)

REPORT #	**3057**
CLIENT	**Newcrest Mining Limited – SE Australia Exploration**
ORDER NO	**Letter, I. Tedder, 13 Dec 2004**
CONTACT	**Mr Ian Tedder**
REPORT BY	**Dr Douglas R Mason**
SIGNED	
	for Mason Geoscience Pty Ltd
DATE	**18 January 2005**



Petrographic Descriptions for One Grab Rock Sample from the Mt Read Volcanics (Tasmania) and Four Drill Core Samples from the Cadia Area (NSW)

SUMMARY

1. Rock Samples

- Five rock samples have been studied using petrographic methods: 1 grab rock sample from the Mt Read Volcanics south of Queenstown in Tasmania, and 4 drill core rock samples from the Cadia area in central western New South Wales.

[THIS REPORT WAS MODIFIED BY NEWCREST, WITH PERMISSION FROM DOUG MASON TO EXCLUDE NON RELEVANT DESCRIPTIONS]

2. Brief Results

- *A summary of rock names and mineralogy* is provided in TABLE 1.
- *Mt Read Volcanics*
  - **Sample A233** formed as a primary partly-sorted fragmental deposit of sedimentary or possibly reworked tuffaceous origin. A significant amount of disseminated framboidal pyrite formed at an early stage, possibly during diagenesis. Low-grade regional metamorphism in the greenschist facies was accompanied by a directed regional stress regime which generated the foliated assemblage of sericite + quartz + carbonate (?siderite) + pyrite + sphalerite + chlorite + trace tourmaline + leucoxene. At this time, thin fractures developed slightly discordant to the foliation, and were filled by quartz (lineated)+ arsenopyrite + tourmaline + carbonate (?siderite) + pyrite + sphalerite + trace galena. Precursor pyrite framboids suffered varied degrees of annealing.

TABLE 1: SUMMARY OF ROCK NAMES AND MINERALOGY

SAMPLE	ROCK NAME	MINERALOGY*		
		Primary**	**Alteration*****	**Fracture fillings**
Mt Read Volcanics, Tasmania				
A233	Sericite-carbonate-sulphide schist (altered meta-?tuff)	Qtz, mus	Py; Ser, qtz, car(?sid), py, sph, chl, tou, leu	Qtz, asp, car(?sid), sph, py, gal

NOTES:
*: Minerals are listed in each paragenesis according to approximate decreasing abundance.
**: Only primary minerals currently present in the rock are listed. Others may have been present, but are altered.
***: Earlier parageneses are separated from later parageneses by a semicolon.

Mineral abbreviations:
Alb = albite; ana = anatase; apa = apatite; asp = arsenopyrite; cal = calcite; car = undifferentiated carbonates (possible mineral in brackets); chl = chlorite; epi = epidote; gal = galena; grp = graphite; leu = leucoxene (undifferentiated Ti-phase); mt = magnetite; mus = muscovite; opq = undifferentiated opaques (possible mineral in brackets); py = pyrite; qtz = quartz; rut = rutile; ser = sericite; sid = siderite; sph = sphalerite; tou = tourmaline; ?min = uncertain mineral identification.

1 INTRODUCTION

A suite of 5 rock samples was received from Mr Ian Tedder (Newcrest Mining Limited, SE Australia Exploration, Cadia, via Orange, NSW) on 20 December 2004.

It was indicated that 1 grab rock sample originates from the Mt Read Volcanics south of Queenstown in Tasmania, and 4 drill core samples originate from the Cadia area in central western New South Wales. Particular requests were:

i) Prepare a polished thin section and combined petrographic/mineragraphic description for grab rock sample A233 from the Mt Read Volcanics.

ii) Prepare a standard thin section and petrographic description for the 4 drill core samples from Cadia.

iii) For each sample, report on their mineralogy, alteration and paragenesis.

Excerpts from this report were provided by email to Mr Tedder on 17 January 2005. This report contains the full results of this work.

2 METHODS

The samples were examined in hand sample and marked for thin section preparation. Thin sections were obtained from an external commercial laboratory (Petrographic Technical Services Pty Ltd, Buderim, Queensland).

At Mason Geoscience Pty Ltd conventional transmitted polarised light microscopy was used to prepare the routine petrographic descriptions. Additional mineragraphic observations are provided where a polished thin section is available.

Discussion of the results with the client confirmed that selected photomicrographs for sample A233 should be included in the report. These have been included with the petrographic/mineragraphic description.

3 PETROGRAPHIC DESCRIPTIONS

The petrographic descriptions are provided in the following pages. A combined petrographic/mineragraphic description is given for the sample A233 for which a polished thin section was obtained.

SAMPLE : A233 (Mt Read Volcanics, south of Queenstown, Tasmania)

SECTION NO : A233

HAND SPECIMEN : The surface grab rock sample represents a fine-grained, grey, schistose rock in which small pale white grains are faintly discernible. No compositional layering is evident. Sparsely scattered through the rock are euhedral lustrous silvery sulphide grains (?arsenopyrite).

The sample fails to bubble in reaction with dilute HCl, suggesting calcite and dolomite are absent.

ROCK NAME : Sericite-carbonate-sulphide schist (altered meta-?tuff)

PETROGRAPHY AND MINERAGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

Mineral	Vol %	Origin
Quartz	2	Primary crystal fragments 1
Muscovite	Tr	Primary crystal fragments 1
Pyrite (framboidal)	1	Relict ?diagenetic 2
Sericite	76	Metamorphic ?alteration 3
Quartz	10	Metamorphic 3 / fracture fillings 3
Carbonate (?siderite)	5	Metamorphic ?alteration 3
Pyrite (euhedral)	2	Metamorphic 3 / fracture fillings 3
Sphalerite	1	Metamorphic 3 / fracture fillings 3
Chlorite	1	Metamorphic 3
Tourmaline	<1	?Primary fragments 1 / m'ic 3 / fracture fillings 3
Leucoxene	Tr	Metamorphic 3
Arsenopyrite	<1	Fracture fillings 3
Galena	Tr	Fracture fillings 3

In polished thin section, this sample displays a partly-preserved primary fragmental (clastic) texture, modified by ductile metamorphic deformation and associated alteration.

White mica dominates the rock, and occurs in two forms:

i) A very small amount occurs as small but well-shaped flakes that are very sparsely scattered through the rock. Their size and clean form suggests that they represent primary clastic muscovite particles.

ii) Most of the white mica occurs as small, poorly-crystallised flakes whose strong preferred orientation defines a strongly foliated mat throughout the rock. The foliated mat is not uniform, but contains poorly-defined wispy lenticles aligned in the trace of the strong foliation: these possibly represent deformed and altered lithic fragments of unknown type (eg ?volcanics), but no primary minerals or textures are preserved to aid identification.

Quartz is moderately abundant, and occurs in different forms:

i) Some quartz occurs as small angular crystal fragments ~0.1-0.2 mm in size. They are sparsely but irregularly scattered through the rock without layering. Some represent fragments of single crystals, but others display varied degrees of shadowy strain extinction and partial recrystallisation to finer-

grained microgranular mosaics. None display elongation in the trace of the foliation (ie they have remained competent in a strained matrix).

ii) Some quartz occurs in moderate amount as tiny anhedral grains that are sprinkled through the foliated sericitic matrix. This quartz appears to be of metamorphic origin.

iii) A minor amount of quartz occurs as clear lineated aggregates that are concentrated in local fractures oriented at an acute angle to the foliation. In these fractures, the lineated quartz has developed around euhedral tourmaline crystals and larger euhedral arsenopyrite crystals.

Carbonate occurs in minor amount as small rhombic grains and slightly larger anhedral aggregates. Most of the carbonate is disseminated through the rock, but in places tends to be loosely concentrated in particular horizons subparallel to the foliation. Their grain shapes, other optical properties (strong double refraction, slightly turbid appearance) and lack of bubbling in reaction with dilute HCl suggests that it is siderite.

Pyrite is present in significant amount, and two different types are distinguished:

i) Some pyrite forms tiny round grains of framboidal appearance. Most are quite small (~5-12 µm diameter), but some range up to ~20 µm. They are distributed sparsely throughout the rock, but locally tend to be concentrated in thin discontinuous folia that are oriented subparallel to the structure through the rock. The framboids display varied stages of annealing, from framboids that essentially retain their primary microgranular texture, through partly-annealed round grains with only a few micro grains, to subhedral pyrite grains.

ii) More pyrite occurs as well-crystallised small cubic crystals that range in size from ~10 µm up to ~0.2 mm. They are disseminated through the rock, and the larger ones tend to display small lineated pressure shadows of quartz.

Sphalerite occurs in minor amount as anhedral grains scattered sparsely through the rock. The more elongate grains range up to ~0.4 mm long and are aligned in the trace of the foliation. Larger grains of sphalerite also occur in the slightly discordant fracture fillings dominated by quartz, tourmaline and arsenopyrite. The lack of colour suggests a low-Fe composition.

Tourmaline occurs in minor amount. Most forms small euhedral stumpy prisms pleochroic in greens, concentrated in the slightly discordant fracture fillings with quartz and sulphides. A trace amount of tourmaline also occurs as single small angular grains very sparsely scattered through the rock: these possibly represent relict primary crystal fragments.

Arsenopyrite occurs as large euhedral crystals up to ~2 mm long with typical white colour and moderate anisotropism. They occur only in the slightly discordant fracture fillings with quartz and tourmaline.

Chlorite is present in minor amount as pleochroic pale green aggregates of small flakes. It tends to be concentrated in the fracture fillings, but some is intergrown with sericite elsewhere through the rock.

Galena is rare, forming small ragged fillings in minor thin fractures in and at the margins of the large arsenopyrite crystals.

Leucoxene occurs as uncommon turbid dark grains (altered precursor ?Fe-Ti oxide grains).

INTERPRETATION :

This sample is considered to have formed as a primary fragmental deposit of sedimentary or possibly reworked tuffaceous origin. It originally contained minor small crystal fragments (quartz, trace ?Fe-Ti oxide) and may have contained moderately abundant lithic fragments (?volcanics) whose shapes and mineralogy have been obscured by subsequent events. The presence of a significant amount of framboidal pyrite

suggests that some sulphide formed early, possibly at the diagenetic stage, and may have formed from sulphur that was already in the sediment.

Low-grade regional metamorphism in the greenschist facies has affected the rock. This occurred in the presence of a directed regional stress regime, resulting in pervasive recrystallisation of the precursor silicate components to produce a foliated matrix dominated by sericite. The primary quartz grains survived this event with only weak recrystallisation and little or no deformation: they remained competent during deformation. Some of the early-formed pyrite framboids suffered varied degrees of annealing, but additional pyrite formed as euhedral small to larger crystals. The development of small lineated quartzose pressure shadows at margins of some pyrite crystals suggests that pyrite crystallised synchronously with the deformation. Local shear planes formed slightly discordant to the foliation, allowing local migration of more mobile components to produce thin discontinuous fracture fillings composed of quartz + tourmaline + arsenopyrite + minor carbonate + sphalerite + pyrite + galena + trace chlorite. Carbonate (?siderite) formed small rhombic grains that tend to be concentrated in particular horizons and also in the fracture fillings.

