APPENDIX III:

EL 2505, 2506 & 2516

MASON GEOSCIENCE PTY. LTD.

PETROGRAPHIC REPORTS

#2251, 2259, 2270, 2282.

Mason Geoscience Pty Ltd: Drill Sample Listings

SAM #	LOCATION	HOLE	EAST	NORTH	EL	UNIT	LITHOLOGY	cf in this report
77708	Caramal	CA40 @ 60.0m	321341	8617596	2505	Phk1	sl.chl. sst sr limonitic fracture weak gamma 90cps	fig 2
77709	Caramal	CA40 @ 150.3m	321341	8617596	2505	Pxm2	cg albitised and silicified well banded meta arkose	fig 2
77710	Caramal	CA40 @ 156.2m	321341	8617596	2505	Pxm2	fg pale green (Mg chl?) well banded meta-arkose	fig 2
77711	Caramal	CA40 @ 205.9m	321341	8617596	2505	Pxm2	cg silic (quartzitic) biotite gneiss, mod gamma (Th) 90 cps	fig 2
77716	Caramal	CA46 @ 64.9m	321459	8617732	2505	Pxm2	Illite-rock	fig 2
77717	Caramal	CA47 @ 40.5m	321261	8617712	2505	Pxm2	Meta Arkose with hem and big ovoid qz-mica patches	fig 2
77718	Caramal	CA47 @ 50.5m	321261	8617712	2505	Pxm2	Fgr MA, clay spots, chlorite blebs	fig 2
77719	Caramal	CA47 @ 78.6m	321261	8617712	2505	Pxm2	mgr lime green altd MA with hematite patches	fig 2
77720	Caramal	CA47 @ 98.2m	321261	8617712	2505	Pxm2	cgr pink olive green rock	fig 2
77721	Caramal	CA47 @ 119.4m	321261	8617712	2505	Pxm2	grey pink Kqz with spotted clays	fig 2
77722	Caramal	CA47 @ 126.7m	321261	8617712	2505	Pxm2	wk chl alteree wavy irregularly foliated Kqz	fig 2
77723	Caramal	CA47 @ 153.2m	321261	8617712	2505	Pxm2	alterd MA, with ovoid qz-mica pathces H along clevage	fig 2
77724	Caramal	CA47 @ 162.1m	321261	8617712	2505	Pxm2	cgr MA, purple color, lite green clay/chlorite spots	fig 2
77725	Caramal	CA47 @ 173.3m	321261	8617712	2505	Pxm2	mgr Kqz with albitisation and clay spots	fig 2
77726	Caramal	CA47 @ 174.1m	321261	8617712	2505	Pxm2	well foliated Kqz	fig 2
77727	Caramal	CA47 @ 175.1m	321261	8617712	2505	Pxm2	hematite altered schist? well foliated, discontinuous frags	fig 2
77730	Caramal	CA41 @ 106.5m	321529	8617605	2505	Pxm2	altered chlorite schist, 135cps Mt.Sopris	fig 2

SAM #	LOCATION	HOLE	EAST	NORTH	EL	UNIT	LITHOLOGY	cf in this report
77732	Caramal	CA41 @ 116.0m	321529	8617605	2505	Pxm2	altered chlorite schist, 135-175cps Mt.Sopris	fig 2
77733	Caramal	CA41 @ 117.0m	321529	8617605	2505	Pxm2	altered chlorite schist, 240cps Mt.Sopris	fig 2
77734	Caramal	CA42 @ 142.5m	321551	8617566	2505	Pxm2	altered chlorite schist, 90cps auslog	fig 2
77735	Caramal	CA42 @ 151.3m	321551	8617566	2505	Pxm2	altered chlorite schist, 250cps Auslog	fig 2
79389	Caramal	CA36 @ 100.9m	321281	8617598	2505	Pxm2	sr hem-illitised nodular frags	fig 2
79390	Caramal	CA33 @ 72.2m	321428	8617583	2505	Pxm2	sr hem-illitised frags with flow textures	fig 2
79391	Caramal	CA33 @ 81.5m	321428	8617583	2505	Pxm2	Silicified nodular frags with strong hem-illite	fig 2
79392	Caramal	CA33 @ 81.9m	321428	8617583	2505	Pxm2	As above with illitised frags and chlorite layers	fig 2
79393	Caramal	CA28 @ 55.3m	321167	8617549	2505	Pxm2	sr hem-illitised frags with elongated nodules	fig 2

Mason Geoscience Pty Ltd Reports: Grab Samples Listings

SAM #	LOCATION	EAST	NORTH	EL	UNIT	LITHOLOGY	cf in this report
77702	South Horn	320925	8611175	2506	Pdo	red-orange clay over alt granophyre	plate 2
77712	South Horn	320475	8610370	2506	Pdo	c.g k-fels granophyre	plate 2
77713	South Horn	320525	8611060	2506	Pdo	m.g. intermediate differentiation of granophyre	plate 2
77714	South Horn	320575	8610950	2506	Pdo	m.g.-c.g. well jointed igneous rock	plate 2
77715	South Horn	320550	8610930	2506	Pdo	f.g. mafic igneous rock with felds xenocrysts	plate 2
79380	Gurrigarri	309128	8625515	2516	Pdz	Alt amphibolite? banded feldspathic schist	plate 7
79382	Gurrigarri	309117	8625522	2516	Pdz	Silicified rock adjacent to alt amphibolite	plate 7
79384	Gurrigarri	309053	8625667	2516	Pdz	Alt amphibolite?	plate 7
79387	North Horn	324105	8617321	2505	Pdo	Chlorite quartz hematite fine grained rock	plate 7
79388	North Horn	324105	8617521	2505	Pxnm	Felsic gneiss flow crenulations, up to 1500cps	plate 7
79394	N. Caramal	320360	8618800	2505	Pgt	Sheared brecciated Tin Camp Crk Granite	plate 7
79395	South Horn	321000	8611450	2506	Pdo	Ferruginous mg granophyre	plate 2
79396	South Horn	320600	8611010	2506	Phk	mg lim qtz sst, hotspot to 7500cps	plate 2
79397	South Horn	320670	8611050	2506	Pxnm	f-mg q-f-bio-(hbl?) gneiss	plate 2
79398	South Horn	320725	8611100	2506	Pxnm	cg migmatised q-f-bio(hbl?) gneiss	plate 2
79399	South Horn	321000	8611250	2506	Pkk?	mg q-rich kaol-ser hem meta-arkosic rock	plate 2
79400	South Horn	320950	8611150	2506	Pdo	lim and hem clay over alt(?) granophyre, hot qv	plate 2

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Mason Geoscience Pty. Ltd.

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REPORT TITLE	**Petrographic Descriptions for a Suite of Twelve Rock Samples, Northern Territory**
REPORT #	2251
CLIENT	Queensland Mines Ltd.
ORDER NO.	21168
CONTACT	Mr. John Thevissen
REPORT BY	Dr Douglas R. Mason
SIGNED	 for Mason Geoscience Pty. Ltd.
DATE	23 October 1996

Petrographic Descriptions for a Suite of Twelve Rock Samples, Northern Territory

SUMMARY

1. Rock Samples

- A suite of twelve (12) rock samples has been studied using petrographic and limited X-ray diffraction methods.

2. Brief Results

- Rock names and mineralogy are summarised in Table 1.

- Medium-grade regional metamorphic rocks dominate the suite. They were composed of foliated granoblastic assemblages of feldspar, muscovite, biotite and minor garnet and apatite. Bulk compositions were broadly pelitic and quartzo-feldspathic. Relict particulate sandy textures in some samples indicate a clastic sedimentary precursor.

- Micro-graphic granite is represented by one sample (79395). It was composed of feldspar, quartz, ferromagnesian grains, and accessory ?monazite.

- Retrogressive alteration is observed in the suite:

  - Some metamorphic rocks retain elements of their primary microtexture, and some of their primary metamorphic minerals. Alteration minerals are mainly sericite, chlorite, and quartz.

  - Some rocks display a massive hydrothermal alteration texture, suggestive of complete replacement of the precursor rocks. Sample 79382 is composed of a massive assemblage of quartz + biotite + chlorite + trace rutile, and sample 79387 is composed of quartz + muscovite + biotite.

  - Lensoidal aggregates and small patches of fine-grained, soft, pale cream to white phyllosilicate mineral have formed in some samples (79389, -391, -392, -393). X-ray diffraction studies confirm that the soft phyllosilicate is a white mica (muscovite-3T, unstable 3T structure). It is not a genuine clay mineral. The cream patches may have formed as replacement patches (probably after a single mineral phase), or as fillings of solution cavities: their abundance and shape suggest the former, but no precursor crystal forms or relict kernels are preserved to aid identification of the precursor mineral. The cream patches are unlikely to represent altered lithic fragments because they are compositionally homogeneous and they lack any precursor minerals or textures which would have been generated during initial metamorphism. The presence of the cream phyllosilicate patches therefore cannot be used as evidence of a "fragmental" primary texture.

  - Weathering has affected some rocks, generating very fine-grained diffuse patches of iron oxide. In places weathering effects are difficult to distinguish from retrogressive alteration effects.

TABLE 1: SUMMARY OF ROCK NAMES AND MINERALOGY

SAMPLE	ROCK NAME	MINERALOGY*		
		Primary**	Alteration	Weathering
79380	Weathered quartzo-feldspathic mica schist	Qtz,tou	?Ser	Cla,goe,leu,opq
79382	Weathered quartz-biotite hydrothermal rock	-	Qtz,bio,chl,rut	Goe
79384	Chlorite-altered mica schist	Bio,apa,rut,mon	Chlc,ser,chlg,opq	-
79387	Weathered quartz-mica hydrothermal rock	-	Qtz,mus,bio	Goe
79388	Muscovite-biotite-garnet quartzo-feldspathic gneiss	Qtz,Kf,pla,mus,bio,gar	-	-
79389	Weathered, altered medium-grained metamorphic rock (?semi-pelite)	Apa,mon	?Ser	Hem
79390	Retrogressively altered mica schist	Qtz,mus,tou,rut,bio	Ser,opq(?hem)	-
79391	Weathered, retrogressively altered meta-clastic sedimentary rock	Qtz,zir; Qtz,apa	Ser,chlg,?hem	?Hem,goe
79392	Retrogressively altered quartz-mica schist	Qtz	Qtz,ser,chlg,?hem	?Hem,goe
79393	?Weathered, retrogressively altered mica schist	Qtz,tou,apa	Ser,?hem	?Hem,goe
79394	Retrogressively altered quartzo-feldspathic mica schist	Qtz,mus,bio	Ser	?Cla,hem
79395	Weathered micro-graphic granite	Qtz,Kf,?mon	-	Cla,hem,leu

NOTES:
*: Minerals are listed in each paragenesis in approximate order of decreasing abundance.
**: Only primary minerals now present are listed. Others may have been present, but have been destroyed by subsequent events.

Mineral abbreviations: Apa = apatite; bio = biotite; chlc = chlorite (colourless, Mg-rich); chlg = chlorite (green, Fe-rich); cla = undifferentiated clays (illite, smectite); gar = garnet; goe = goethite (hydrated iron oxide); hem = hematite; Kf = K-feldspar; leu = leucoxene (TiO_2 polymorph, possibly anatase); mon = monazite; mus = muscovite; opq = undifferentiated opaques; pla = plagioclase; qtz = quartz; rut = rutile; ser = sericite; tou = tourmaline; zir = zircon; ? = uncertain paragenesis.

1. INTRODUCTION

A suite of twelve (12) surface rock samples was received from Mr. John Thevissen (Queensland Mines Ltd., Darwin, Northern Territory) on 30 September 1996.

Particular requests were:

i) To prepare a standard thin section and routine petrographic description for each sample.

ii) To provide colour photomicrographs at discretion.

The summary of this report was provided by facsimile to the Darwin office of Queensland Mines on 23 October 1996. This report provides the full results of this work.

2. METHODS

The samples were examined in hand specimen and marked for section preparation. Standard thin sections were obtained from an external commercial laboratory (Pontifex & Associates Pty. Ltd., Rose Park, South Australia).

At Mason Geoscience Pty. Ltd., conventional transmitted light microscopy was used to prepare routine petrographic descriptions. A limited number of colour photomicrographs was selected to represent specific mineralogical and microtextural features. These are provided in Appendix 1.

Petrographic work indicated that very fine-grained colourless phyllosilicate minerals were present in some samples. For positive identification, one sample was selected for mineral identification by X-ray diffraction methods. The sample selected was 79392: mineral identifications were obtained separately for the cream patches and the dark mauvish grey matrix which characterise the sample. The results are given in Appendix 2, and are also integrated with the petrographic description.

3. PETROGRAPHIC DESCRIPTIONS

The petrographic descriptions are provided in the following pages.

SAMPLE : 79380 Corrigarry amph ?

SECTION NO. : 79380

HAND SPECIMEN : The surface rock sample represents a medium-grained, compositionally uniform schist composed of aligned ferruginised brownish material and tiny white altered feldspar grains.

ROCK NAME : **Weathered quartzo-feldspathic mica schist**

PETROGRAPHY :

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

Mineral	**Vol.%**	**Origin**
Quartz	20	Metamorphic
Tourmaline	Tr	Metamorphic (inclus. in quartz)
Phyllosilicate (incl. ?illite, ?sericite)	50	Alteration (?weathering, after ?plag.)
Hydrated iron oxides (goethite)	25	Alteration (weathering)
Leucoxene	Tr	Alteration (?weathering)
Opaques	Tr	Alteration (?weathering)

In thin section, this sample displays a foliated granoblastic metamorphic texture, modified by moderately severe pervasive alteration.

Quartz is moderately abundant, occurring as anhedral grains ~0.2-0.4 mm distributed more-or-less uniformly throughout the rock. In places they are weakly elongated within the trace of the foliation

Tourmaline is the only other relict primary mineral. It occurs as tiny equant prisms, <0.1 mm in size, located entirely within quartz grains. They have been preserved at least in part because of their isolation from alteration fluids.

Phyllosilicate material occurs abundantly as tiny, randomly oriented flecks that are concentrated in anhedral grain sites ~0.2-0.4 mm in size. The precursor grains (probably feldspar/s) were oriented weakly within the trace of the foliation. Much of the phyllosilicate is colourless and displays low-order birefringence (up to yellow-red of first order), and may therefore be illite or possibly sericite (i.e. a white mica). In many of the phyllosilicate patches, a turbid darker yellowish appearance may be attributable to further alteration (possibly clays, such as smectite).

Hydrated iron oxide (goethite) occurs as cryptocrystalline turbid dark reddish brown materials that are concentrated in poorly-defined grains which retain a strong cleavage. They most likely were micas, probably biotite, and their alignment defined a moderately strong metamorphic foliation.

Leucoxene occurs in trace amount as cryptocrystalline turbid dense aggregates, very sparsely scattered through the rock, that have replaced precursor Ti-rich grains (possibly rutile or ilmenite).

Opaques occur in trace amount as small dense aggregates that tend to be concentrated along discordant thin fractures. It may be a Mn oxide phase.

INTERPRETATION:

This sample represents a foliated granoblastic metamorphic rock which most likely was composed of feldspar, quartz, biotite, and accessory Ti-phase and tourmaline. It was broadly of quartzo-feldspathic to semi-pelitic bulk composition.

Moderately severe alteration has affected the rock. Some phyllosilicate alteration of ?feldspar may have occurred prior to weathering, in response to a retrogressive alteration event. Some may be attributed to weathering, which generated turbid ?smectite clay after white mica and goethite after ?biotite. A trace amount of opaques (possibly an Mn oxide phase) formed along thin discordant fractures.

SAMPLE : 79382 Gerr garry "chert"

SECTION NO. : 79382

HAND SPECIMEN : The surface rock sample is composed mostly of very fine-grained translucent grey siliceous material. Indistinct thin paler cream veinlets cut the rock. Scattered though the rock are small dark green to black angular patches. Under the hand lens, angular patches of very fine orange material are also disseminated as very small ragged patches throughout the rock.

ROCK NAME : **Weathered quartz-biotite hydrothermal rock**

PETROGRAPHY :

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

Mineral	**Vol.%**	**Origin**
Quartz	85	Hydrothermal alteration / vein filling
Biotite (brown to green, incl. tr. chlor.)	10	Hydrothermal alteration
Rutile	Tr	Hydrothermal alteration / vein filling
Opaques	Tr	Hydrothermal alteration
Hydrated iron oxide (goethite)	5	Alteration (weathering)

In thin section, this sample displays a massive microgranular texture of probable hydrothermal alteration origin, modified slightly by selective pervasive alteration of weathering origin.

Quartz dominates the rock. Most occurs as small anhedral grains ~0.05-0.2 mm in size, forming a massive sutured granular mosaic throughout the rock. In places, the grains are larger and subhedral to bladed in shape, forming coarser-grained patches of irregular size and shape. A small amount of quartz is concentrated in poorly-defined veins.

Biotite is moderately abundant. It occurs mostly as tiny ragged grains irregularly scattered throughout the rock, and larger angular monominerallic massive aggregates up to several millimetres in size. Pleochroism varies from orange-brown to deep green. The presence of bright interference colours strongly suggests that the phase is biotite, and not chlorite. However, there are some limited areas where the phyllosilicate displays low-order interference colours, suggesting that incipient replacement of biotite by chlorite has locally occurred.

Rutile is uncommon, forming small angular grains and small aggregates. Some occurs disseminated through the rock, and some also occurs within the quartz-rich, biotite-poor indistinct veins that cut the rock.

Goethite occurs in small amount as turbid dark brownish patches, in places concentrated in biotite-rich patches.

INTERPRETATION:

This sample formed as a massive rock composed of fine-grained quartz + biotite + accessory rutile. The mineralogy and texture are suggestive of a hydrothermal alteration origin. There is some suggestion that the precursor rock was fragmental in texture, being composed of angular fragments several millimetres in size, but all primary mineralogy of the precursor has been destroyed by the alteration process.

Subsequent mild weathering has generated turbid brown patches of goethite in some areas of the rock.

SAMPLE : 79384

SECTION NO. : 79384

HAND SPECIMEN : The surface rock sample is uniformly fine-grained, dark greenish grey, and strongly schistose.

ROCK NAME : **Chlorite-altered mica schist**

PETROGRAPHY :

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

Mineral	Vol.%	Origin
Biotite	Tr	Relict metamorphic
Monazite	Tr	Relict metamorphic
Apatite	Tr	?Relict metamorphic
Rutile	<1	?Relict metamorphic
Chlorite (colourless)	60	Alteration / vein filling
Sericite	20	Alteration
Chlorite (green)	10	Alteration (after biotite)
Opaques (incl. hematite)	8	Alteration

In thin section, this sample displays a relict strongly foliated metamorphic texture, modified by strong pervasive alteration.

Large biotite flakes ~0.4 mm long were distributed more-or-less uniformly throughout the rock, and their strong preferred orientation defined a strong foliation. Most have suffered replacement by bright green chlorite with typical pleochroism and drab anomalous grey interference colours, but some flakes retain drab brown pleochroism and brighter interference colours confirming the biotite precursor.

Other primary metamorphic minerals are preserved in minor amount. Rutile occurs as small subrounded deep yellow grains, aligned in the trace of the foliation. Apatite occurs as anhedral equant clear grains, commonly in small groups also aligned within the trace of the foliation. Monazite occurs as small equant to subrounded disseminated grains with typical high relief and very high birefringence.

Colourless chlorite is abundant, mostly occurring as fine flakes aligned within the trace of the foliation. The lack of colour and appropriate low anomalous grey interference colours are suggestive of an Mg-rich composition. The strong foliation of the colourless chlorite suggests it formed by replacement of precursor foliated phyllosilicate flakes (?biotite, ?muscovite). A small amount of colourless chlorite occurs as fillings in thin, tortuous (i.e. non-planar) veins that cut the rock.

Sericite is present in significant amount, forming fine-grained randomly-oriented ragged flakes concentrated in small aggregates scattered through the rock.

Opaques form tiny ragged grains and small but dense fine-grained aggregates, commonly aligned within the trace of the foliation. Local discordant discontinuous indistinct veins are filled by opaques. In places, thin edges of grains display deep blood red colour in transmitted light, suggesting that hematite may be the dominant opaque phase.

INTERPRETATION:

This sample represents a strongly foliated mica schist. It has suffered strong pervasive hydrothermal alteration, generating the alteration assemblage of chlorite (colourless) + sericite + chlorite (green) + opaques (?hematite).

Relict metamorphic phases are preserved in small amount, including brown biotite, and accessory apatite, rutile, and monazite. The precursor rock is inferred to have been a mica schist of broadly pelitic bulk composition.

SAMPLE : 79387 N Harr.

SECTION NO. : 79387

HAND SPECIMEN : The surface rock sample is uniformly fine-grained and massive, with abundant tiny lustrous mica flecks. Weathering has generated a pervasive reddish brown discolouration which is more abundant near active weathering surfaces, but also occur as disseminated small reddish patches.

ROCK NAME : **Weathered quartz-mica hydrothermal rock**

PETROGRAPHY :

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

Mineral	**Vol.%**	**Origin**
Quartz	55	Alteration
Muscovite	35	Alteration
Biotite (incl. tr. green chlorite)	10-Tr	Alteration (incl. tr. weathering)
Goethite	Tr-10	Alteration (after biotite, weathering)

In thin section, this sample displays a massive poikiloblastic hydrothermal texture, modified by selective pervasive oxidation attributed to weathering.

Quartz is abundant, occurring as anhedral grains ~0.2-0.4 mm in size, and larger poikiloblastic plates up to ~3 mm in size.

Muscovite is moderately abundant. It forms randomly oriented small colourless flakes which tend to be concentrated in subradiating aggregates ~0.4 mm in size. The muscovite is distributed more-or-less uniformly through the rock.

Biotite forms ragged flakes ~0.2-1.0 mm in size, pleochroic in drab browns. Most flakes have suffered incipient oxidation, and in parts of the rock the biotite is completely replaced by turbid dark cryptocrystalline hydrated iron oxide (goethite). The biotite is intergrown with muscovite, and is similarly distributed throughout the rock. A trace of green chlorite occurs as partial replacements of some biotite flakes.

INTERPRETATION:

The mineralogy (quartz >> muscovite > biotite) and massive texture suggest the rock formed by intense hydrothermal alteration. No minerals or textures have been preserved from the precursor rock.

SAMPLE : 79388

SECTION NO. : 79388

HAND SPECIMEN : The surface rock sample represents a medium-grained, crystalline, felsic rock with sparsely scattered small dark mica flakes. In the sawn section, a heterogeneous texture of possible fragmental origin is preserved, with cm-sized angular white crystalline fragments in a slightly more mafic crystalline matrix.

ROCK NAME : **Muscovite-biotite(-garnet) quartzo-feldspathic gneiss**

PETROGRAPHY :

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

Mineral	**Vol.%**	**Origin**
Quartz	40	Metamorphic
K-feldspar (orthoclase)	35	Metamorphic
Plagioclase	20	Metamorphic
Muscovite	2	Metamorphic
Biotite	2	Metamorphic
Garnet	<1	Metamorphic

In thin section, this sample displays a granoblastic metamorphic texture, with somewhat irregular mineral distribution.

Quartz is abundant, occurring as anhedral equant grains ~0.5-1.0 mm in size, and larger ragged patches up to ~2 mm in size. Most grains display mild shadowy strain extinction.

K-feldspar (orthoclase) forms anhedral ragged grains similar in size to quartz, but in places builds larger poikiloblastic grains up to ~6 mm in size. Most grains are clear, but some display incipient alteration in the form of diffuse submicroscopic dark specks (?hematite).

Plagioclase builds anhedral equant grains mostly ~0.4-0.6 mm in size. They display limited twinning, and most have suffered incipient turbid brownish alteration to very fine phyllosilicate flecks (?illite, ?sericite). Grain margins with quartz and K-feldspar are quite irregular.

Muscovite builds large, well-crystallised flakes up to ~2 mm long. They are irregularly scattered through the rock, and may poikiloblastically enclose smaller quartz grains.

Biotite is present as well-crystallised flakes ~0.2-0.6 mm long. They are pleochroic in dark browns to pale straw colours, but may display incipient oxidation.

Garnet (almandine) forms small equant but anhedral grains ~0.2-0.4 mm in sizes, sparsely and irregularly scattered through the rock. They may occur within feldspar or quartz.

INTERPRETATION:

This sample represents a quartzo-feldspathic precursor rock that has suffered complete recrystallisation under medium-grade regional metamorphic conditions. This generated the observed granoblastic metamorphic assemblage of quartz > K-feldspar > plagioclase >> muscovite = biotite > garnet.

No primary minerals of the precursor rock have been preserved. However, the apparent coarse fragmental texture observed in hand specimen suggests that the precursor may have been a coarse quartzo-feldspathic clastic sedimentary rock such as an arkose.