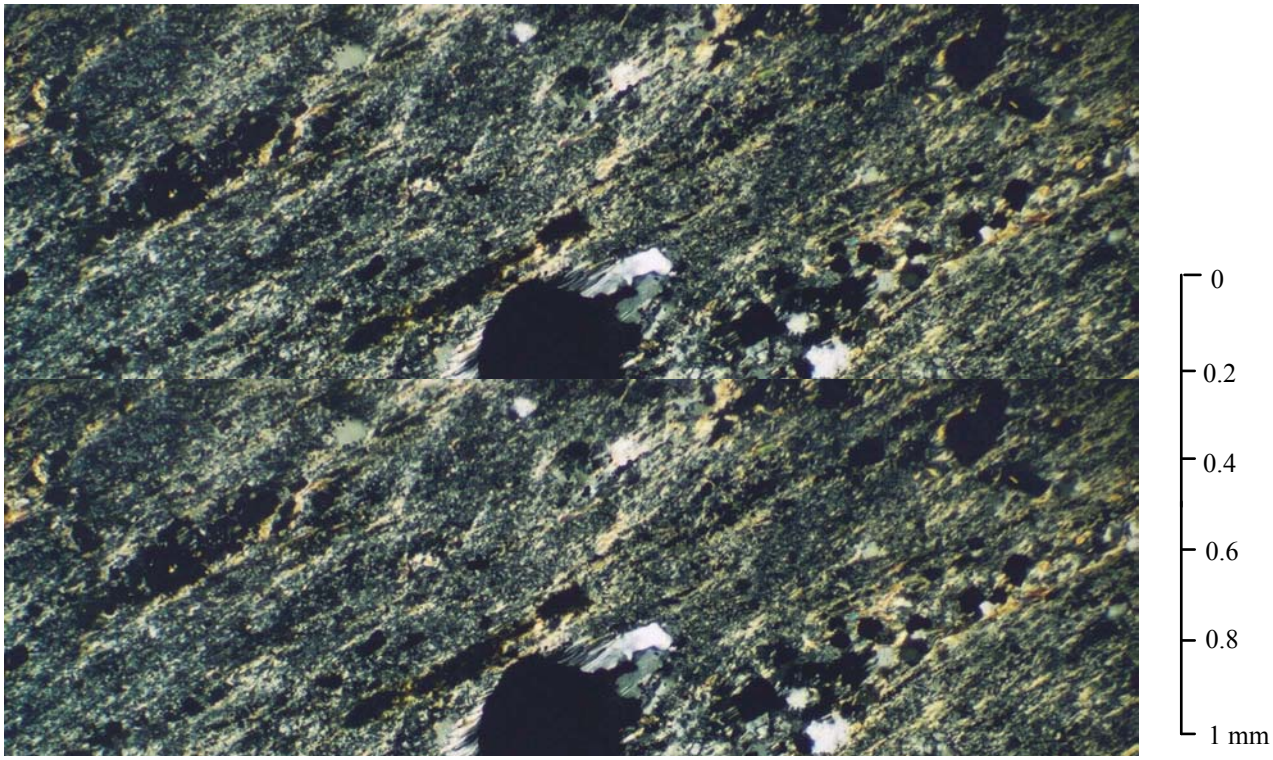


FIG. 1: SAMPLE A233 (Transmitted light, crossed polarisers, x5, Film 1 / Frame 1A)
This general view illustrates the deformed and altered primary fragmental texture. Relict primary quartz fragments (white; bottom left, centre left) are preserved, but fine-grained foliated sericite (yellow to dull colours, oriented NE-SW) has replaced most of the rock. Note the small lineated quartz beards (white to grey) marginal to the pyrite crystal (black, centre).

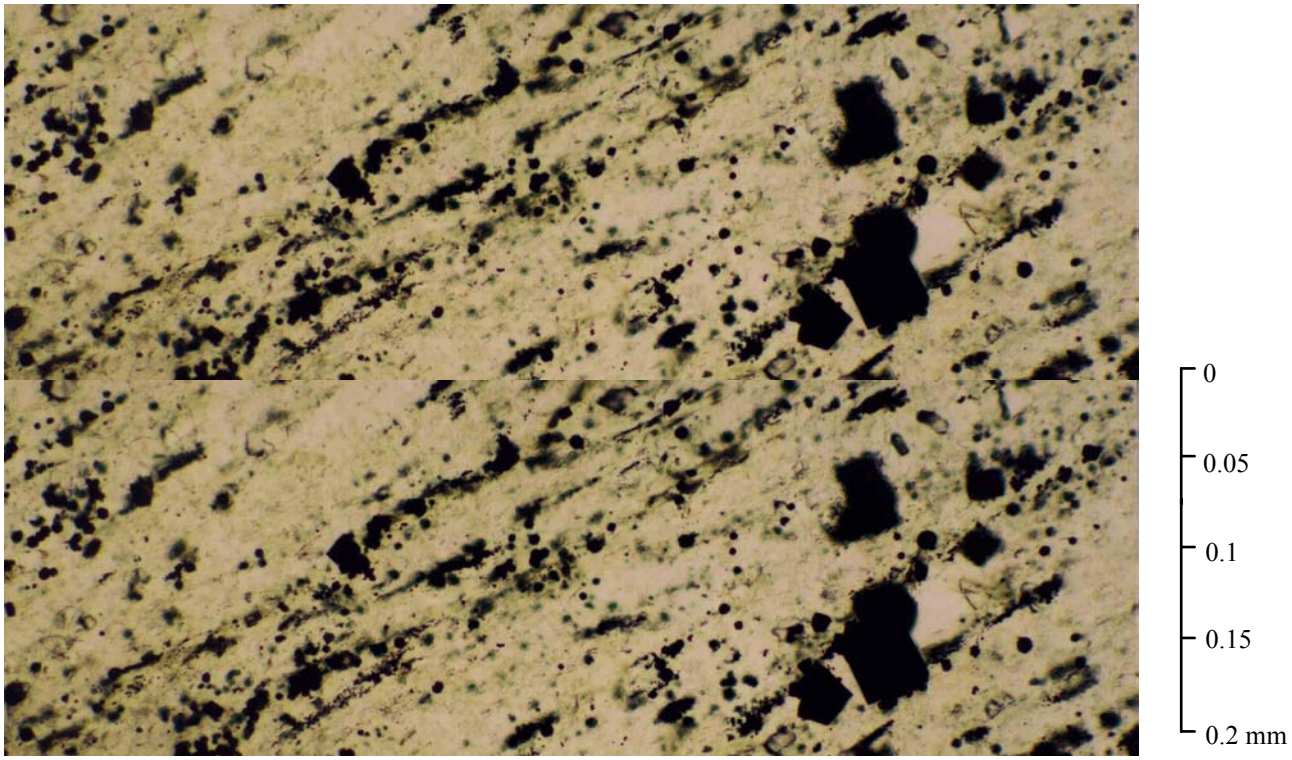


FIG. 2: SAMPLE A233 (Transmitted plane polarised light, with condenser, x20, Film 1 / Frame 7A)
This view illustrates two generations of pyrite (black): earlier framboidal pyrite (tiny ovoid grains) are sprinkled throughout, and later alteration pyrite (larger equant euhedral crystals; top right, bottom left) are irregularly disseminated.

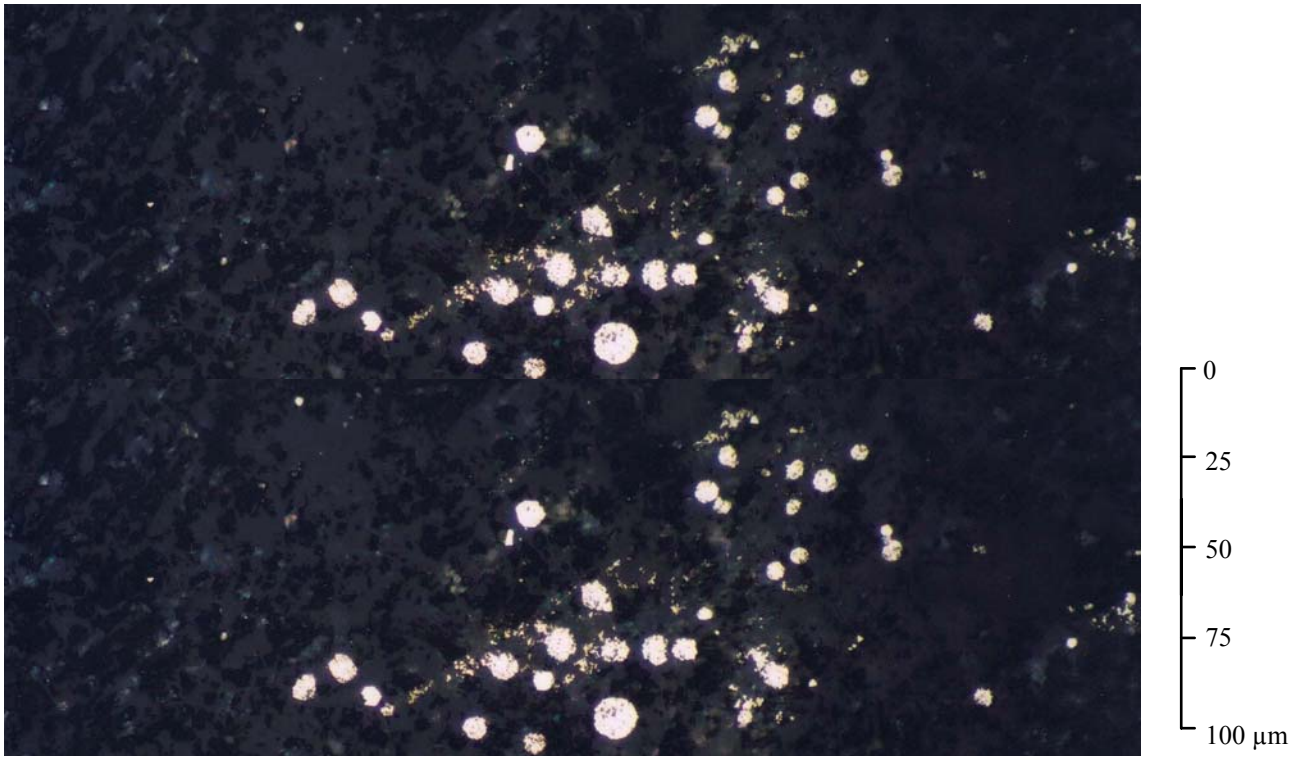


FIG. 3: SAMPLE A233 (Reflected plane polarised light, x40, Film 1 / Frame 6A)
This is a closer view of tiny framboids of pyrite (white). Note their ovoid shape and their microgranular texture defined by minute discrete closely-packed pyrite specks. Most display partial annealing in response to the low-grade regional event. In this view the largest framboid is ~10 µm in size.

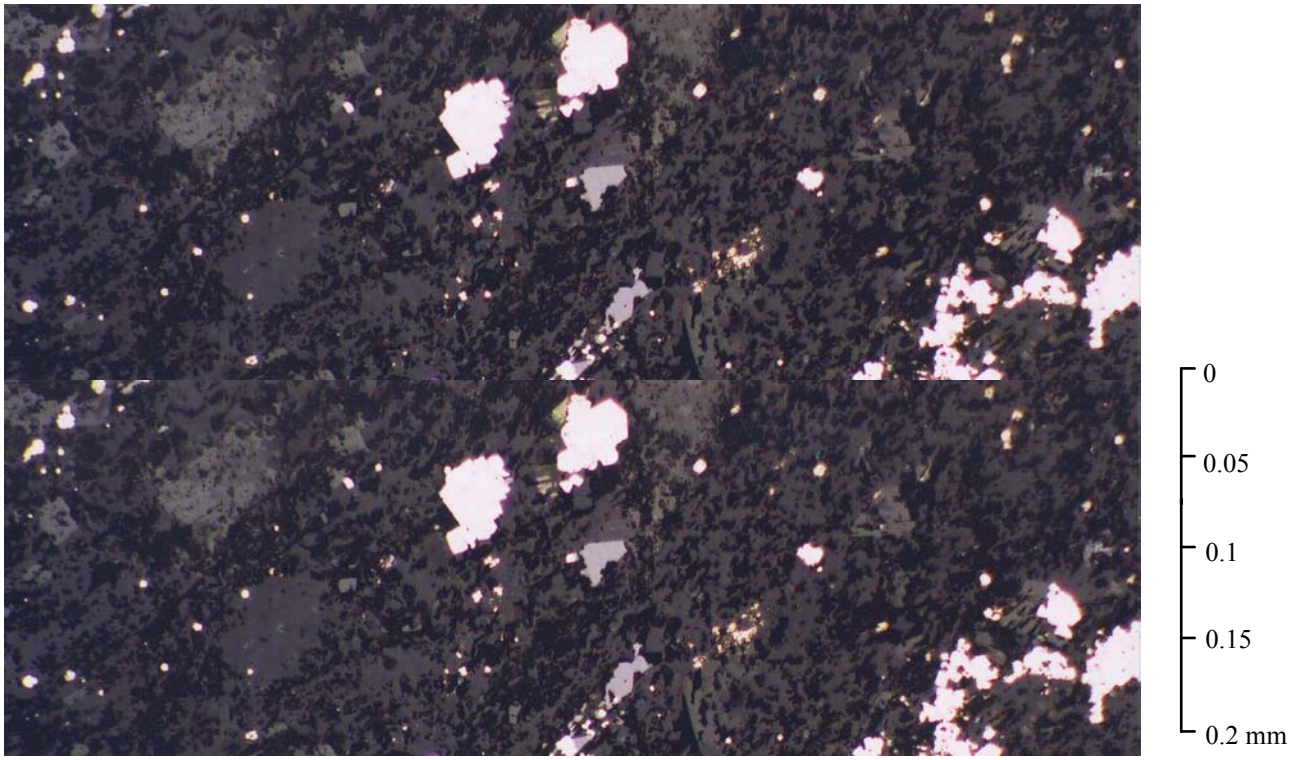


FIG. 4: SAMPLE A233 (Reflected plane polarised light, x20, Film 1 / Frame 4A)
This view illustrates the presence of sphalerite (medium grey) which is disseminated sparsely through the rock as small lenticular aggregates aligned in the trace of the foliation (centre) and as small ragged grains (right). Note the association of the sphalerite with well-shaped pyrite crystals of the second pyrite generation (compare FIG. 2).