SAMPLE : 79389 CA 26 - 122.87m

SECTION NO. : 79389

HAND SPECIMEN : The drill core rock sample is composed of small (mm-sized), pale yellowish cream, moderately abundant, angular pelletal patches that are closely packed in a fine-grained mauve-grey matrix. The rock is soapy to the touch.

ROCK NAME : **Weathered, altered medium-grained metamorphic rock (?semi-pelite)**

PETROGRAPHY :

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

Mineral	Vol.%	Origin
Apatite	Tr	Metamorphic
Monazite	Tr	Metamorphic
Muscovite/sericite	20	Alteration / ?relict metamorphic
Phyllosilicate (colourless, ?sericite)	70	Alteration
Iron oxides (?hematite)	6	Alteration (?weathering)
Leucoxene	<1	Alteration

In thin section, this sample displays a relict foliated metamorphic texture that has suffered severe modification by selective replacement in large ragged patches.

Much of the rock is composed of colourless phyllosilicate materials, which occur in two sites:

i) Most occurs as very fine-grained massive aggregates which have completely replaced or filled large ragged patches that range up to several mm in size. The fine grain size, massive nature, and soapy feel in hand specimen suggest that the phyllosilicate is a clay, but the first-order birefringence (yellow-reds) is consistent with a fine-grained white mica (e.g. sericite; note positive identification by XRD of identical material in sample 79392a as the unstable muscovite-3T).

ii) A significant amount occurs as better-formed flakes in a foliated to massive matrix that encloses the larger ragged aggregates of i) above. This phyllosilicate displays first-order interference colours, suggestive of a white mica composition. At least some of this white mica appears to have suffered partial replacement by cryptocrystalline colourless phyllosilicate similar to that which occurs within the large ragged alteration patches.

Iron oxides (probably hematite) occur in moderate amount as very fine-grained, dense aggregates, patches and trails whose alignment appears to mimic a precursor foliation in the sericitic matrix. The deep dark reddish brown colour suggests the iron oxide is hematite.

Apatite occurs in trace amount as large, equant, well-crystallised grains up to ~0.5 mm in size. They are sparsely and irregularly scattered through the rock, occurring only within the sericitic matrix and not within the dense cryptocrystalline sericite aggregates. Some of the apatite grains have suffered partial replacement by iron oxide around margins, confirming the earlier paragenesis of the apatite.

Monazite forms accessory small equant to subrounded grains <0.2 mm in size. They too occur only in the sericitic matrix, not in the dense clay aggregates.

Leucoxene occurs as turbid, very fine-grained aggregates sparsely scattered through the rock. They appear to represent altered precursor Ti-rich grains (possibly rutile).

INTERPRETATION:

This sample has suffered strong pervasive alteration, generating abundant very fine-grained colourless phyllosilicate (muscovite-3T by analogy with sample 79392a) in mm-sized patches which were aligned within a foliation. Alteration has also generated abundant fine-grained hematite and sericite in the matrix. All of the alteration could have been generated by retrogressive alteration processes, but it remains possible that weathering has overprinted the precursor retrogressive alteration phases.

The precursor rock is difficult to identify, owing to the intense effects of alteration. A medium-grade regional metamorphic precursor is suggested by:

i) The presence of coarse-grained accessory apatite, monazite, and a Ti-bearing phase (probably rutile).

ii) The presence of a foliated matrix dominated by altered white mica. This suggests that the precursor contained a significant pelitic component.

The precursor nature of the large phyllosilicate-altered patches or lenses remains obscure. No precursor mineral kernels have been preserved, and no precursor mineral forms have been formed or were developed. It is suggested that the patches, which are so evident in hand specimen, were coarse-grained anhedral metamorphic grains (?scapolite, ?pyroxene, ?staurolite, or other medium-grade metamorphic phase).

SAMPLE : 79390 CA 33 - 72.15 m

SECTION NO. : 79390

HAND SPECIMEN : The drill core rock sample represents a foliated, medium-grained, micaceous schist with a mauvish grey colour arising from pervasive ferruginous oxidation products (?hematite), in places concentrated along thin foliation planes.

ROCK NAME : **Retrogressively altered mica schist**

PETROGRAPHY :

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

Mineral	Vol.%	Origin
Quartz	40	Metamorphic
Muscovite	25	Relict metamorphic
Tourmaline	Tr	Metamorphic
Rutile	Tr	Metamorphic
Biotite	Tr	Metamorphic (inclus. in quartz)
Sericite	22	Retrogressive alteration
Opaques (incl. hematite)	12	?Retrogressive alteration / ?weathering

In thin section, this sample displays a strongly schistose metamorphic texture, modified by moderately strong selective pervasive alteration.

Quartz is abundant ,occurring as anhedral grains ~0.4-1.0 mm in size, distributed more-or-less uniformly through the rock. Some grains are elongated within the trace of the foliation, and most grains display weak shadowy strain extinction.

White mica is abundant, and two types are distinguished:

i) Much occurs as relatively large, well-crystallised flakes and subpoikilitic plates that range up to ~1.5 mm long. Their strong preferred orientation defines a foliation through the rock, which in places wraps around coarser quartz-rich areas.

ii) A similar amount of white mica occurs as tiny flecks (sericite) which occur mostly as dense, massive (i.e. non-foliated) replacement patches within the muscovite-rich foliae. The fine-grained sericite may have formed entirely by replacement of precursor muscovite, but it remains possible that other precursor phases, now completely replaced, were also present. Note that this fine-grained white mica is very similar to that observed as ragged cream patches in sample 79392, and may therefore be the unstable muscovite-3T identified by XRD.

Tourmaline occurs in trace amount as anhedral grains, pleochroic in yellow-orange colours, that are intergrown with quartz in a limited area of the rock.

Biotite is rare, occurring as tiny well-crystallised flakes, pleochroic from brown to straw yellow. They occur only as inclusions in single quartz grains. Their presence indicates that biotite was a stable metamorphic phase, and may have formed larger flakes (now altered) elsewhere through the rock.

Rutile is uncommon, occurring as relatively large anhedral to equant grains ~0.2 mm in size, very sparsely and irregularly scattered through the rock.

Opaques occur in significant amount as very fine-grained dense aggregates, concentrated mainly within the phyllosilicate-rich foliae. Positive identification is impossible without reflected light observations, but the local presence of deep reddish brown absorption colours suggests that much (if not all) of the opaque materials is hematite. This is supported by the mauvish colour of the hand specimen.

INTERPRETATION:

This sample represents a medium-grained, strongly foliated, granoblastic metamorphic rock which was originally composed of quartz + muscovite + biotite + accessory tourmaline + rutile. The primary rock was a pelitic sedimentary rock.

Following medium-grade dynamic regional metamorphism, the rock body suffered a retrogressive alteration event which caused partial replacement of muscovite by fine-grained massive sericite. It is possible that much of the opaque materials (?hematite) formed at this time, possibly in part by replacement of metamorphic biotite. It is possible that some of the ferruginous alteration materials formed at a later time, in response to circulation of meteoric waters (i.e. weathering), but it is difficult to separate these effects from the inferred hematitic retrogressive alteration products.

SAMPLE : 79391 C1 22 81.57m

SECTION NO. : 79391

HAND SPECIMEN : The drill core rock sample displays a moderately strong foliation, defined by thin wispy foliae emphasised by dark mauve-red oxidation products. Compositional layering on the centimetre scale is defined by variable abundances of dark and light-coloured components. Scattered through the rock are ragged pale yellow-cream soft clay-rich patches several millimetres in size.

ROCK NAME : **Weathered, retrogressively altered meta-clastic sedimentary rock**

PETROGRAPHY :

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

Mineral	Vol.%	Origin
Quartz	5	?Relict clastic fragments
Zircon	Tr	?Relict clastic crystals
Quartz	50	Metamorphic
Apatite	Tr	Metamorphic
Sericite	30	Retrogressive alteration (after mica)
Chlorite	2	Retrogressive alteration (after mica)
Phyllosilicate (colourless, ?sericite)	8	?Alteration
Opaques (?hematite, ?goethite)	5	?Alteration / ?weathering

In thin section, this sample displays a poorly-preserved clastic sedimentary texture with indistinct layering, modified by metamorphic recrystallisation and retrogressive alteration overprint.

Quartz is abundant, and occurs in two principal forms:

i) Most occurs as small anhedral grains <0.1 mm in size. They build a fine-grained sutured granoblastic mosaic which is abundant in many layers in the rock. In places, lenses or discontinuous layers are composed of coarser-grained monominerallic granoblastic quartz. All of this quartz appears to be of metamorphic origin.

ii) A lesser amount occurs as large anhedral grains ~0.2-0.6 mm in size. They are more abundant in some layers than in others, and appear to represent relict clastic particles. In places, they are elongated and slightly drawn out within the trace of the foliation (which is subparallel to layering).

Phyllosilicates of three types are distinguished:

i) Much occurs as fine- to medium-grained white mica (sericite) which appears to have replaced precursor foliated phyllosilicate flakes of uncertain nature (possibly muscovite and lesser biotite).

ii) A significant amount of cryptocrystalline turbid pale brownish phyllosilicate (unstable muscovite-3T by analogy with sample 79392a) occurs as dense massive monominerallic mats that completely fill angular to wispy patches that range up to several millimetres in size. The patches are very irregular in shape, commonly elongate within the plane of layering, with wispy margins drawn out in the trace of the foliation. They are

remarkably uniform in composition, being composed almost entirely of the cryptocrystalline massive phyllosilicate, with a trace amount of reddish brown iron oxide as tiny patches and rare small polycrystalline quartz patches. Although possibly of volcanogenic lithic origin, there are no relict phenocrysts or phenocryst sites in the patches.

iii) A small amount of chlorite occurs as very pale green to colourless replacements of precursor phyllosilicate flakes.

Opaques occur in moderate amount, mostly as cryptocrystalline turbid dark reddish brown aggregates and wispy indistinct patches that tend to be concentrated within the trace of the foliation. Although distributed throughout the rock, it is more abundant in some layers than in others. Some appears to be hematite, but goethite may also be present.

Apatite forms sparsely scattered subhedral to anhedral grains up to ~0.4 mm in size. They appear to be in textural equilibrium with recrystallised quartz, and therefore belong to the metamorphic event.

Zircon is rare, occurring as small subhedral crystals.

INTERPRETATION:

This sample appears to represent a clastic sedimentary rock, of broadly pelitic composition, within which primary layering was defined by variable abundances of clastic particles and detrital clay materials.

Dynamic regional metamorphism of moderate grade caused recrystallisation of the finer-grained matrix to quartz + micas (muscovite, ?biotite) + accessory apatite. Larger quartz particles retained their identity. Large ragged patches may have formed through the rock, possibly of a reactive metamorphic mineral such as scapolite, pyroxene, staurolite, or cordierite. These patches are not considered to be relict clastic fragments, such as rhyolitic lithic fragments, because they contain no potential phenocryst sites, and failed to recrystallise to medium-grained polymineralllic phases during the metamorphic event.

Subsequent retrogressive alteration generated the assemblage sericite + chlorite. As part of this event, very fine-grained massive sericite (muscovite-3T) formed ragged patches scattered through the rock. It remains unknown whether they formed as replacements of a precursor reactive phase, or whether they formed by infilling of solution cavities. Deposition of cryptocrystalline iron oxide (?hematite, ?goethite) along foliation planes and in particular layers may have occurred as a later weathering event.

SAMPLE : 79392

SECTION NO. : 79392

HAND SPECIMEN : The drill core rock sample is composed of very fine-grained cream ragged patches ~2-8 mm in size that are elongated within a fine-grained greenish grey to mauve-brown schistose matrix.

ROCK NAME : **Retrogressively altered quartz-mica schist**

PETROGRAPHY :

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

Mineral	**Vol.%**	**Origin**
Quartz	53	Relict metamorphic / alteration
Sericite (incl. muscovite)	20	Relict metamorphic / alteration
Chlorite (pale green)	2	Alteration
Phyllosilicate (colourless, ?mica)	20	Alteration
Iron oxide (?hematite, ?goethite)	5	Alteration

[Note: X-ray diffraction has identified unstable muscovite-3T as the colourless phyllosilicate in the cream patches; matrix minerals are chlorite, muscovite, quartz, hematite and ?calcite.]

In thin section, this sample displays a relict foliated granoblastic metamorphic texture that has been severely modified by pervasive alteration, including development of fine-grained sericite-rich patches.

Quartz is abundant. Most occurs as small anhedral equant grains ~0.2-0.4 mm in size that form a more-or-less sutured granoblastic mosaic. It is most abundant in particular horizons which lends a layered structure to the rock. In places, quartz forms larger ragged patches up to several mm in size. In general, the quartz has the appearance of hydrothermal alteration quartz.

Colourless phyllosilicates are abundant, and occur in two principal sites:

i) Some occurs as flakes ~0.4-0.6 mm in size, whose preferred orientation contributes to a relict metamorphic foliation. Some of the flakes retain their optical continuity, but others appear to have recrystallised to finer-grained mats. Many of the flakes display very pale greenish pleochroism, but their relatively high birefringence confirms that they are a white mica, not a chlorite (this is confirmed by XRD, which identifies muscovite in the matrix).

ii) A significant amount of colourless phyllosilicate with low to moderate birefringence (first-order yellow-red) occurs as minute micron-sized flecks of random orientation that fill large angular patches with wispy margins. These are the large cream patches observed in hand specimen. In places, elongate wisps project from the patches into the adjacent wall rock, but in general the patches display quite sharp contacts with wall rock. The patches are mostly devoid of other phases, except for small cryptocrystalline aggregates of iron oxide and uncommon small quartz-rich aggregates. This phase has been identified by XRD as a metastable mica (muscovite-3T).

Chlorite occurs in minor amount as pleochroic ragged pale green aggregates intergrown with sericite/muscovite in white-mica-rich foliated patches or laminae.

Cryptocrystalline dense massive aggregates of iron oxide occur as opaque to very dark reddish brown material. It tends to be concentrated as dense diffuse aggregates within mica-rich laminae, but it also occurs as thin linings around margins of clay-rich patches, and as small dense aggregates within the clay rich patches. The colour and appearance of the iron oxide suggests it is composed of hematite and/or goethite (hematite confirmed by XRD).

INTERPRETATION:

This sample represents a strongly foliated schistose metamorphic rock, originally composed of a medium-grained granoblastic foliated assemblage of quartz + mica (muscovite, ?biotite). Scattered patches of a reactive metamorphic mineral (?scapolite) may have formed at this time. A broadly pelitic bulk composition is inferred for the precursor sedimentary rock.

Subsequent to metamorphism, the rock body suffered moderately severe pervasive hydrothermal alteration. This resulted in recrystallisation of the quartz-rich areas to sutured granoblastic mosaics, and replacement of metamorphic phyllosilicates by sericite + chlorite.

The confirmation of a muscovite composition for the phyllosilicate patches suggests it is a retrogressive alteration phase. It is possible that the patches formed either by infilling of ragged solution cavities, or by replacement of precursor metamorphic mineral/s. A replacement origin is preferred, by analogy with other samples in this suite in which the shape and high abundance of the patches more strongly support a replacement origin. However, no precursor crystal shapes or crystal kernels have been preserved.

SAMPLE : 79393 CA 25 - 55 32m

SECTION NO. : 79393

HAND SPECIMEN : The drill core rock sample is composed of abundant cream to white ragged patches several mm in size, broadly of ragged lensoidal shape, that lie within a foliation defined by dark reddish brown very fine-grained iron oxide. The rock is soft and soapy to the touch.

ROCK NAME : **?Weathered, retrogressively altered mica schist**

PETROGRAPHY :

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

Mineral	**Vol.%**	**Origin**
Tourmaline	<1	Relict metamorphic
Apatite	Tr	Relict metamorphic
Quartz	Tr	Relict metamorphic
Phyllosilicate (patches, ?sericite)	80	Alteration
Phyllosilicate (sericite)	10	Alteration
Chlorite (pale green)	2	Alteration
Iron oxide (?hematite, ?goethite)	5	Alteration
Leucoxene	Tr	Alteration

In thin section, this sample displays a relict foliated metamorphic texture, strongly modified by pervasive alteration.

Colourless phyllosilicate minerals dominate the rock, and occur in two sites:

i) Most occurs as uniformly very fine-grained, dense, massive mats that fill large bulbous lensoidal patches that are elongated within the trace of a relict foliation. The mineral displays first-order yellow interference colours, and may be a sericite (note it is identical to unstable muscovite-3T identified by XRD in sample 79392). There are no relict minerals or structures within the massive patches.

ii) A significant amount of fine-grained sericite occurs as aggregates that have replaced precursor foliated phyllosilicate flakes (possibly muscovite). The ?muscovite was concentrated in foliae which enclosed or wrapped around the dense sericite-rich patches.

Chlorite is uncommon, occurring as tiny flakes in subradiating aggregates, weakly pleochroic in pale greens. The chlorite is concentrated in lensoidal patches aligned within the trace of the foliation. Large ragged relict kernels of weakly pleochroic orange tourmaline lie within the chlorite-rich lenses. Optical continuity of the kernels suggests that the precursor tourmaline grains were quite large (>2 mm).

Apatite occurs in trace amount as relatively large anhedral equant grains that are sparsely scattered through the rock. They tend to be located within the altered phyllosilicate-rich laminae or matrix areas.

Quartz is uncommon, occurring as granoblastic mosaics in one area of the rock.

Iron oxide occurs as very fine-grained dense dark reddish brown patches, aggregates and trails. It is most abundant within the phyllosilicate-rich laminae or matrix areas, but a trace occurs within the massive sericite-rich patches as small disseminated spots.

Leucoxene occurs in trace amount as small, very fine-grained, turbid aggregates ~0.2 mm in size. They appear to represent altered precursor Ti-rich mineral (e.g. rutile).

INTERPRETATION:

This sample is inferred to have been a foliated metamorphic rock of possible pelitic bulk composition. It contained foliated mica (?muscovite), with intergrown accessory tourmaline and apatite.

Subsequent alteration caused severe replacement of ?muscovite by fine-grained sericite. Dense sericite-rich patches formed, either by replacement of unidentified precursor mineral/s or by filling of solution cavities. A replacement origin seems more in keeping with the abundance and shape of the patches, and the precursor mineral may have been a reactive phase (?scapolite, ?pyroxene, ?staurolite). Fine-grained iron oxide developed through the altered matrix areas of the rock. Some of the alteration may be of near-surface weathering origin.

SAMPLE : 79394

SECTION NO. : 79394

HAND SPECIMEN : The surface rock sample represents a hard, competent, quartzo-feldspathic rock with pale pinkish cream colour and moderate foliation. Small translucent grey quartz grains are distinguishable, and larger ragged cream patches appear to define a precursor fragment texture.

ROCK NAME : **Retrogressively altered quartzo-feldspathic mica schist**

PETROGRAPHY :

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

Mineral	**Vol.%**	**Origin**
Quartz	65	Relict metamorphic
Muscovite	5	Relict metamorphic
Biotite	Tr	Relict metamorphic
Sericite (incl. ?clays)	30	Alteration (incl. ?weathering)
Iron oxide (?hematite)	Tr	?Weathering

In thin section, this sample displays a relict foliated granoblastic metamorphic texture, modified by strong pervasive alteration.

Quartz is abundant, occurring as anhedral to ovoid grains that range widely in size (~0.2-2.0 mm). Mostly it forms a coarse-grained granoblastic mosaic throughout the rock, but small oriented quartz grains form small micrographic patches in limited areas.

Colourless phyllosilicate minerals comprise most of the rest of the rock, and occur in two different forms:

i) Some occurs as large ragged well-crystallised plates up to ~2 mm in size. They tend to be densely intergrown in some phyllosilicate-rich areas, and the preferred orientation of the plates contributes to definition of a metamorphic foliation.

ii) Most of the colourless phyllosilicate occurs as tiny, randomly oriented flecks that form dense mats through the rock. In places it is associated with large muscovite plates, but elsewhere it forms ragged patches which may represent altered feldspar grains but none is preserved for confirmation. Turbid, less birefringent materials (possibly clays) form diffuse patches in the sericite-rich areas, possibly representing incipient weathering of these areas.

Biotite is very rare, occurring as tiny but well-crystallised flakes entirely enclosed within single quartz grains. The biotite is pleochroic from reddish brown to pale straw yellow, suggesting a relatively reduced composition.

Iron oxide occurs in trace amount as tiny ragged specks concentrated in small loose aggregates in limited areas of the rock. It appears to be hematite.

INTERPRETATION:

This sample represents a foliated granoblastic metamorphic rock which may have been composed of quartz + feldspar + mica. A quartzo-feldspathic composition is likely, and the possible relict fragmental texture in hand specimen allows an arkosic sedimentary origin.

Subsequent to metamorphism, retrogressive alteration caused replacement of micas and ?feldspar by fine-grained white mica (sericite). A small amount of colourless, poorly-crystallised clay and hematite may represent a weathering overprint.

SAMPLE : 79395

SECTION NO. : 79395

HAND SPECIMEN : The surface rock sample represents a weathered massive felsic granitoid, composed of abundant pink weathered feldspar, translucent grey quartz, and scattered ragged altered green ferromagnesian patches.

ROCK NAME : **Weathered micro-graphic granite**

PETROGRAPHY :

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

Mineral	**Vol.%**	**Origin**
Quartz	40	Igneous
?Monazite	Tr	Igneous
K-feldspar (orthoclase)	<1	Relict igneous
Clays (?illite, ?kaolinite, chlorite)	58	Weathering
Iron oxide	Tr	Weathering
Leucoxene	Tr	Weathering

In thin section, this sample displays a well-preserved micro-graphic granitoid texture, modified by strong selective pervasive alteration of weathering origin.

Quartz is abundant. It forms anhedral grains ~1-2 mm in size. Some are clear, but many contain oriented inclusions of (now-altered) feldspar in micro-graphic texture.

K-feldspar (orthoclase) formed randomly oriented blocky prisms up to ~2 mm long, and micro-graphic intergrowths with quartz. Only a trace amount is preserved in some blocky crystals, where its primary simple twinning is preserved.

Clays are abundant, and different types are distinguished:

i) Some occurs as tiny colourless flecks that form replacement patches within feldspar crystal sites. This has the appearance of illite.

ii) Some occurs as cryptocrystalline dense turbid material that has replaced primary feldspar. This may be kaolinite, but the identification is uncertain.

iii) Tiny clay flakes occur as alteration in primary ferromagnesian sites (possibly biotite, but none is preserved). Most are heavily stained by reddish iron oxide, but some pleochroic green chlorite flakes are also present.

Iron oxide occurs in trace amount. Submicroscopic specks (possibly hematite) are peppered through altered feldspar crystals, contributing to the pinkish colour in hand specimen.

Possible monazite occurs as small equant crystals, sparsely scattered through the rock.

Leucoxene occurs as rare turbid dark cryptocrystalline replacements of a precursor Ti phase.

INTERPRETATION:

This sample represents an intrusive acid igneous rock of felsic granitic composition. It was originally composed of quartz, feldspar, minor ferromagnesian grains, and accessory ?monazite and a Ti phase. Its well-developed micrographic texture suggests it crystallised relatively quickly, either in a small intrusive body or near the margin of a larger intrusive body.

Near-surface weathering has caused almost complete replacement of feldspar and ferromagnesian minerals by clays and associated iron oxide.

APPENDIX 1: COLOUR PHOTOMICROGRAPHS / MACROPHOTOGRAPHS

A small selection of colour photographs is provided in the following pages. They are mainly photomicrographs that illustrate mineralogical and microtextural features of the rock samples, but some macrophotographs of section offcuts are also presented to illustrate aspects of the cream muscovite alteration patches.

The photographs are presented in order of increasing sample number.