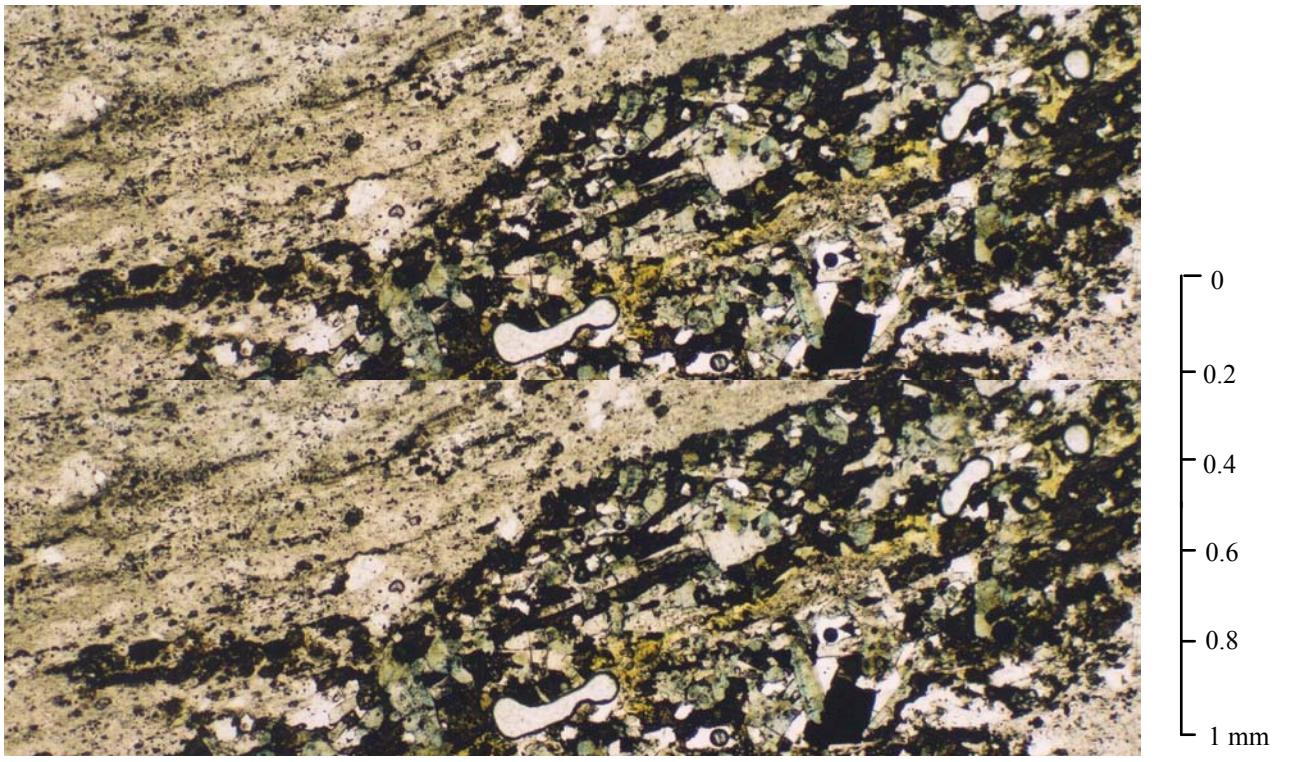


FIG. 5: SAMPLE A233 (Transmitted plane polarised light, x5, Film 1 / Frame 11A)
This view captures part of a vein (oriented NE-SW) composed of tourmaline (green stumpy crystals), quartz (colourless), sphalerite (turbid dark grains), and opaques (pyrite). Other minerals in this vein are illustrated in FIGS 6 and 7.

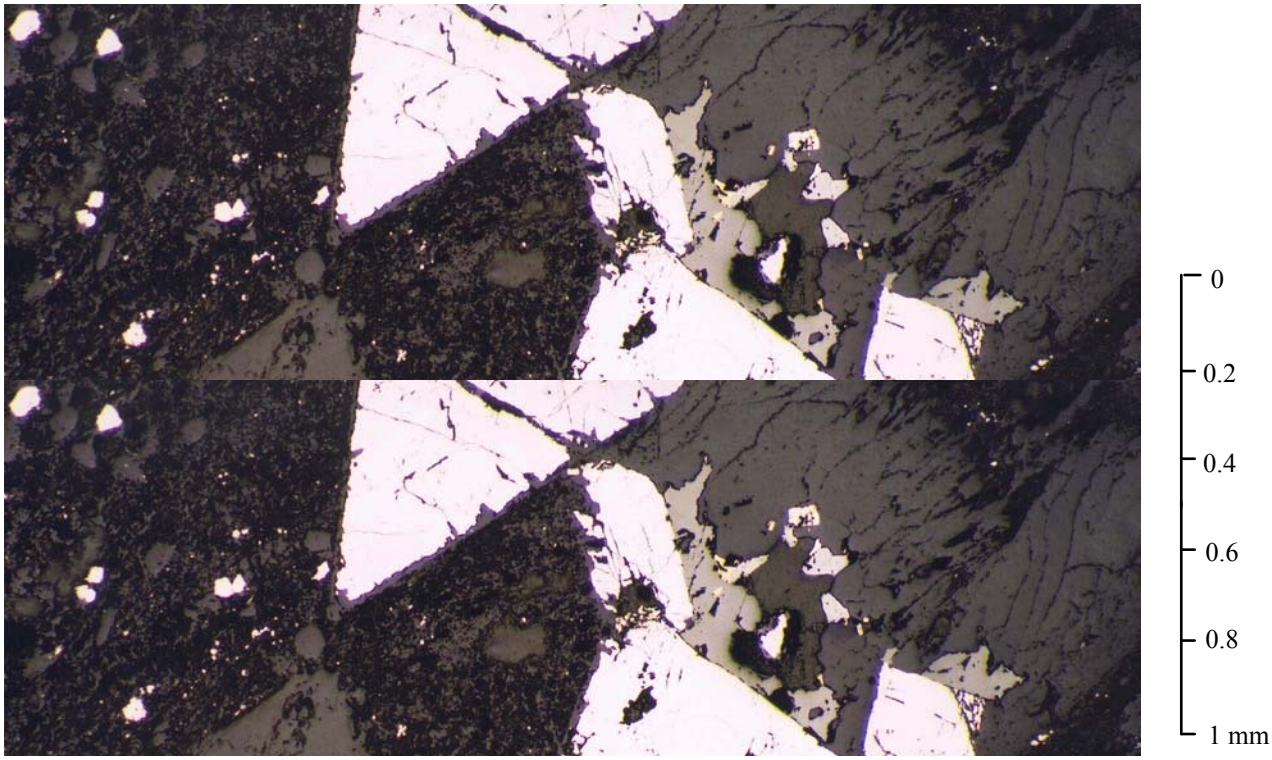


FIG. 6: SAMPLE A233 (Reflected plane polarised light, x5, Film 1 / Frame 10A)
This view captures tension gash fillings marginal to the vein illustrated in FIG. 5. Note the euhedral large crystals of arsenopyrite (white), with associated sphalerite (ragged grains, medium grey, adjacent to arsenopyrite). Traces of galena and chalcopyrite also are present.

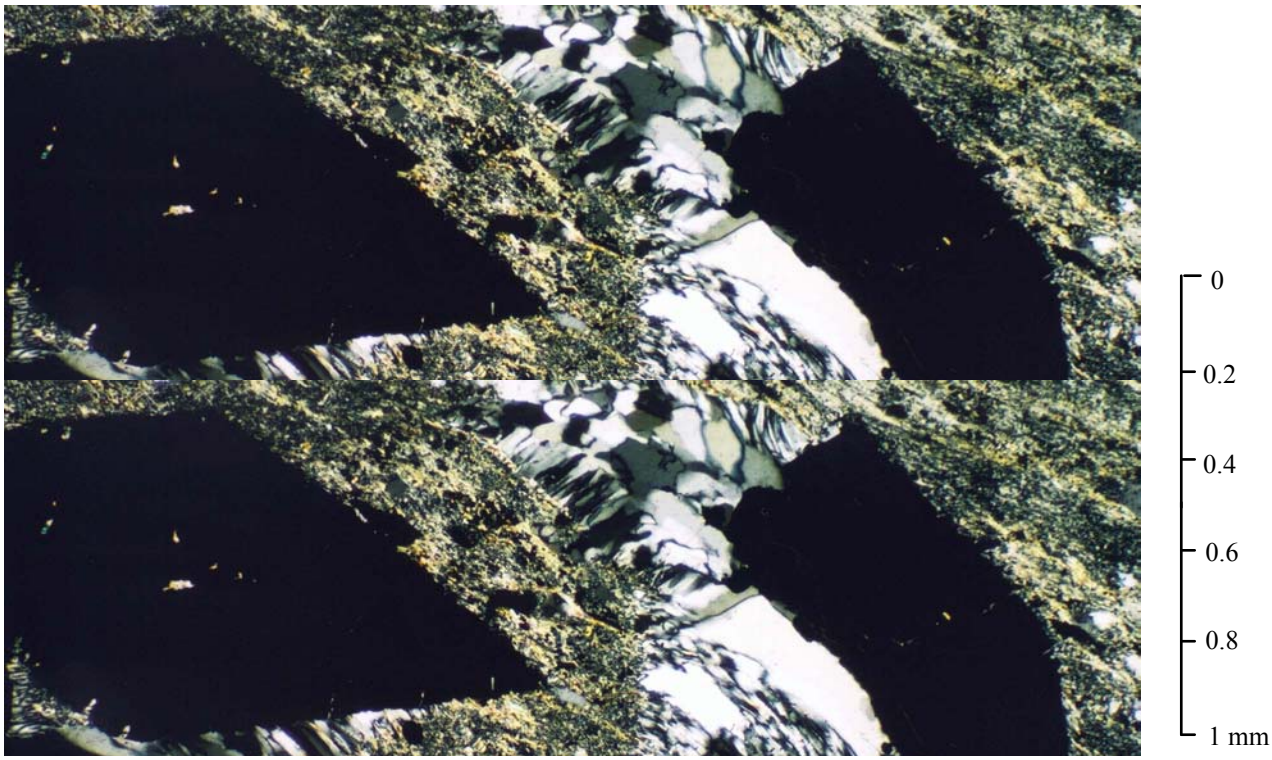


FIG. 7: SAMPLE A233 (Transmitted light, crossed polarisers, x5, Film 1 / Frame 12A)
This is another view of the tension gash fillings. Arsenopyrite forms the large euhedral crystals (black). Lineated quartz (white to grey) accompanies the arsenopyrite in the tension gashes, with lineation aligned parallel with foliated sericite (yellow, oriented NW-SE) in host rock. Alignment of the lineated quartz and foliated sericite suggests that the tension gash fillings, with associated veinlet fillings and mineralisation, all formed more-or-less synchronously with deformation.