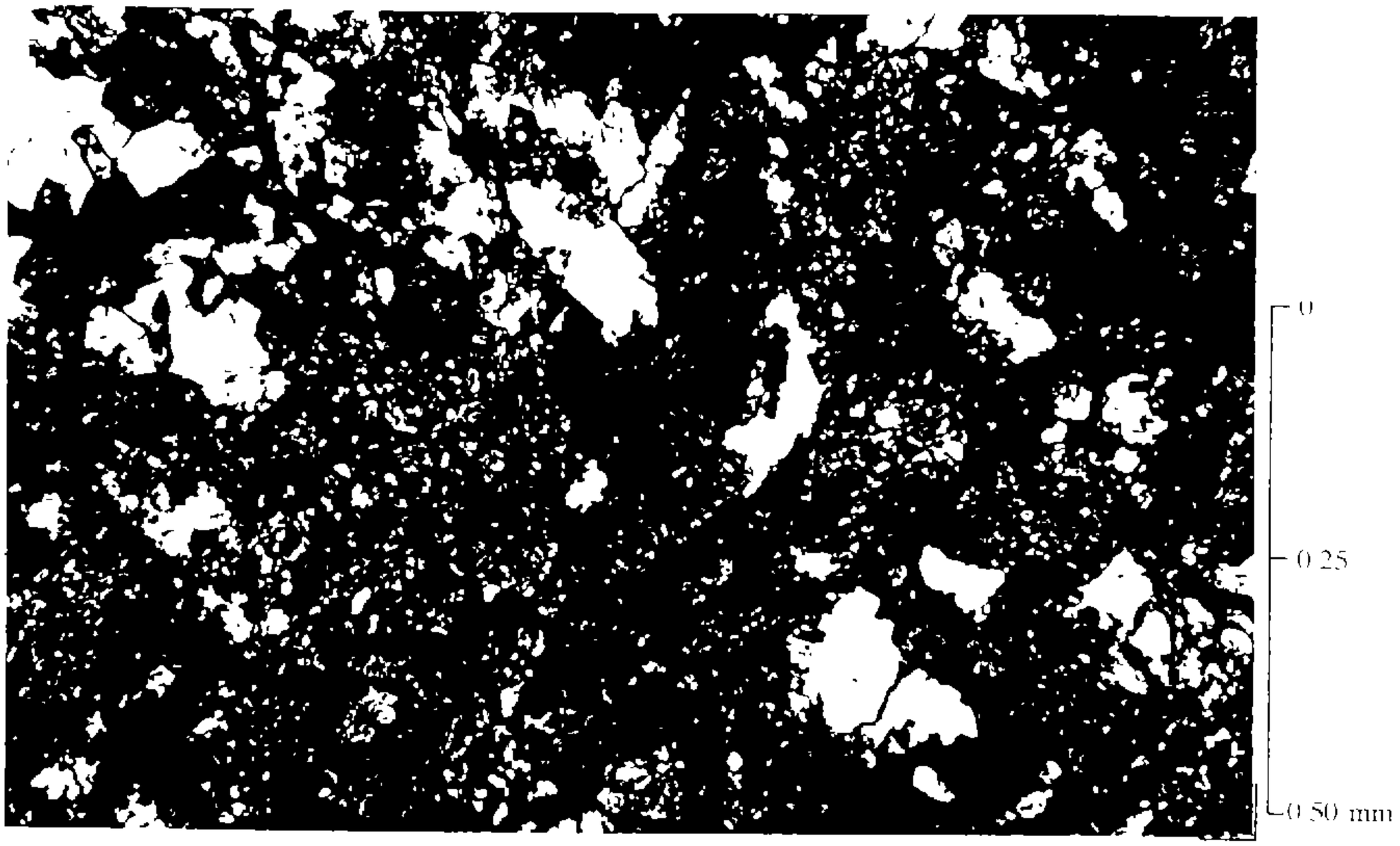

PLATE 1 SAMPLE 79382 (Transmitted light, crossed polarisers, x10, Frame 1)
This view displays the fine-grained alteration biotite (orange brown colours) that is distributed irregularly through a matrix of quartz (white to grey). A hydrothermal origin is inferred

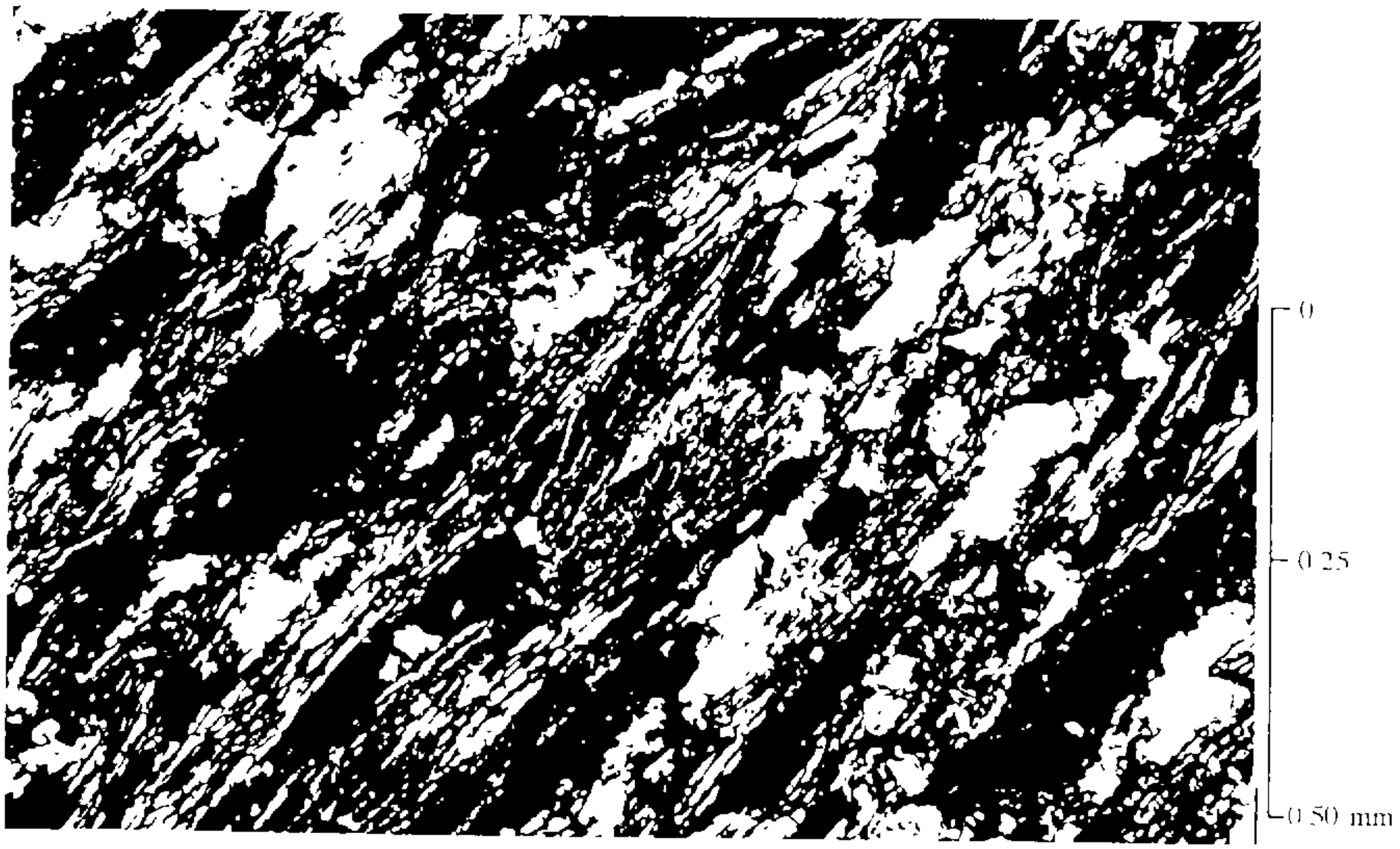

PLATE 2 SAMPLE 79384 (Transmitted light, crossed polarisers, x10, Frame 2)
This view illustrates the well-preserved strongly foliated metamorphic texture of a pelitic schist. It has suffered strong pervasive retrogressive alteration to chlorite after biotite (yellow-orange flakes, centre), and to another chlorite phase that is colourless in plane light (drab green anomalous interference colours in this view). Quartz is white to pale grey

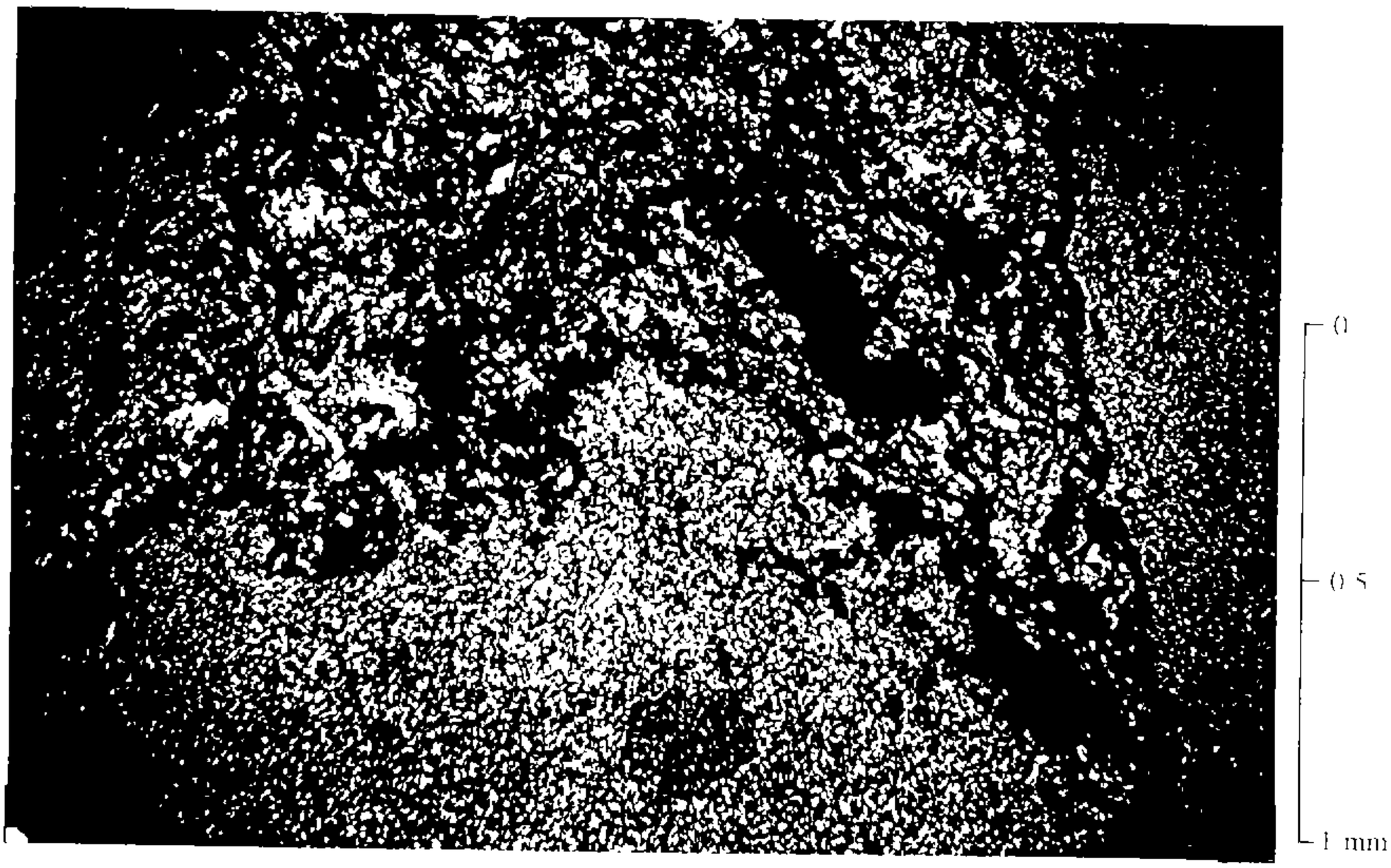

PLATE 3 SAMPLE 79389 (Transmitted light, crossed polarisers with condenser lens, x5, Frame 4)
Large ragged replacement patches of muscovite (bottom, far right) lie in a foliated matrix of alteration sericite (after muscovite), dense dark hematite, and uncommon large apatite crystals (larger dark grains centre right, bottom right). The muscovite patches are white in hand specimen.

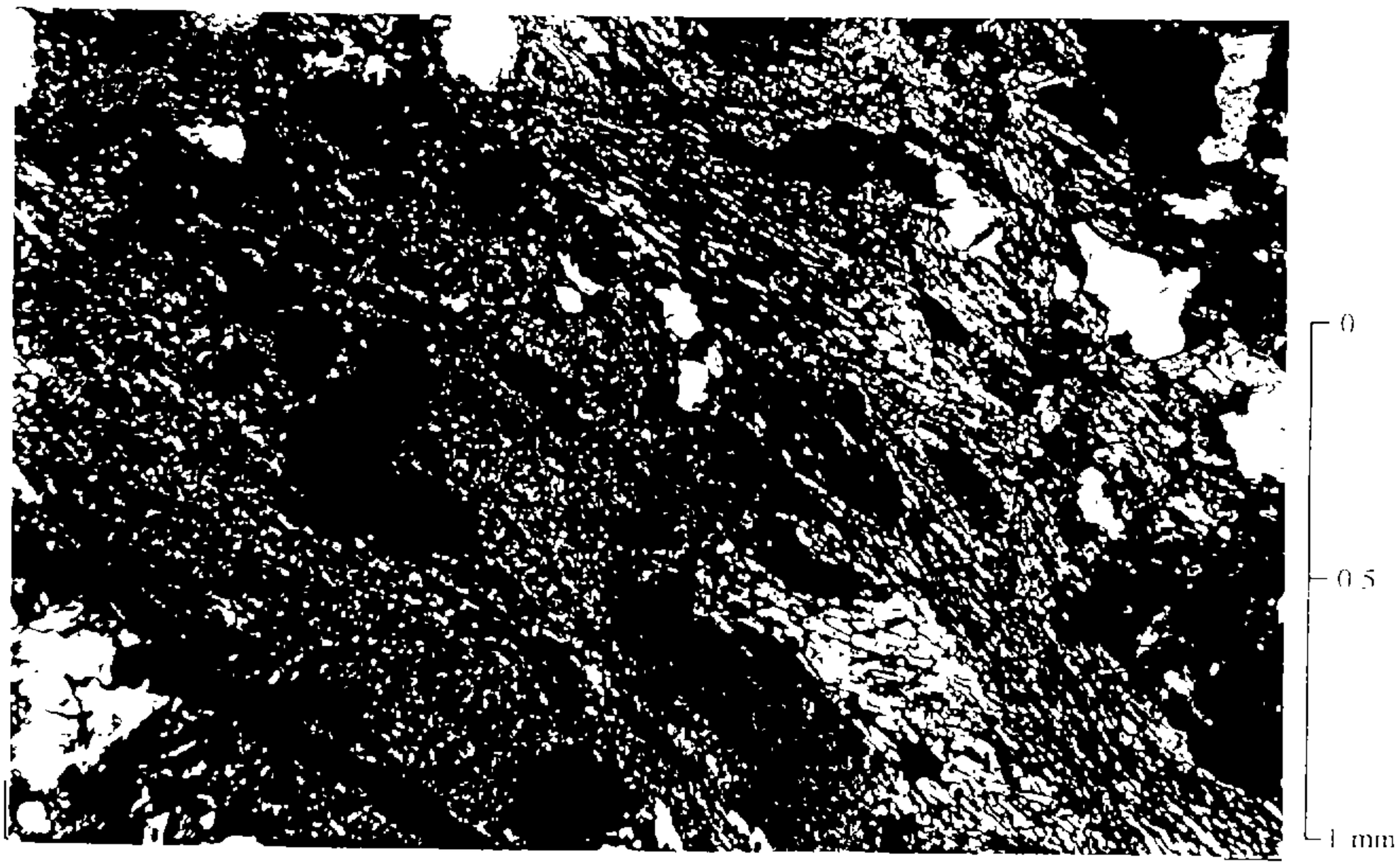

PLATE 4 SAMPLE 79390 (Transmitted light, crossed polarisers, x5, Frame 5)
Fine-grained retrogressive sericite (left half of view) has replaced precursor metamorphic muscovite (bright yellows, bluish greens) in this pelitic schist. The alteration sericite is optically similar to the muscovite that fills the white patches in similar rocks.

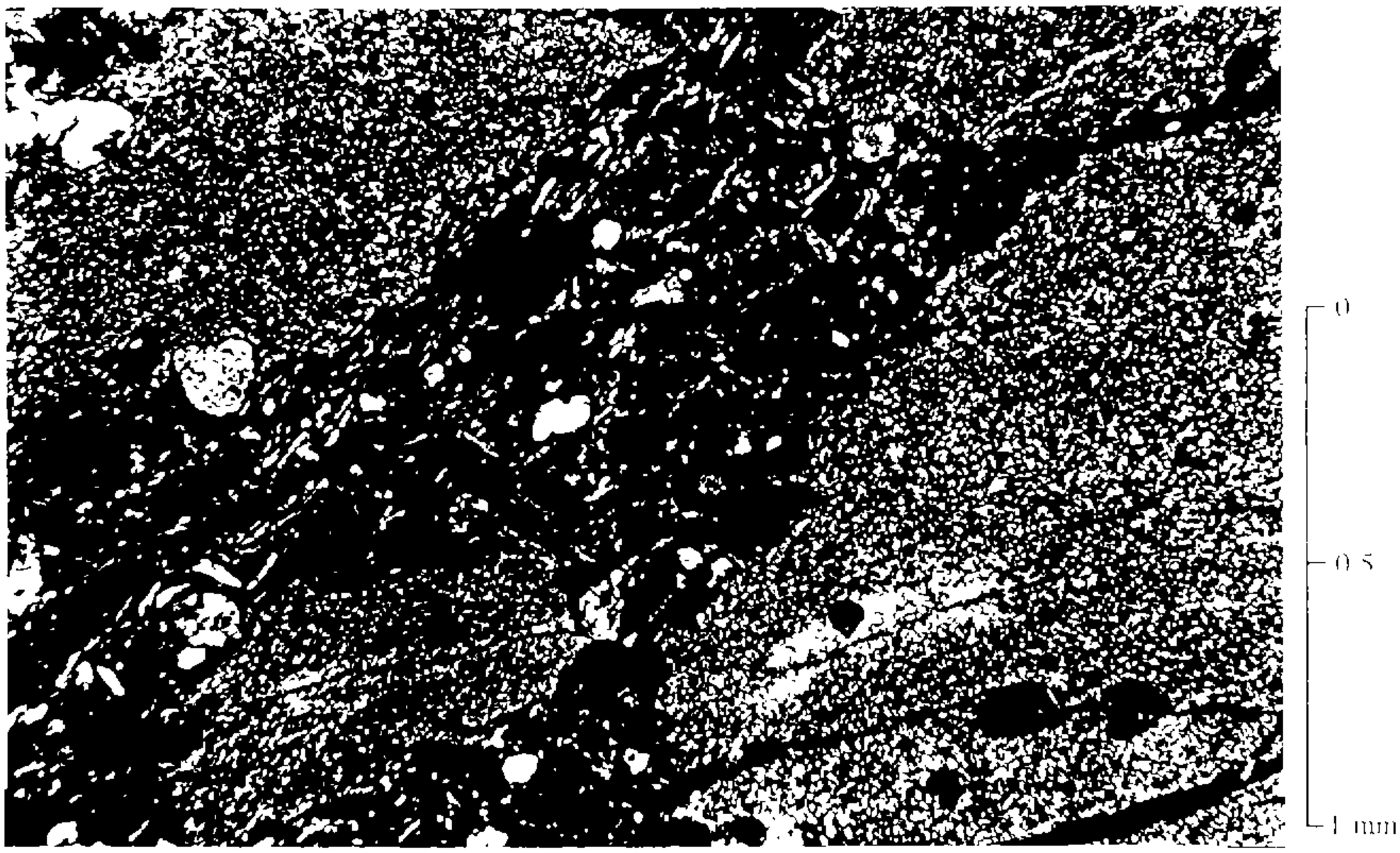

PLATE 5 SAMPLE 79392 (Transmitted light, crossed polarisers, x5, Frame 8)
This view illustrates the large ragged muscovite-rich patches (right, top left, bottom left). Note their massive (non-foliated) texture and monomineralic composition. They lie in a foliated meta-pelitic matrix of altered metamorphic muscovite, quartz and hematite (dark).

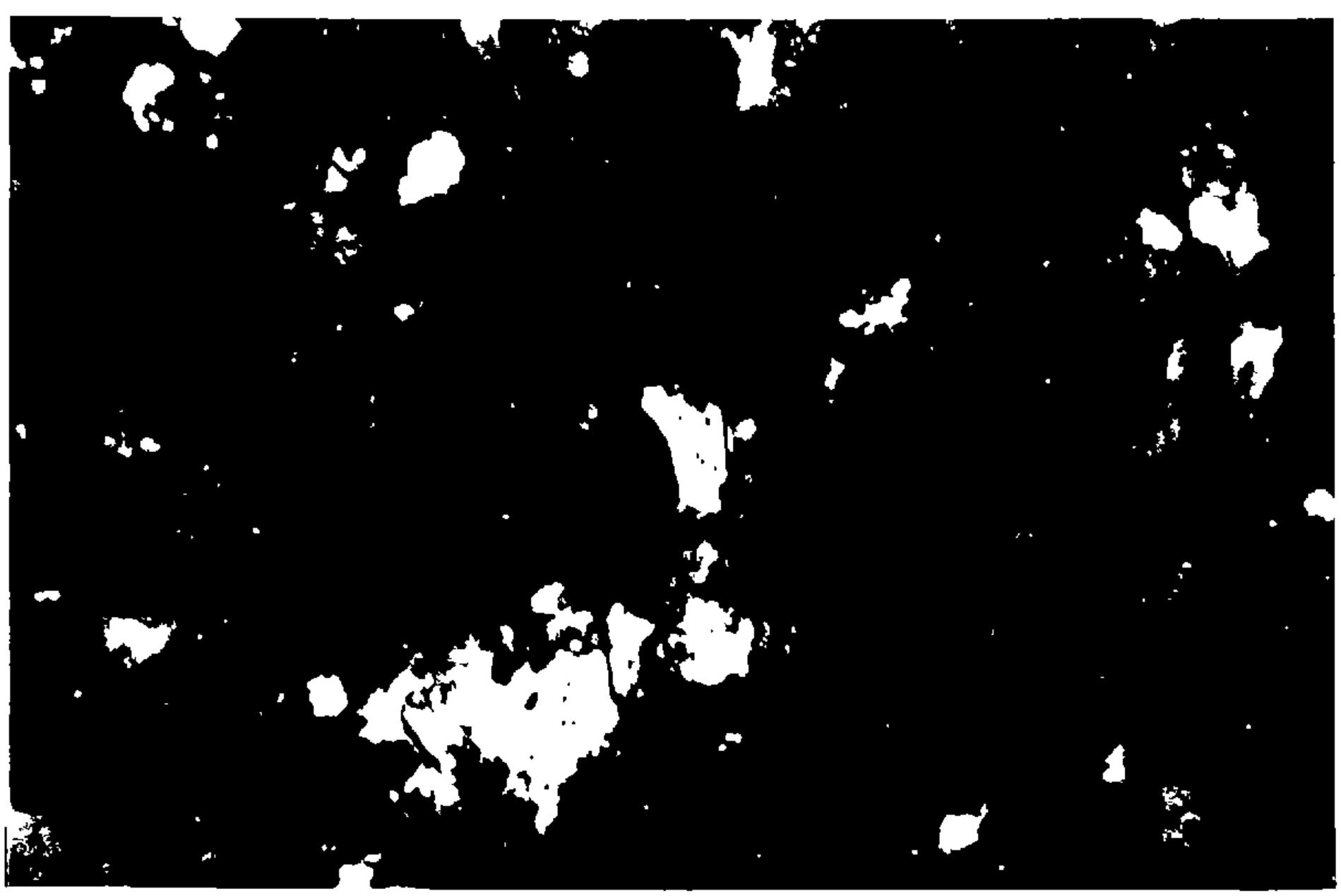

PLATE 6 SAMPLE 79392 (Binocular microscope, section offcut, 13.5 mm left to right)
This view of the section offcut illustrates the ragged shapes of the white muscovite-rich patches, which tend to be slightly elongated within the trace of the metamorphic foliation (N-S).