Mason Geoscience Pty Ltd

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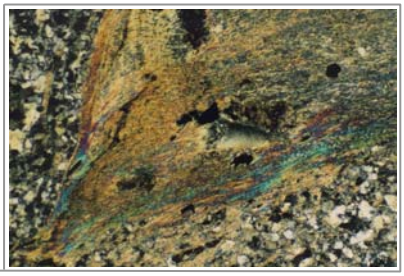
Petrographic Descriptions for Five Rock Samples from Drill Hole NCT003 (Mt Read Volcanics, Queenstown Region, Tasmania)

REPORT #	**3063**
CLIENT	**Newcrest Mining Limited**
ORDER NO	**E 13172**
CONTACT	**Mr Ian Tedder**
REPORT BY	**Dr Douglas R Mason**
SIGNED	
	for Mason Geoscience Pty Ltd
DATE	**22 February 2005**



Petrographic Descriptions for Five Rock Samples from Drill Hole NCT003 (Mt Read Volcanics, Queenstown Region, Tasmania)

SUMMARY

1. Rock Samples

- A suite of 5 rock samples from drill hole NCT003 (Mt Read Volcanics, Queenstown region, Tasmania) has been studied using routine petrographic methods, supplemented by reflected light observations for 1 sample.

2. Brief Results

- *A summary of rock names and mineralogy* is provided in TABLE 1.

- *Primary rock types*

  – **Fragmental rocks** formed as the primary rock for all samples. All are inferred to have formed as volcanogenic fragmental deposits of tuffaceous origin and broadly felsic (?dacitic) bulk composition. Most were dominated by abundant moderately large acid volcanic lithic fragments up to centimetre size, but one sample (NCT003, 733.9m) was composed of smaller fragments that appear to have been partly sorted.

- *Metamorphism and alteration*

  – **Low-grade regional metamorphism** in the lower greenschist facies has affected all rocks. This generated foliated fine-grained replacement assemblages that range from least-altered (albite + sericite + chlorite + carbonate + trace Ti-phase + hematite ± sulphide) to more strongly altered (quartz + sericite + carbonate + trace Ti-phase + sulphide). The high intensity of alteration requires that a large amount of hydrothermal fluid invaded the rock body, with smaller amounts of fluid invading the least-altered parts. A significant amount of sphalerite formed as part of the alteration sulphide assemblage in NCT003, 495.9m. The least-altered rocks (NCT003, 284.98m and 733.9m) enclose intervening more strongly altered rocks (NCT003, 495.9m, 528.8m, 606.1m). A moderately strong preferred orientation in sericite and chlorite (where present) confirms that the phyllosilicate minerals formed in the presence of a directed regional stress regime. Only two mineral paragenetic assemblages can be distinguished: minor relict primary minerals (plagioclase, apatite, zircon) and the replacement assemblage. There is no unequivocal petrographic evidence to suggest that the rocks had suffered alteration prior to the principal metamorphic event; on the contrary, the preservation of primary plagioclase in the two least-altered samples suggests that at least those samples had not suffered a strong precursor (eg syn-volcanic) alteration event which most likely would have destroyed all primary plagioclase.

TABLE 1: SUMMARY OF ROCK NAMES AND MINERALOGY

SAMPLE	ROCK NAME	MINERALOGY*			
		Primary**	**Alteration*****	**Veins**	**Weathering**
NCT003, 284.9m	Weakly foliated low- to medium-intensity albite-chlorite-sericite-hematite altered meta-dacite breccia (lithic ?tuff)	Pla, apa, zir	Alb, ser, chl, qtz, car(cal), hem, leu	-	-
NCT003, 495.9m	Foliated high-intensity sericite-quartz-carbonate-sulphide altered meta-fragmental rock (lithic ?tuff)	Zir	Ser, qtz, car(?sid), sph, leu, py, cpy	-	-
NCT003, 528.8m	Foliated high-intensity quartz-sericite-carbonate altered meta-fragmental rock (lithic ?tuff)	Apa, zir	Qtz, ser, car(cal), leu(?ana), opq(?py)	-	-
NCT003, 606.1m	Foliated high-intensity quartz-sericite-carbonate altered meta-fragmental rock (lithic tuff)	-	Qtz, ser, car(cal), leu(?ana), opq(?py)	-	-
NCT003, 733.9m	Foliated low- to medium-intensity albite-sericite-chlorite-hematite altered meta-fragmental rock (crystal-lithic tuff)	Pla, zir	Ser, alb, chl, qtz, car(cal), leu, opq(?py), hem	-	-

NOTES:
*: Minerals are listed in each paragenesis according to approximate decreasing abundance.
**: Only primary minerals currently present in the rock are listed. Others may have been present, but are altered.
***: Earlier parageneses are separated from later parageneses by a semicolon.

Mineral abbreviations:
Alb = albite; ana = anatase; apa = apatite; cal = calcite; car = carbonate mineral (possible mineral in brackets); chl = chlorite; cpy = chalcopyrite; hem = hematite; leu = leucoxene (very fine-grained Ti-phase, possible mineral in brackets); opq = opaque mineral (possible mineral in brackets); pla = plagioclase; py = pyrite; qtz = quartz; ser = sericite (fine-grained white mica); sid = siderite; sph = sphalerite; zir = zircon; ?min = uncertain mineral identification).

1 INTRODUCTION

A collection of 5 drill core rock samples was received from Mr Ian Tedder (Newcrest Mining Limited – SE Australia Exploration Office, Cadia, via Orange, New South Wales) on 3 February 2005.

It was indicated that the samples originate from the Mt Read Volcanics, south of Queenstown, Tasmania. Particular requests were:

i) To prepare a thin section and petrographic description for each sample. Sphalerite is present in some samples, and therefore polished thin sections may be required.

ii) Report on sample mineralogy, alteration and paragenesis.

Excerpts from this report were provided by email to Mr Tedder on 21 February 2005. This report contains the full results of this work.

2 METHODS

The drill core samples were examined in hand specimen and marked for thin section preparation. A polished thin section was deemed appropriate for sample NCT003, 496.9m, in which visible disseminated brown sphalerite is observed. All sections were obtained from an external laboratory (Pontifex & Associates Pty Ltd, Rose Park, South Australia).

At Mason Geoscience Pty Ltd conventional transmitted polarised light microscopy was used to prepare the routine petrographic descriptions. Additional mineragraphic observations are provided where a polished thin section is available. A selection of colour photomicrographs has been included to illustrate some of the relict primary and alteration textures.

3 PETROGRAPHIC DESCRIPTIONS

The petrographic descriptions are provided in the following pages.

SAMPLE : NCT003, 284.9m (Mt Read Volcanics, Queenstown region, Tasmania)

SECTION NO : NCT003, 284.9m

HAND SPECIMEN : The drill core sample represents a mottled fine-grained greenish grey rock in which mottling appears to indicate a fragmental texture, with large pale pink fragments up to centimetre size and smaller dark green to black fragments. Blocky white feldspar crystals are sparsely scattered through the rock. A preferred alignment of the darker fragments, some of which are wispy, suggests they may represent fiammé.

The section offcut effervesces in local small patches, suggesting minor calcite is present.

ROCK NAME : Weakly foliated low- to medium-intensity albite-chlorite-sericite-hematite altered meta-dacite breccia (lithic ?tuff)

PETROGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

Mineral	Vol %	Origin
Plagioclase	5	Primary crystals
Apatite	Tr	Primary crystals
Zircon	Tr	Primary crystals
Felsic mosaic (mainly albite, minor quartz)	78	Metamorphic alteration
Sericite	10	Metamorphic alteration
Chlorite	5	Metamorphic alteration
Carbonate (calcite)	<1	Metamorphic alteration
Hematite	Tr	Metamorphic alteration
Leucoxene	Tr	Metamorphic

In polished thin section, this sample displays a faintly preserved coarse primary fragmental texture, modified by pervasive alteration.

Fine-grained felsic mosaic dominates the rock. It occurs as indistinct fragments commonly >1-2 mm in size, and is considered to be dominated by albite, but a small amount of quartz occurs concentrated in minor thin discontinuous veinlet-like bodies.

Plagioclase occurs in minor amount as relatively large blocky prismatic crystals ~0.5-1.0 mm long. They display their primary twinning and weak normal compositional zoning. Most occur as glomerocrystic aggregates, either occurring as phenocrysts within lithic fragments or as discrete aggregates and crystal fragments.

Sericite is present in moderate amount, forming tiny flakes whose preferred orientation contributes to a weak foliation through the rock. Much of the sericite is concentrated in ragged patches and trails that appear to occupy interstices between the altered lithic fragments, but thin discontinuous foliated trails of sericite also cut the faintly preserved fragments.

Chlorite occurs in moderate amount as tiny pleochroic green flakes that are sprinkled pervasively through the altered lithic fragments and in interstices. Locally, chlorite is densely concentrated in wispy altered lithic fragments aligned in the trace of the structures. These fragments may have formed as glassy volcanogenic fragments, possibly fiammé.

Hematite is uncommon, forming minute dark red specks that sparsely pervade some of the lithic fragment sites. This is responsible for the pinkish colour of some lithic fragments in hand specimen.

Leucoxene occurs in trace amount as turbid small granules that are concentrated in dense patches in some of the lithic fragments, commonly in close association with the relict plagioclase phenocrysts. The leucoxene appears to have formed by replacement of precursor primary Fe-Ti oxide grains.

Calcite occurs in minor amount as ragged grains locally concentrated in small aggregates.

Apatite occurs in trace amount as small stumpy colourless prisms located in plagioclase phenocrysts and also in some of the altered lithic fragments. They are inferred to represent relict primary microphenocrysts.

Zircon is rare, forming tiny terminated prisms of relict primary igneous origin. They have been observed in some of the altered lithic fragments.

INTERPRETATION :

This sample is considered to have formed as a primary fragmental rock of volcanogenic origin. It was originally composed of closely-packed abundant lithic fragments, mostly glassy plagioclase-phyric ?dacite, and minor crystals (plagioclase, Fe-Ti oxide) derived from the phenocrysts. Some fragments were wispy in shape, and may have formed as glassy fiammé. A tuffaceous origin is considered likely.

Following deposition, the rock body subsequently suffered low-grade regional metamorphism in the presence of a weak directed regional stress regime. This generated the weakly foliated metamorphic replacement assemblage of albite + sericite + chlorite + minor quartz + trace leucoxene.