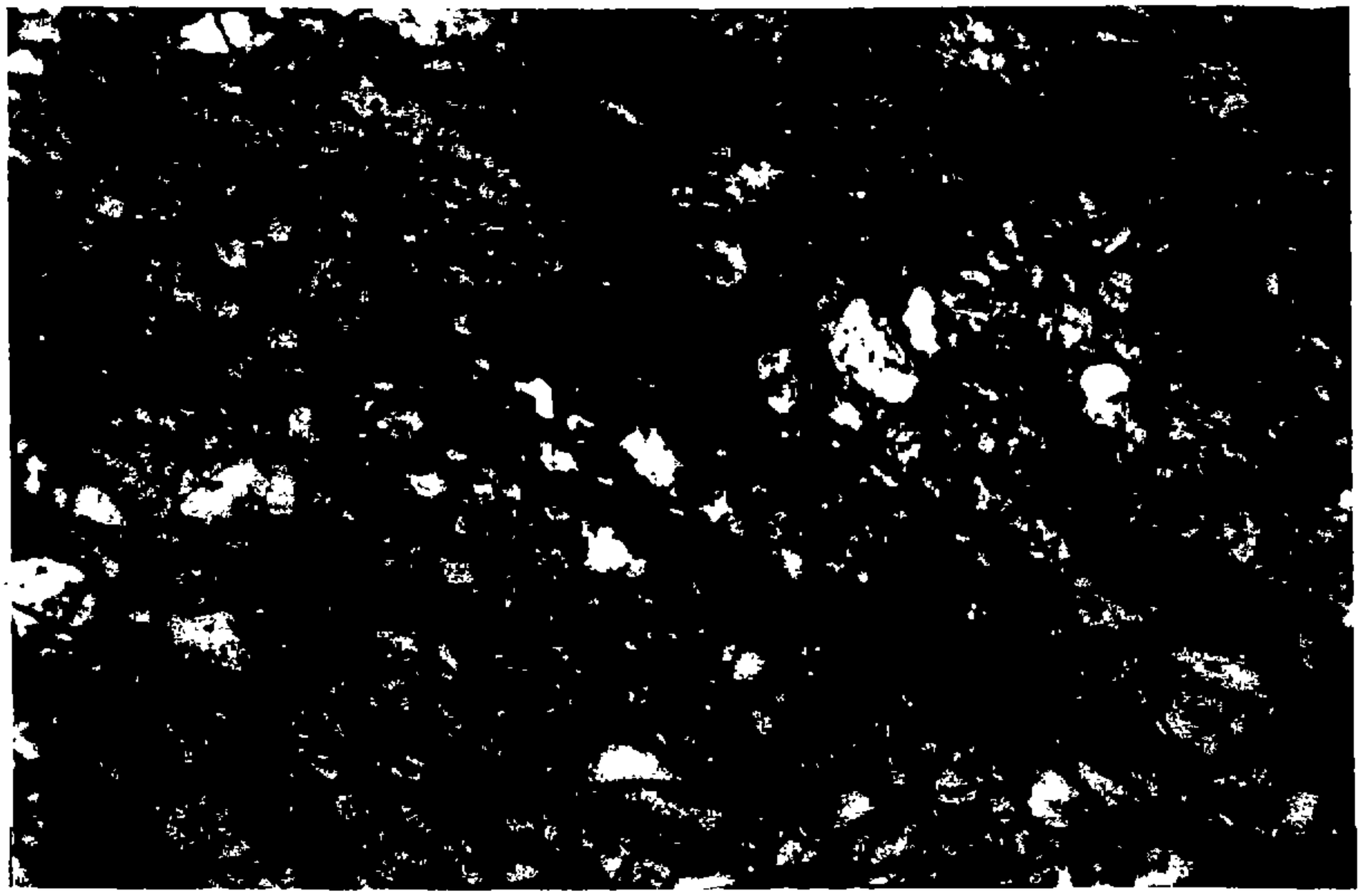

PLATE 7: SAMPLE 79393 (Binocular microscope, section offcut, 13 5 mm left to right)
This sample contains abundant muscovite-rich alteration patches (white). Their size, subrounded shapes, elongation within the foliation (NW-SE), and their high abundance support an origin involving retrogressive alteration replacement of precursor metamorphic monomineralic crystalline material (?scapolite, ?pyroxene, ?staurolite). No relict kernels or crystal shapes have been preserved to positively identify the phase. The white alteration phase has been positively identified in sample 79392 as a metastable muscovite (muscovite-3T).

APPENDIX 2: MINERAL IDENTIFICATIONS BY X-RAY DIFFRACTION METHODS

[This report is transcribed *verbatim* from a facsimile report received from Amdel Limited on 22 October 1996. The work was performed by Mr Michael Till under the direction of Dr Keith Henley.]

Introduction

A sample was received from Dr D.R. Mason of Mason Geoscience Pty. Ltd. with a request for identification of specified cream patches and grey matrix.

Procedure

The cream patches and the grey matrix were drilled separately and then analysed by X-ray diffraction. Identification of the mineral in 79392a was assisted by a computer-based search/match program.

Results

MINERAL	79392a	79392b
	Cream patches	Grey matrix
Muscovite	D*	A**
Chlorite	-	D
Quartz	-	A
Hematite	-	Tr
?Calcite	-	Tr

*: The mica in 79392a has a crystal structure similar to muscovite-3T or taeniolite-3T. The 3T structures are metastable and less abundant in nature. Taeniolite is a very rare mica.
**: Muscovite in 79392b is poorly crystalline.

Semi-quantitative abbreviations:

D = Dominant. Used for the component apparently most abundant, regardless of its probable percentage level.
CD = Co-dominant. Used for two (or more) predominating components, both or all of which are judged to be present in roughly equal amounts.
SD = Sub-dominant. The next most abundant component(s), providing its percentage level is judged to be above about 20%.
A = Accessory. Components judged to be present between the levels of roughly 5 and 20%.
Tr = Trace. Components judged to be below about 5%.

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REPORT TITLE	**Petrographic and Mineralogical Studies for Six Rock Samples, Northern Territory**
REPORT #	2259
CLIENT	Queensland Mines Pty. Ltd.
ORDER NO.	21059
CONTACT	John Thevissen

REPORT BY Dr Douglas R. Mason

SIGNED 

for Mason Geoscience Pty. Ltd.

DATE 9 December 1996

CONTENTS

Petrographic and Mineralogical Studies for Six Rock Samples, Northern Territory

SUMMARY

1. Rock Samples

- A collection of six (6) rock samples has been studied using petrographic, mineragraphic, and limited autoradiograph, X-ray diffraction, and qualitative electron-probe microanalytical methods.

2. Brief Results

- Rock names and mineralogy are summarised in Table 1.

- Rock types are dominated by quartzo-feldspathic gneiss, quartz-veined micrographic granite, and quartzite. Most have suffered alteration, as well as a moderate to strong weathering overprint.

- X-ray diffraction study of a quartz vein from sample 79400 identified only quartz.

- Autoradiograph of the section offcut of sample 79396 failed to identify any radioactive materials (but see next).

- Qualitative electron-probe microanalysis of the polished thin section of sample 79396 identified rare U-bearing minerals and native gold. Three U-bearing minerals were identified: one contained essential U with minor Pb (probable uraninite), one contained essential Th and P with minor U and Ca (possible monazite, brabantite, or grayite), and one contained essential Zr and Si with minor U and Fe (U-bearing zircon).

TABLE 1: SUMMARY OF ROCK NAMES AND MINERALOGY

SAMPLE	ROCK NAME	MINERALOGY*			
		Primary**	Metamorphic	Alteration***	Veins
77702	Weathered, veined, altered micrographic granite	Qtz,apa	-	Ser,rut/leu; Cla,goe	Qtz
79396	Weathered quartzite	?Qtz,?zir	Qtz,py,cpy	Cla,hem	-
79397	Weathered, altered biotite(-hornblende) quartzo-feldspathic gneiss	-	Pla,qtz,Kf,bio,hbl,apa,all	Act,pre; Cla	Pre
79398	Weakly altered hornblende-biotite quartzo-feldspathic gneiss	-	Pla,qtz,hbl,Kf,bio,apa,zir	Pre,chl,act,epi	-
79399	Sericite-hematite-altered quartzo-feldspathic gneiss	-	Qtz,mon	Ser,hem	-
79400	Weathered, veined, altered micrographic granite	Qtz,apa	-	Qtz,ser,rut/leu; Goe,cla	Qtz

All Rock chip ↓

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: Act = actinolite; all = allanite; apa = apatite; bio = biotite; cla = undifferentiated clays; cpy = chalcopyrite; epi = epidote; goe = goethite; hbl = hornblende; hem = hematite; Kf = K-feldspar; leu = leucoxene; mon = monazite; pla = plagioclase; pre = prehnite; py = pyrite; qtz = quartz; rut = rutile; ser = sericite; zir = zircon; ? = uncertain paragenesis.

1. INTRODUCTION

A batch of six (6) rock samples was received from Mr. John Thevissen (Queensland Mines Pty. Ltd., Darwin, Northern Territory) on 21 October 1996.

Particular requests were as indicated in Table 2.

TABLE 2: SERVICE REQUESTS

SAMPLE	SERVICE REQUEST/S
77702	Petrographic description (special section), U-mineral identification in vein and wallrock
79396	Petrographic description, U-mineral identification, autoradiograph
79397	Petrographic description
79398	Petrographic description
79399	Petrographic description
79400	Petrographic description (special section), U-mineral identification in vein.

Preliminary observations regarding U-mineral identification were provided by facsimile to Mr Thevissen (Queensland Mines bush camp) on 7 November 1996. This report contains the full results of this work.

2. METHODS

The samples were examined in hand specimen, and marked for section preparation. A standard thin section was obtained for those samples for which routine petrographic description was required. A polished thin section was obtained for those samples for which U-mineral identification was required; these polished thin sections were prepared at 2" x 1" size, in anticipation of possible subsequent electron probe work. All sections were obtained from an external commercial laboratory (Amdel Limited, Thebarton, South Australia). Also at Amdel Limited, an autoradiograph was obtained for sample 79396, and a whole-rock X-ray diffraction analysis of sample 79400 was obtained. The results of the autoradiograph and XRD are contained in the full Amdel Report provided as Appendix 1.

At Mason Geoscience Pty. Ltd., conventional transmitted and reflected polarised light microscopy was used to prepare petrographic and mineragraphic descriptions.

Qualitative electron-probe microanalysis was undertaken at the Centre for Electron Microscopy and Microstructural Analysis (CEMMSA, University of Adelaide, South Australia). The polished thin section for sample 79396 was carbon-coated and subjected to the beam in a CAMECA SX-51 electron-probe microanalyser running at 20 kV with energy-dispersive secondary X-ray detector and on-line spectrum analysis for elements. The section was scanned at low power, seeking 'bright' grains in the back-scattered electron image which correlate with phases of 'high average atomic number' (and therefore likely to be U-bearing). Where observed, the 'bright' grains were examined at higher power, the secondary X-ray spectrum was captured from the energy-dispersive detector, and elements present in the spectrum were identified with the aid of computer-based methods. Technical problems with the probe rendered it unworkable for three weeks, causing late reporting of this work.

3. PETROGRAPHIC DESCRIPTIONS

The petrographic descriptions are provided in the following pages. Where a polished thin section was prepared, a combined petrographic and mineragraphic description is provided.

U 3500
Th 14
Au 3250 ppb

South Horn

SAMPLE : 77702

SECTION NO. : 77702 (C67119)

HAND SPECIMEN : The surface rock sample represents a medium-grained quartzo-feldspathic rock, with uncommon thin quartz-rich veins ~2 mm thick subparallel to the foliation. The rock has been pervasively affected by near-surface weathering, generating a pervasive pale brown discolouration.

ROCK NAME : **Weathered, veined, altered micrographic granite**

PETROGRAPHY AND MINERAGRAPHY :

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

Mineral	**Vol.%**	**Origin**
Quartz	53	Relict igneous
Apatite	Tr	Relict igneous
Sericite	20	Alteration
Rutile / leucoxene	2	Alteration (after Fe-Ti oxides)
Goethite	10	Alteration (weathering)
Clays (?smectite)	10	Alteration (weathering)
Quartz	5	Vein filling

In polished thin section, this sample retains a poorly-preserved equigranular granitoid texture that is weakly micrographic in places, strongly modified by alteration and weathering.

Quartz is abundant, and occurs in two sites:

i) Most occurs as large anhedral grains ~1-2 mm in size. They are distributed throughout the rock. In some grains, small oriented aggregates of alteration sericite define precursor feldspar (most likely K-feldspar) in micrographic intergrowth relationship with the quartz.

ii) A small amount of quartz occurs as equant subhedral crystals that fill a vein cutting the rock.

Apatite occurs in trace amount as randomly oriented acicular crystals up to ~2 mm long. They occur within quartz, but also occur in other mineral sites that have been severely altered.

Rutile (and more turbid leucoxene) occur as pseudomorphous replacements of precursor blocky to acicular Fe-Ti oxide crystals (possibly ilmenite and/or magnetite) scattered through the rock.

Fine-grained phyllosilicate minerals form tabular replacement patches pseudomorphous after precursor crystals (feldspar, ?biotite), and scattered fine-grained patches of replacement origin in quartz. Some of the phyllosilicate materials is colourless white mica (sericite), which in places formed coarser flakes possibly pseudomorphous after primary mica (?biotite). Dense fine-grained aggregates of clays (orange-green ?smectite) and dark red-brown hydrated iron oxides (goethite) may be intimately intermixed with each other and with sericite in some crystal sites. The goethite also occurs in irregularly oriented thin microveinlets that traverse the rock.

INTERPRETATION:

This sample represents a micrographic granitoid, originally composed of a massive assemblage of quartz, feldspar, minor ferromagnesians (probably biotite) and accessory Fe-Ti oxides and apatite. The presence of relict micrographic texture and acicular apatite crystals suggests that the rock body crystallised relatively quickly, even though it displays an overall medium grain size.