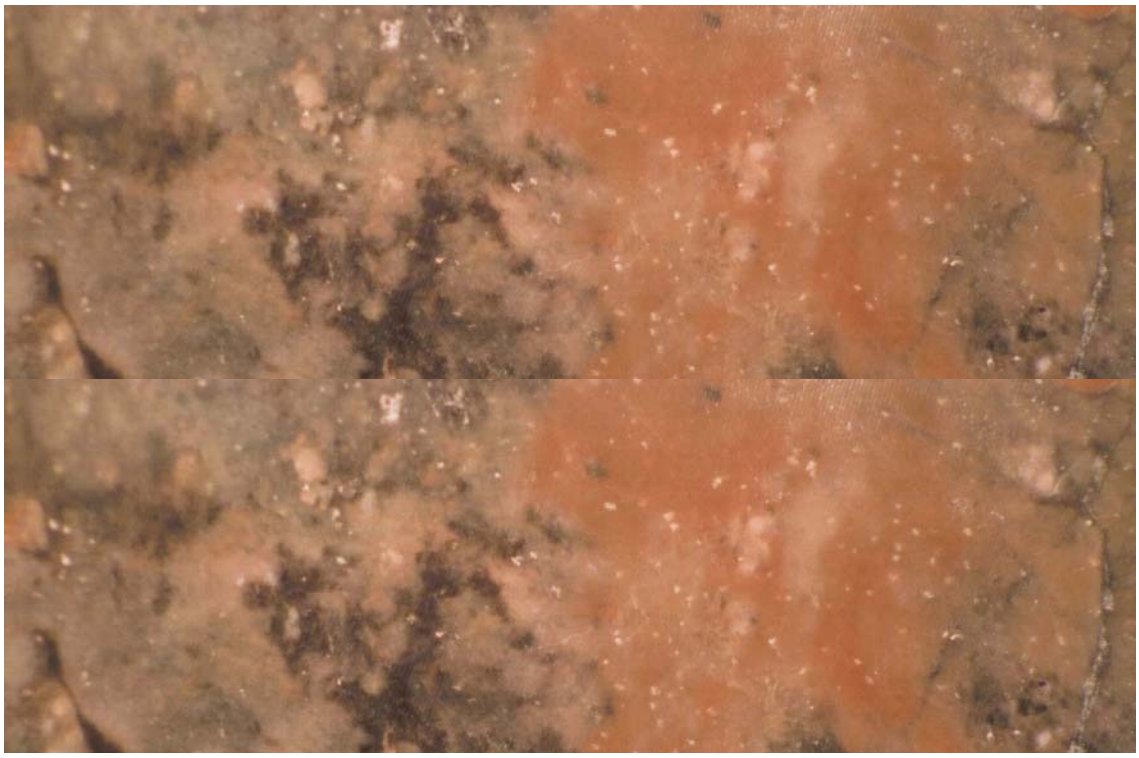


FIG. 1: SAMPLE NCT003, 284.9m (Macrophotograph of section offcut, 2.7 cm left to right, Film 1 / Frame 14)
This view illustrates the faintly preserved primary fragmental texture in this sample. Very fine hematite generates a pale pink colour in a large lithic fragment (upper right). Partly-preserved primary plagioclase crystals (white to pale pinkish white) are also evident.

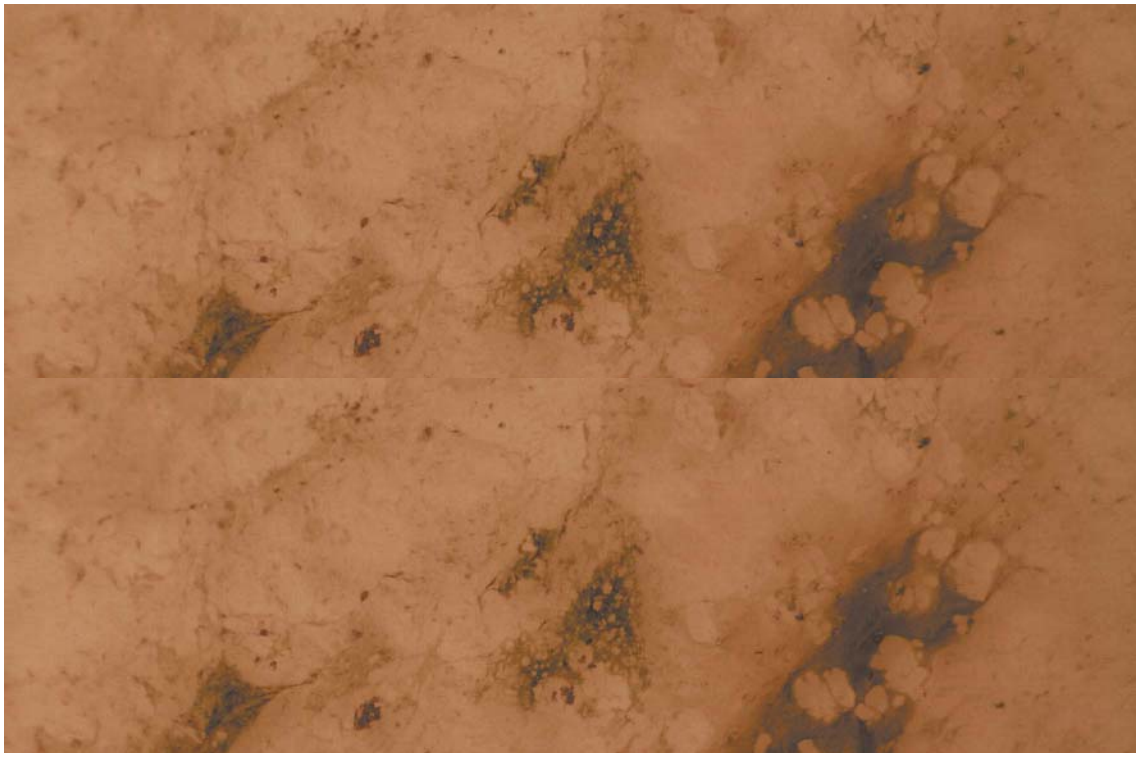


FIG. 2: SAMPLE NCT003, 284.9m (Macrophotograph of thin section, 2.7 cm left to right, Film 1 / Frame 15)
This view illustrates chlorite- and sericite-altered wispy lithic fragments (dark; centre left, centre, centre right) which most likely formed as plagioclase-phyric glassy lithic fragments possibly of fiammé origin.

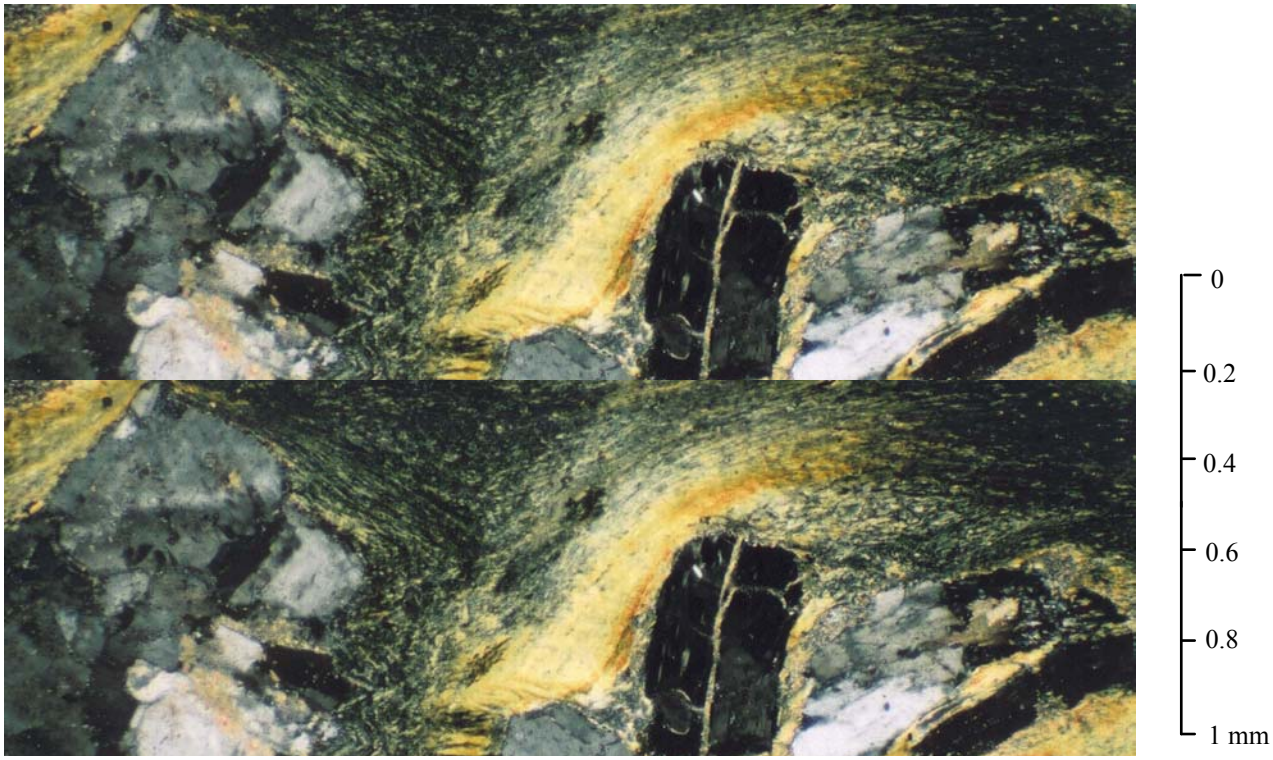


FIG. 3: SAMPLE NCT003, 284.9m (Photomicrograph, transmitted light, crossed polarisers with condenser, x5, Film 1 / Frame 2). This view was taken from a wispy lithic fragment (?fiammé), and shows the relatively well-preserved primary plagioclase phenocrysts (white to grey blocky crystals) in a foliated mat of sericite and lesser chlorite. Relatively good preservation of the primary plagioclase phenocrysts suggests that precursor (synvolcanic) alteration probably did not affect the rocks.

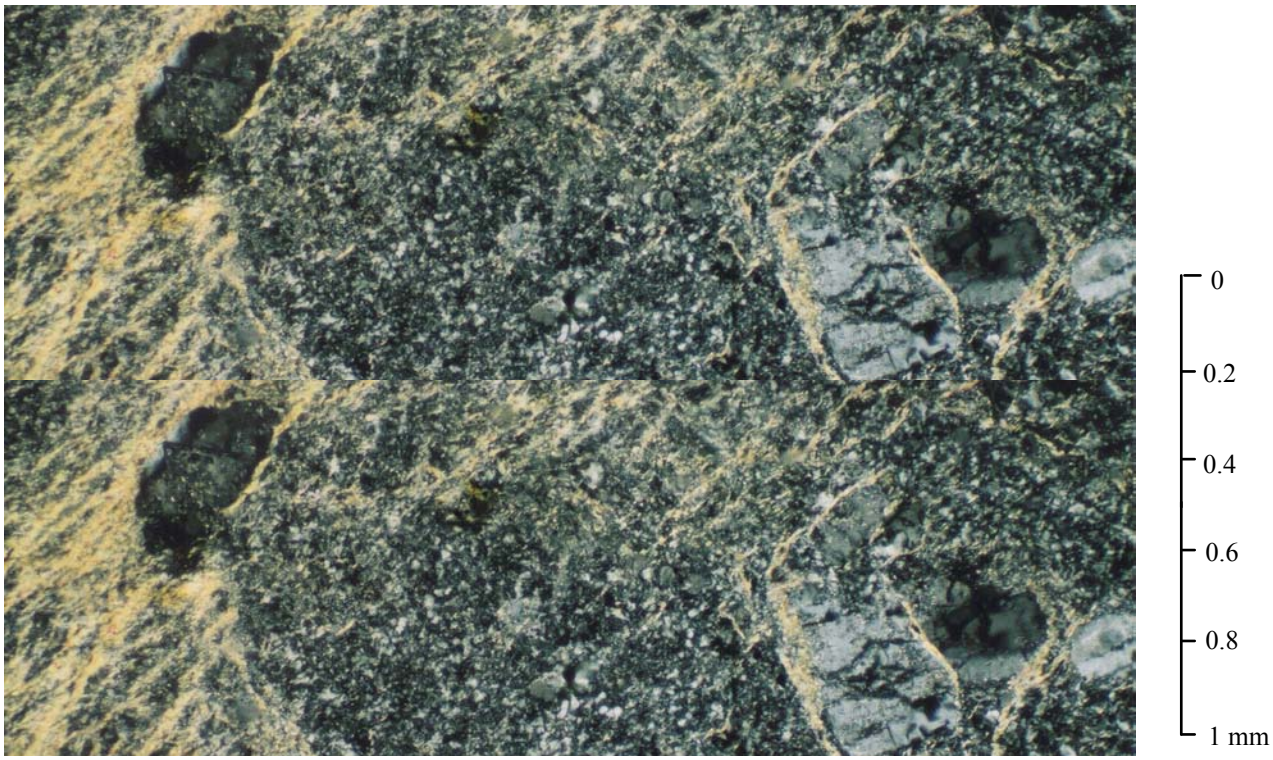


FIG. 4: SAMPLE NCT003, 284.9m (Photomicrograph, transmitted light, crossed polarisers with condenser, x5, Film 1 / Frame 1). This view illustrates the weak metamorphic foliation defined by aligned small flakes of sericite (yellow, oriented NE-SW), which enwraps faintly preserved primary lithic fragments now composed mostly of an albitic mosaic (dull grey). Some small plagioclase crystal fragments (grey, centre right, lower centre) are partly preserved.

SAMPLE : NCT003, 495.9m (Mt Read Volcanics, Queenstown region, Tasmania)

SECTION NO : NCT003, 495.9m

HAND SPECIMEN : The drill core sample appears to display a fragmental texture, in which indistinctly shaped blotchy pale greenish cream fragments from several millimetres to centimetre size are closely packed in a fine-grained darker greenish matrix in which a moderate foliation is evident. Ragged small brownish grains and patches of sphalerite are sparsely scattered through the rock.

ROCK NAME : Foliated high-intensity sericite-quartz-carbonate-sulphide altered meta-fragmental rock (lithic ?tuff)

PETROGRAPHY AND MINERAGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

Mineral	Vol %	Origin
Zircon	Tr	Primary crystals
Sericite	55	Metamorphic alteration
Quartz	30	Metamorphic alteration
Carbonate (?siderite)	10	Metamorphic alteration
Sphalerite	3	Metamorphic alteration
Leucoxene	<1	Metamorphic alteration
Pyrite	Tr	Metamorphic alteration
Chalcopyrite	Tr	Metamorphic alteration (inclusions in sphal.)

In polished thin section, this sample displays a faintly preserved fragmental texture, modified by strong alteration.

Sericite dominates the rock, forming small flakes that are concentrated in a foliated mat throughout the rock.

Quartz is the other principal phase, occurring as small equant anhedral grains. Their local concentration in areas several millimetres in size appears to define precursor lithic fragments, and local preferred orientation of quartz mosaics in some of these fragments represents relict precursor structure (eg flow banding in lava).

Carbonate is moderately abundant, forming small ragged grains and granular aggregates scattered through the rock. The somewhat turbid appearance of the carbonate and its strong double refraction, together with the lack of bubbling of the hand sample in reaction with dilute HCl, suggests that the carbonate may be siderite.

Sphalerite is present in minor amount, forming small grains and larger aggregates up to several millimetres in size scattered irregularly through the rock. Most of the grains and aggregates are quite ragged in shape, but locally some of the grains are oriented in the trace of the structure better defined by sericite.

Leucoxene occurs in trace amount as small turbid granules and aggregates sparsely and irregularly scattered through the rock.

Pyrite is present in trace amount as small cubic crystals, Some occur within the larger sphalerite aggregates, but some pyrite crystals are discretely sprinkled elsewhere through the rock.

Chalcopyrite occurs only as minute small grains concentrated in some of the sphalerite aggregates.

Zircon occurs as uncommon tiny terminated prismatic crystals that occur in some of the indistinct altered lithic fragment sites. They are inferred to represent primary crystals in dacitic lava.

INTERPRETATION :

This sample is considered to have formed as a primary fragmental deposit, originally composed of closely-packed lithic fragments of probable glassy volcanic origin. A tuffaceous origin is likely, and a bulk dacitic composition is possible.

The rock body suffered strong pervasive alteration and mild ductile deformation. This generated the foliated metamorphic assemblage of sericite + quartz + carbonate (?siderite) + minor sphalerite + trace pyrite + leucoxene. It remains possible that the volcanic deposit suffered alteration prior to the metamorphic event, but alteration is pervasive and complete which prevents the mineralogy and microtextures from being used to determine a paragenetic evolution.

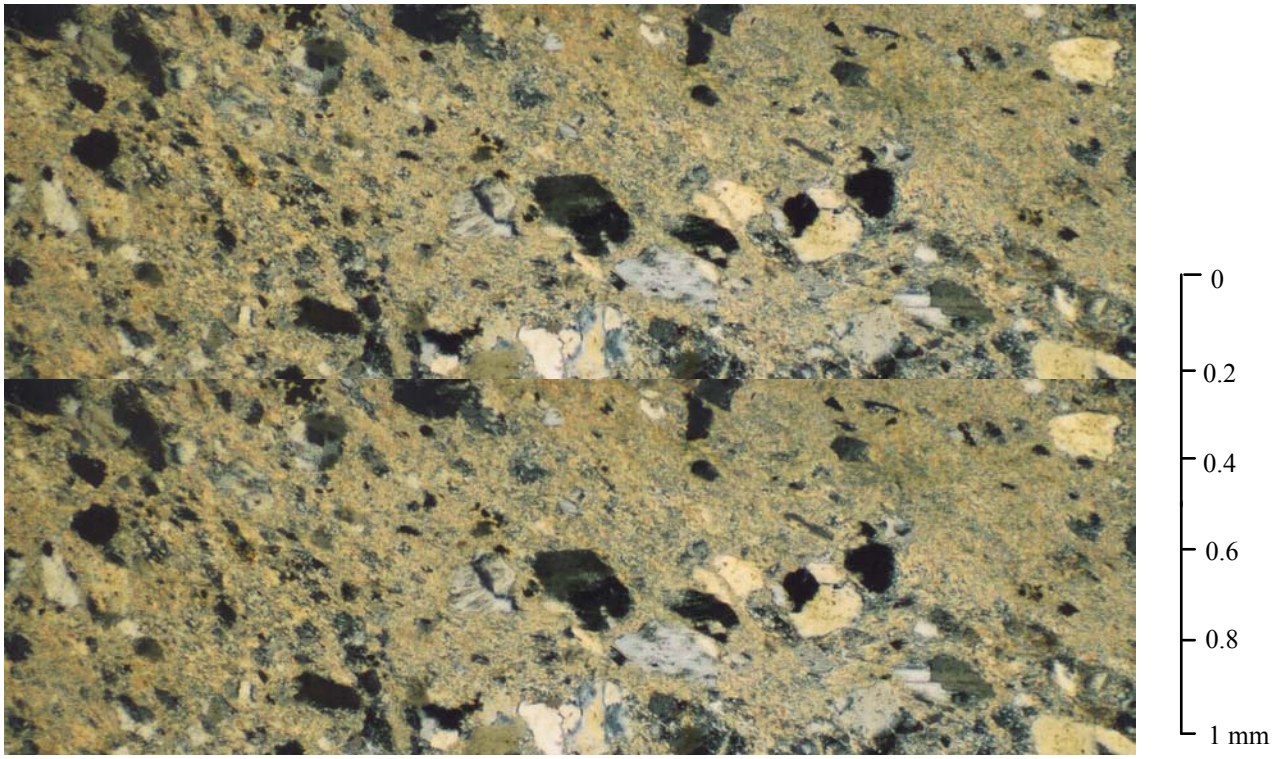


FIG. 5: SAMPLE NCT003, 495.9m (Photomicrograph, transmitted light, crossed polarisers with condenser, x5, Film 1 / Frame 3). This view illustrates the high intensity of alteration of this sample, with complete replacement of a precursor lithic ?fragment by granular quartz (lower right, mosaic of white to grey grains) in an altered matrix dominated by sericite (bright yellow colours, foliated in orientation NW-SE) with minor quartz (pale yellow to grey).

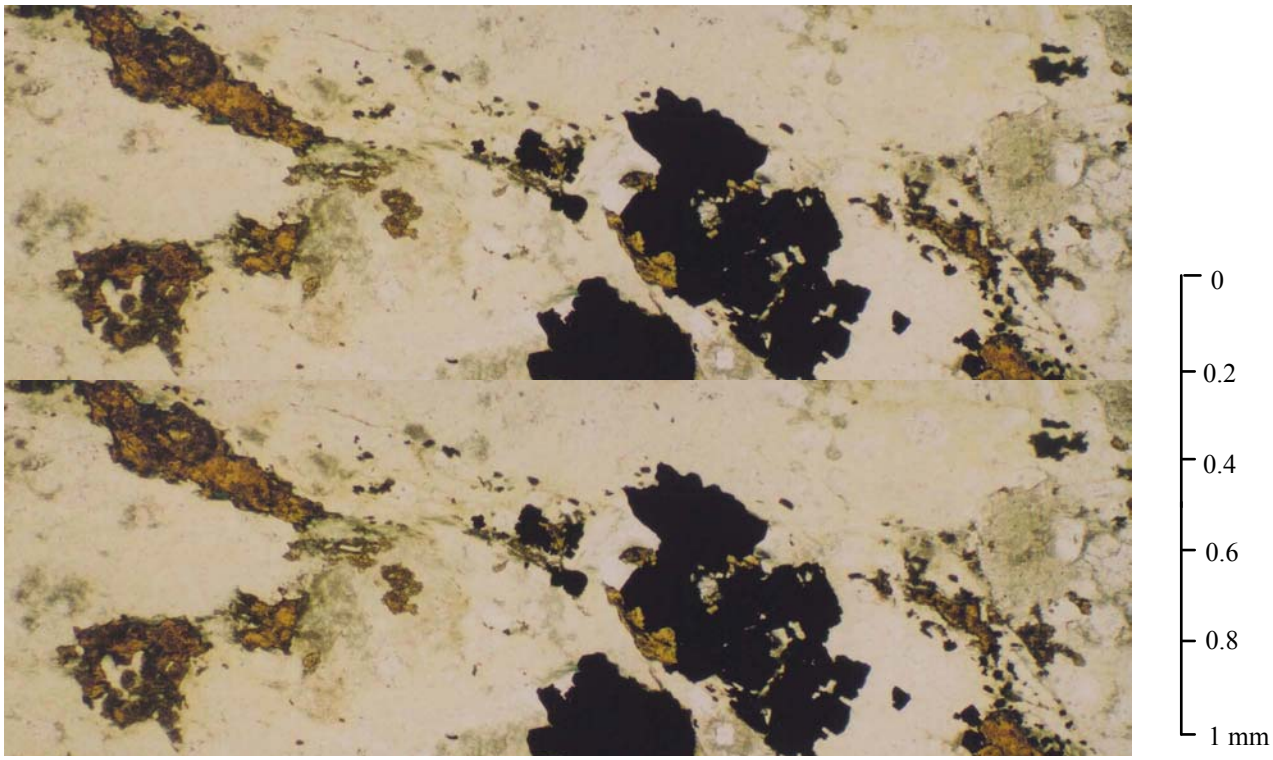


FIG. 6: SAMPLE NCT003, 495.9m (Photomicrograph, transmitted plane polarised light with condenser, x5, Film 1 / Frame 4). This view illustrates the occurrence of moderately abundant sphalerite (reddish brown ragged grains) with associated opaques (black, pyrite). Note the tendency of some of the sphalerite to be elongated in the trace of the metamorphic foliation (oriented NW-SE).

SAMPLE : NCT003, 528.8m (Mt Read Volcanics, Queenstown region, Tasmania)

SECTION NO : NCT003, 528.8m

HAND SPECIMEN : The drill core sample represents a drab pale yellowish grey rock in which paler patches on the scale of millimetres to centimetres are elongated in the trace of a structure (foliation) through the rock.

The sample effervesces strongly in small patches, suggesting calcite is present.

ROCK NAME : Foliated high-intensity quartz-sericite-carbonate altered meta-fragmental rock (lithic ?tuff)

PETROGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

Mineral	Vol %	Origin
Apatite	Tr	?Relict primary igneous crystals
Zircon	Tr	Primary igneous crystals
Quartz	54	Metamorphic alteration
Sericite	40	Metamorphic alteration
Carbonate (calcite)	4	Metamorphic alteration
Leucoxene (?anatase)	Tr	Metamorphic alteration
Opaques (?pyrite)	Tr	Metamorphic alteration

In thin section, this sample displays an indistinctly preserved fragmental texture, modified by deformation and strong pervasive alteration.

Quartz is abundant, forming small equant anhedral grains that are distributed throughout the rock as a fine-grained mosaic.

Sericite is the other principal phase. It forms small wispy flakes with strong preferred orientation that defines a foliation through the rock. The sericite tends to be concentrated in dense patches of variable size, some many millimetres long of lithic fragment origin (possibly ?fiammé).

Carbonate occurs in minor amount as small ragged grains and aggregates scattered irregularly through the rock. Their strong double refraction and effervescent reaction with dilute HCl in hand specimen suggests that most of the carbonate is calcite.

Leucoxene occurs in trace amount as turbid dark aggregates, some of which occur as small lath-like crystals (precursor ?ilmenite) in the elongated sericite-rich lithic fragments. Similarly, small stumpy apatite crystals and rare tiny terminated zircon crystals also occur in the sericite-rich lithic fragment sites, and these two phases appear to be of relict primary igneous origin.

A trace amount of opaques occurs as tiny equant crystals that are very sparsely scattered through the rock. It most likely is pyrite.

INTERPRETATION :

This sample is considered to have formed as a primary fragmental rock of probable tuffaceous origin. It most likely was composed mostly of felsic lava fragments, including some ?fiammé, in a fine comminuted matrix derived from the same acid volcanic source.

Low-grade regional metamorphism in the lower greenschist facies has affected the rock, generating the new foliated alteration assemblage of quartz + sericite + carbonate (calcite) + trace leucoxene + opaques (?pyrite).

Only two mineral parageneses can be distinguished in this rock: traces of relict primary igneous assemblage (ie trace apatite and zircon), and the principal foliated metamorphic assemblage. It remains possible that the rock suffered earlier pervasive hydrothermal alteration, but that assemblage cannot be distinguished from the metamorphic assemblage.

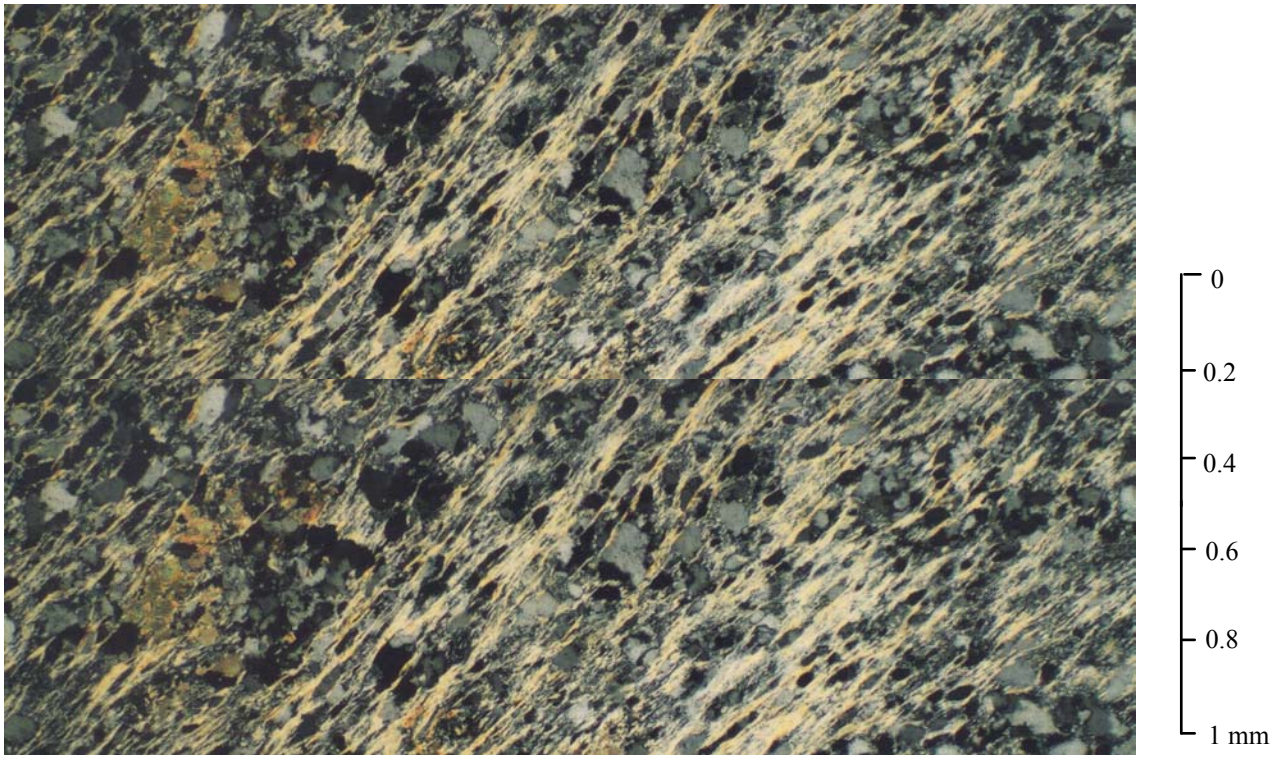


FIG. 7: SAMPLE NCT003, 528.8m (Photomicrograph, transmitted light, crossed polarisers with condenser, x5, Film 1 / Frame 6). This view illustrates the high intensity of alteration of this sample, with abundant foliated sericite (wispy yellow flakes and mats oriented NE-SW) and quartz (grey small grains in mosaics). Also note the presence of minor carbonate (ragged aggregates, bright pastel pink colours, centre bottom, upper left) which occurs in all samples in this suite

SAMPLE : NCT003, 606.1m (Mt Read Volcanics, Queenstown region, Tasmania)

SECTION NO : NCT003, 606.1m

HAND SPECIMEN : The drill core rock sample represents a drab pale yellowish grey rock in which indistinct fragmental texture is defined by paler white equant fragments ~1-2 cm in size and smaller angular to wispy dark green fragments ~1 cm long. One fragment is observed to contain a thin lamination, possibly of flow banding origin. Small white ragged grains and aggregates (carbonate) are sparsely scattered through the rock, mainly in matrix rather than in the indistinct lithic fragment sites.

The section offcut effervesces strongly in reaction with dilute HCl, suggesting calcite is present in moderate amount.

ROCK NAME : Foliated high-intensity quartz-sericite-carbonate altered meta-fragmental rock (lithic tuff)

PETROGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

Mineral	Vol %	Origin
Quartz	59	Metamorphic alteration
Sericite	30	Metamorphic alteration
Carbonate (calcite)	10	Metamorphic alteration
Leucoxene (?anatase)	Tr	Metamorphic alteration
Opaques (?pyrite)	Tr	Metamorphic alteration

In thin section, this sample displays a weakly preserved primary fragmental texture, modified by strong pervasive replacement.

Quartz is abundant, forming small equant anhedral grains that form a more-or-less equigranular mosaic throughout the rock.

Sericite is the other principal phase. It occurs as small flakes that tend to be concentrated in dense foliated wispy elongated patches that appear to represent elongated altered lithic fragments. Coincidence of the preferred orientation of the foliation in sericite and the elongation of the fragments suggests that both are attributable to a directed metamorphic stress regime. One fragment site displays a foliation which overprints a precursor thin structure (probably flow banding in a felsic lava fragment).

Carbonate occurs in moderate amount as ragged grains that form large spongy porphyroblastic grains and smaller granular aggregates. Its strong effervescence in reaction with dilute HCl in hand specimen supports identification as calcite.

Leucoxene is present in trace amount in different forms: some occurs as dense dark replacements of small precursor lath-like crystals (primary ?ilmenite) in the sericite-altered fragments, and some also occurs as fine aggregates in altered blocky crystal sites (primary ?magnetite).

Opaques occur in trace amount as small equant crystals of cubic morphology (probably pyrite), very sparsely scattered through the rock.

INTERPRETATION :

This sample is considered to have formed as a primary fragmental deposit composed of angular lithic fragments of probable felsic volcanic origin.

The rock suffered complete replacement, involving invasion by a significant volume of hydrothermal fluid in the presence of a directed regional stress regime. This generated the foliated assemblage of quartz + sericite + calcite + trace leucoxene (?anatase) + opaques (?pyrite). Only a single alteration paragenesis can be distinguished, although it remains possible that the rock had suffered low-grade alteration prior to the regional event.

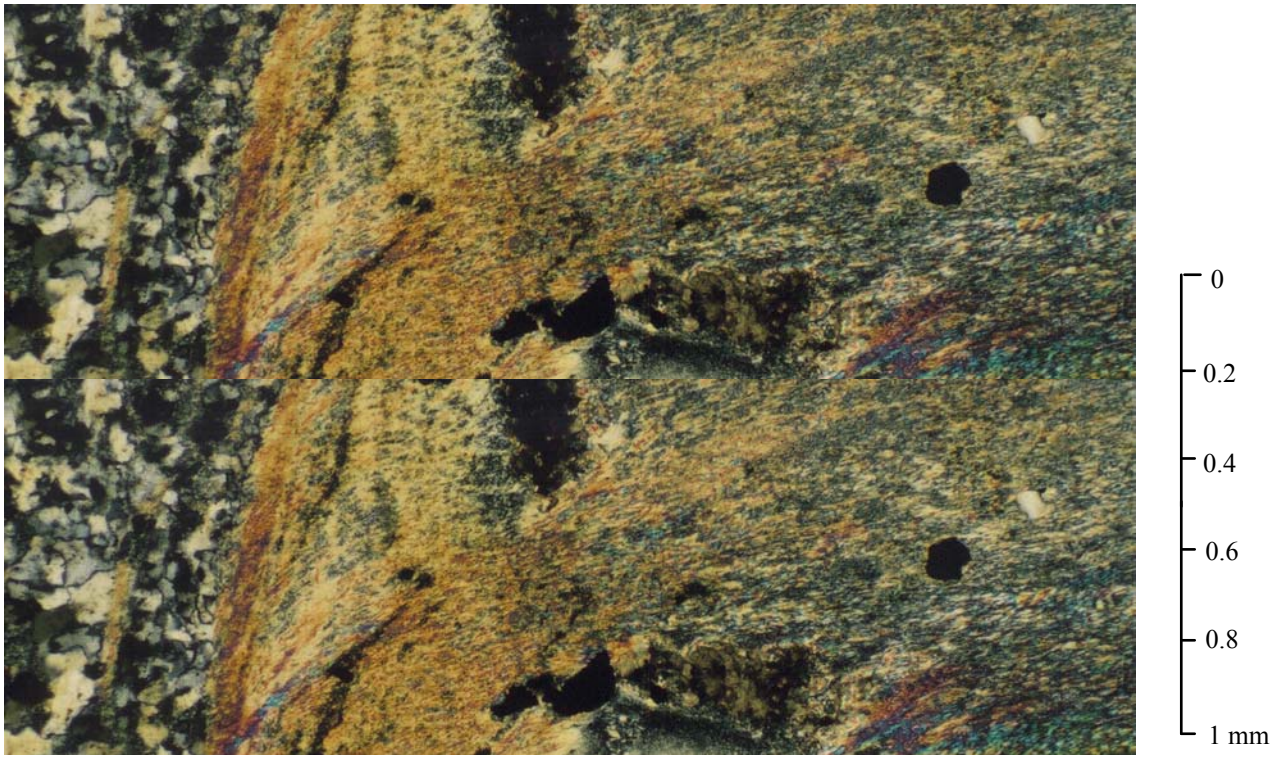


FIG. 8: SAMPLE NCT003, 606.1m (Photomicrograph, transmitted light, crossed polarisers with condenser, x5, Film 1 / Frame 7). This view captures the tapered end of a large sericite-altered lithic fragment (bright yellows, greens, reds) which most likely formed as a glassy volcanic fragment (possibly fiammé). Note the presence of small opaque crystals, now replaced by leucoxene: these may have formed as primary Fe-Ti oxide crystals, possibly ?ilmenite.

SAMPLE : NCT003, 733.9m (Mt Read Volcanics, Queenstown region, Tasmania)

SECTION NO : NCT003, 733.9m

HAND SPECIMEN : The drill core sample represents a fragmental rock in which small (millimetre-sized) pale pink altered feldspar crystals and green (chlorite-altered) lithic fragments are distributed more-or-less uniformly through a fine-grained pale grey matrix.

ROCK NAME : Foliated low- to medium-intensity albite-sericite-chlorite-hematite altered meta-fragmental rock (crystal-lithic tuff)

PETROGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

Mineral	Vol %	Origin
Plagioclase	5	Relict primary igneous crystals
Zircon	Tr	Primary igneous crystals
Sericite	45	Metamorphic alteration
Felsic mosaic (mainly albite)	40	Metamorphic alteration
Chlorite	5	Metamorphic alteration
Quartz	2	Metamorphic alteration
Carbonate (calcite)	2	Metamorphic alteration
Leucoxene	Tr	Metamorphic alteration
Opaques (sulphide)	Tr	Metamorphic alteration
Hematite	Tr	Metamorphic alteration

In thin section, this sample displays a partly-preserved primary fragmental texture, modified by metamorphic replacement and mild ductile deformation.

Feldspar occurs abundantly in two forms:

i) Most occurs as tiny equant anhedral grains that form a uniformly fine-grained felsic mosaic of recrystallisation origin. In places, the albitic mosaic is concentrated in indistinct angular patches that are enwrapped by foliation: these appear to represent primary felsic volcanic fragments.

ii) Some feldspar occurs as well-shaped prismatic crystals ~0.4-1.5 mm in size. They display their primary twinning and indistinct normal compositional zoning, both features of primary igneous origin. Some crystals display mild deformation and local partial recrystallisation to finer-grained sutured mosaics. In places, the crystals are concentrated into glomerocrystic aggregates. All are inferred to represent crystals and crystal fragments of primary igneous origin, liberated in a crystal-lithic tuffaceous deposit.

Sericite is abundant, forming small flakes whose preferred orientation defines a moderately strong foliation through the rock. The sericite tends to be concentrated in subparallel tiny wisps and denser aligned elongate patches, some of which possibly represent severely altered lithic fragments. The sericite wisps wrap around the relatively well-preserved plagioclase crystals.

Chlorite is present in moderate amount as small pleochroic green flakes that are sprinkled throughout the rock, with a preferred orientation in the trace of the foliation. Some chlorite also occurs more densely concentrated in altered lithic fragment sites where it tends to be intergrown with quartz, and a trace amount also forms small replacement flakes in some of the plagioclase crystals.

Carbonate occurs in minor amount as small to larger ragged grains in small aggregates. Some occur as replacements in the plagioclase crystals. The strong effervescence in hand specimen in reaction with dilute HCl supports identification as calcite.

Leucoxene is present in trace amount as turbid microcrystalline replacements of precursor small blocky to elongate crystals (primary ?Fe-Ti oxide crystals). Rare tiny terminated zircon crystals with growth zoning occur in close association with the altered Fe-Ti oxide crystals.

Opaques occur in trace amount as small cubic crystals (probably ?pyrite) and small ragged grains (?chalcopyrite).

Hematite occurs in trace amount as minute dark red specks that are sprinkled in loose clouds through the plagioclase crystals, and also occur locally in the albitic matrix.

INTERPRETATION :

This sample is considered to have formed as a primary crystal-lithic tuffaceous deposit, originally composed of angular felsic lithic fragments (?dacitic lava) and crystal fragments (plagioclase >> Fe-Ti oxide >> zircon) in fine felsic matrix derived from the same felsic volcanic source. A dacitic bulk composition is considered likely. The crystal and lithic fragments appear to have been somewhat smaller than in other samples, possibly suggesting that the primary fragments had suffered some degree of sorting prior to deposition.

The rock has suffered partial modification in response to a low-grade regional metamorphic event in the lower greenschist facies. This generated the new replacement assemblage of albite + sericite + minor chlorite + calcite + trace leucoxene + opaques (?sulphides) + hematite. A directed stress regime acted during this event, producing the foliation defined by aligned sericite and chlorite, with wrapping of sericite wisps around the plagioclase crystals.

It is noted that the primary plagioclase crystals are relatively well preserved: their primary twinning and compositional zoning is preserved, but some crystals display mild deformational and alteration effects. The relatively good preservation of the plagioclase suggests that the rock has suffered only one alteration event (ie the regional metamorphic event), with little or no precursor alteration which would have more severely affected the plagioclase crystals.

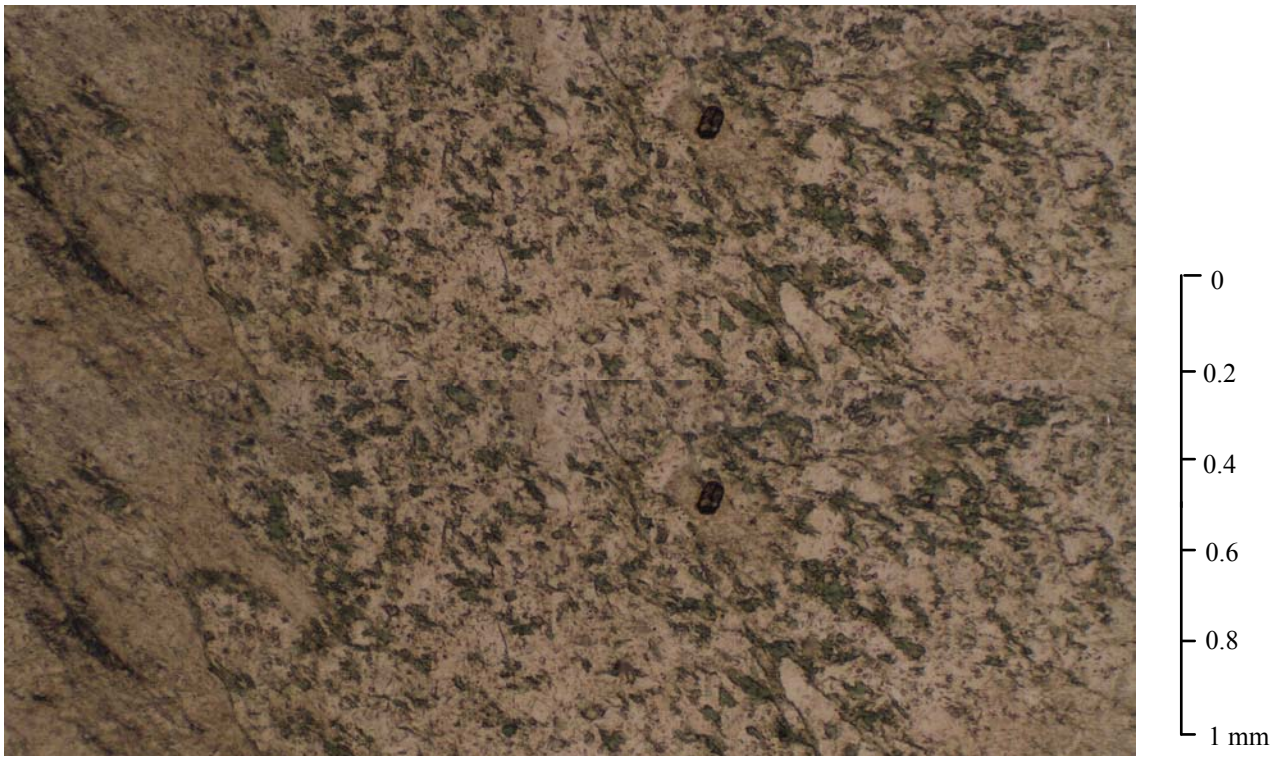


FIG. 9: SAMPLE NCT003, 733.9m (Photomicrograph, transmitted plane polarised light, x5, Film 1 / Frame 8). This view captures part of an altered lithic fragment, now composed of small chlorite flakes (green) in a fine felsic mosaic (mainly albite). Note the presence of a single small stumpy zircon crystal (dark, turbid, toward top right). The lithic fragment most probably formed as a felsic lava.

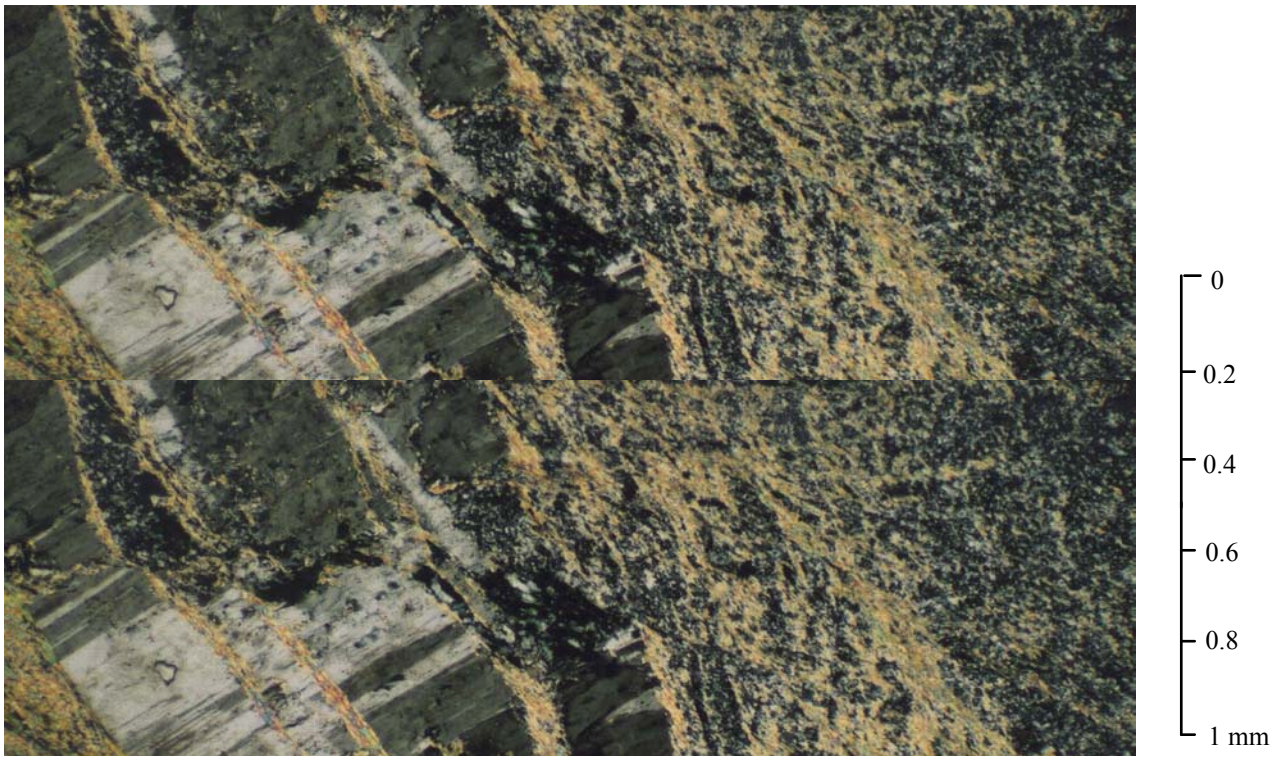


FIG. 10: SAMPLE NCT003, 733.9m (Photomicrograph, transmitted light, crossed polarisers with condenser, x5, Film 1 / Frame 12). This view captures a single large plagioclase crystal (twinned, pale to medium grey) of relict primary origin. Note that it has been cut by thin filaments of sericite (bright yellow colours) aligned in the trace of a moderately strong foliation (oriented NW-SE).