Fracturing of the rock body allowed invasion by hydrothermal fluids, which allowed deposition of quartz-rich veins and pervasive sericitic alteration of the wall rock. Subsequent near-surface weathering processes generated clays and hydrated iron oxides.

U 73
South Horn
Th 7
Au 2 ppb
Cu 110

SAMPLE : 79396

SECTION NO. : 79396 (C67120)

HAND SPECIMEN : The surface rock sample represents an equigranular massive felsic crystalline rock, pervaded by small orange-brown oxidation patches.

ROCK NAME : **Weathered quartzite**

PETROGRAPHY AND MINERAGRAPHY:

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

Mineral	Vol.%	Origin
Quartz	95	Relict clastic / metamorphic
Zircon	Tr	?Relict clastic
Opaque (unknown)	Tr	Metamorphic
Pyrite	Tr	Metamorphic
Chalcopyrite	Tr	Metamorphic
Hematite	Tr	Weathering
Clays	5	Weathering

In polished thin section, this sample displays an equigranular sutured granoblastic metamorphic texture, modified by near-surface weathering.

Quartz dominates the rock. It occurs as equant anhedral grains ~0.2-1.0 mm in size (mostly ~0.6 mm), forming a sutured granoblastic mosaic throughout the rock. Although most grain margins are considered to have formed by grain boundary migration, the relict subrounded shapes of some grains are suggestive of relict clastic particles in a quartzose sandstone.

Zircon is rare, forming small subhedral crystals at quartz-quartz grain boundaries.

Rare tiny equant grains of pyrite and chalcopyrite occur within some quartz grains. The grains are a few tens of microns in size.

An unidentified opaque phase occurs as small euhedral stumpy terminated prisms, and as more anhedral grains. Most are quite small (~0.1 mm), but one large anhedral grain is ~0.5 mm in size. They are isotropic, with a pale grey colour and moderate reflectivity. They are very sparsely disseminated through the rock.

Small angular interstitial patches throughout the rock are filled by fibrous pale greenish brown to colourless clays (?smectite, ?illite), and intimately intergrown iron oxides, some of which are acicular hematite aggregates.

INTERPRETATION:

This sample represents a quartzose sandstone that has suffered metamorphic grain boundary modification, generating the equigranular granoblastic assemblage of quartz + unknown opaque accessory phase. A small amount of phyllosilicate (e.g. muscovite/sericite) may have formed in interstices, but this has been obscured by complete replacement of interstitial materials by clays and intergrown iron oxides of weathering origin.

AUTORADIOGRAPH:

An autoradiograph was obtained from the section offcut. There was a nil response, suggesting that radioactive materials do not occur in any significant amount.

ELECTRON-PROBE MICROANALYSIS

See section 4 of this report.

SAMPLE : 79397 South Horn

SECTION NO. : 79397 (C67121)

HAND SPECIMEN : The surface rock sample represents a banded quartzo-feldspathic gneissic rock, uniformly medium-grained throughout, but composed of thicker greenish grey bands and thinner cream bands.

ROCK NAME : **Weathered, altered biotite(-hornblende) quartzo-feldspathic gneiss**

PETROGRAPHY :

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

Mineral	Vol.%	Origin
Plagioclase (incl. ?sericite, ?illite)	42	Metamorphic (incl. altn, ?weathering)
Quartz	30	Metamorphic
K-feldspar (orthoclase, incl. clouding)	20	Metamorphic (incl. weathering)
Actinolite	1	?Metamorphic / ?alteration
Biotite	Tr	Relict metamorphic
Allanite	Tr	Metamorphic
Apatite	Tr	Metamorphic
Prehnite	1	Alteration / vein filling
Chlorite	5	Alteration (after biotite)

In thin section, this sample displays an equigranular granoblastic metamorphic texture with moderate foliation and mineralogical layering, modified by slight retrogressive alteration and weathering. Mineralogical layering is defined by variable mineral abundances, but an average mode across the whole section is given above.

Plagioclase is abundant, occurring as anhedral grains ~0.4 mm average grain size. Larger grains ~1 mm in size occur in more felsic bands. The plagioclase is distributed more-or-less uniformly through the rock. All grains have suffered partial replacement by minute colourless phyllosilicate flecks (sericite or illite), with faint preservation of primary polysynthetic albite twinning.

Quartz is moderately abundant, forming anhedral equant grains ~0.4-1.0 mm in size. It is uniformly distributed, and most grains display weak shadowy strain extinction.

K-feldspar occurs as anhedral grains similar in size to quartz and plagioclase, and is distributed throughout the rock but is more abundant and coarser grained in the felsic bands (cream in hand specimen). The lack of "tartan" twinning confirms identification as orthoclase rather than microcline. All of the K-feldspar grains display a pale brownish turbid appearance, suggestive of submicroscopic clay alteration.

Biotite was the principal ferromagnesian phase. It formed well-crystallised flakes and aggregates of flakes, whose preferred orientation defines a foliation subparallel to mineralogical layering. Almost all biotite has suffered complete replacement by pale green pleochroic chlorite, but rare small flakes pleochroic in reddish brown colours are preserved in quartz and plagioclase grains.

Actinolitic amphibole occurs as pleochroic ragged grains and subhedral crystals, very sparsely distributed through the rock. It forms subhedral grains ~0.2-0.6 mm in size, in granoblastic equilibrium relationship with the felsic minerals. It occurs sparsely in both the darker green and

paler cream bands in the rock. Most of the amphibole grains are rather fretted, suggesting replacement of precursor hornblende by actinolite.

Allanite is uncommon, forming euhedral terminated prisms ~0.4 mm long. They are completely metamict, being replaced by turbid indeterminate yellowish brown materials.

Apatite occurs in accessory amount as small equant colourless grains, usually at margins of quartz and K-feldspar grains.

Prehnite occurs in two forms:

i) As ragged replacement patches within plagioclase grains.

ii) As better-crystallised grains filling a single fracture that cuts the rock, subparallel to the foliation and mineralogical layering.

INTERPRETATION:

This sample represents a quartzo-feldspathic precursor rock that suffered dynamic regional metamorphism of moderate grade (amphibolite facies), generating the assemblage plagioclase + quartz + K-feldspar + biotite + minor amphibole + accessory apatite + allanite.

Minor fracturing and retrogressive alteration generated prehnite + actinolite + chlorite, an assemblage suggestive of the greenschist facies. More recently, near-surface weathering processes caused clouding in the K-feldspar, and may have generated some fine clays in the plagioclase.

The nature of the precursor rock has been obscured by metamorphic recrystallisation. However, the very felsic metamorphic mineralogy, together with significant biotite and minor hornblende, allow a sedimentary origin in which the primary sedimentary materials were mixtures of quartzo-feldspathic, argillaceous and possible calc-silicate materials.

SAMPLE : 79398 South Horn U 9.1 Th 3.2

SECTION NO. : 79398 (C67122)

HAND SPECIMEN : The surface rock sample represents a coarse-grained gneiss composed of large cream to pale green feldspar crystals in a foliated matrix of slightly finer-grained dark greenish black ferromagnesian grains.

ROCK NAME : **Weakly altered hornblende-biotite quartzo-feldspathic gneiss**

PETROGRAPHY :

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

Mineral	Vol.%	Origin
Plagioclase (incl. ?illite, ?sericite)	45	Metamorphic (alteration)
Quartz	30	Metamorphic
Hornblende	8	Metamorphic
K-feldspar (orthoclase)	5	Metamorphic
Biotite	Tr	Relict metamorphic
Apatite	Tr	Metamorphic
Zircon	Tr	?Metamorphic
Prehnite	5	Alteration (after biotite, plagioclase)
Chlorite	5	Alteration (after biotite)
Actinolite	Tr	Alteration
Epidote	Tr	Alteration

In thin section, this sample displays a coarse-grained foliated granoblastic metamorphic texture, modified by mild retrogressive alteration.

Plagioclase is abundant, occurring as large anhedral grains ~1-4 mm in size. All have suffered severe replacement by ragged small phyllosilicate flecks (possibly illite or sericite).

Quartz is the other principal phase, forming clear anhedral grains mostly ~1-2 mm in size, occupying interstitial areas between plagioclase grains. Some larger grains are elongated within the trace of the foliation.

Hornblende forms anhedral equant grains ~0.4-1.0 mm in size. They tend to form granular aggregates elongated within the trace of the foliation. Pleochroism from brownish green to pale beige brown confirms a genuine hornblendic composition. A small amount of pale green actinolitic amphibole occurs as subhedral grains in aggregates in limited altered areas.

Biotite formed well-crystallised flakes similar in size to hornblende, and commonly was closely associated with the hornblende. A strong preferred orientation of the biotite flakes defined the foliation through the rock. Virtually all biotite has been replaced by either pleochroic pale green chlorite, or bulbous expanded aggregates of prehnite along cleavage traces. A small amount of prehnite also occurs as ragged replacement patches in some plagioclase grains (in the same areas where minor actinolite occurs).

K-feldspar (orthoclase) is uncommon, occurring as large anhedral clear grains, and as minor small angular interstitial grains.

Apatite builds small subhedral clear prisms, commonly located within biotite- and hornblende-rich aggregates.

Zircon is rare, forming small stumpy equant crystals within altered biotite crystal aggregates.

Epidote is uncommon, forming small ragged grains and aggregates in a limited area of the rock, in association with prehnite and actinolite.

INTERPRETATION:

This sample represents a sedimentary rock that has suffered complete recrystallisation under medium grade (amphibolite facies) dynamic regional metamorphic conditions. This generated the coarse-grained foliated granoblastic assemblage of plagioclase + quartz + minor hornblende + biotite + orthoclase + accessory apatite + zircon.

Subsequent mild retrogressive alteration in the greenschist facies generated a small amount of prehnite + sericite + chlorite + epidote.

The nature of the primary rock has been obscured by the complete metamorphic recrystallisation. However, a mixed quartzo-feldspathic and calc-silicate sedimentary composition is inferred from the metamorphic mineralogy.

SAMPLE : 79399 south flank (at u/c) U 1.5 Th 32

SECTION NO. : 79399 (C67123)

HAND SPECIMEN : The surface rock sample represents an equigranular weakly-foliated gneissic rock, cream in colour with a 2 cm thick mauve band.

ROCK NAME : **Sericite-hematite-altered quartzo-feldspathic gneiss**

PETROGRAPHY :

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

Mineral	Vol.%	Origin
Cream bands		
Quartz	55	Metamorphic
Monazite	Tr	Metamorphic
Sericite	40	Alteration (after ?feldspar)
Sericite	5	Alteration (after mica)
Hematite	Tr	Alteration
Mauve band		
Quartz	55	Metamorphic
Monazite	Tr	Metamorphic
Sericite	35	Alteration (after ?feldspar)
Hematite	5	Alteration (after mica)
Hematite	5	Alteration (after ?feldspar)

In thin section, this sample displays a relict equigranular granoblastic metamorphic texture, modified by strong selective pervasive alteration. Mineral abundances are given above for the cream bands and the mauve band. The only differences are in the proportions of hematite and sericite.

Quartz dominates the rock, occurring as anhedral to subrounded grains ~0.5-2.0 mm in size. The larger grains tend to be aligned in the trace of the foliation. In places, shapes of the subrounded grains have the appearance of relict subrounded clastic quartz grains, but this cannot be confirmed.

Sericite is abundant, and occurs in two sites:

i) Most occurs as tiny randomly-oriented flecks that are concentrated as massive replacement mats in anhedral grain sites ~0.4-1.0 mm in size. They most likely were feldspar, but none is preserved.

ii) A lesser amount occurs as optically continuous fibrous replacements of precursor mica flakes. There is no indication whether they were muscovite or biotite, but the general lack of leucoxene (a common host for the Ti in precursor biotite) suggests that the mica was muscovite, not biotite.

Hematite occurs as tiny ragged grains. It tends to be concentrated in the sericitised mica sites, but also is disseminated through sericitised feldspar sites in the mauve band.

Monazite occurs in trace amount as tiny equant growth-zoned crystals, that tend to be located within quartz grains and within altered mica crystal sites.

INTERPRETATION:

This sample is inferred to represent a meta-clastic sedimentary rock, possibly an arkosic sandstone. Whatever the precise nature of the precursor, it was a broadly quartzo-feldspathic rock that suffered dynamic regional metamorphism of moderate grade (?amphibolite facies), generating the medium-grained granoblastic assemblage of quartz + feldspar + minor ?muscovite + trace monazite.

Subsequent retrogressive alteration resulted in complete replacement of ?feldspar and ?muscovite by fine-grained sericite. This generates the pale yellowish cream colour of parts of the rock. Concentration of alteration hematite in particular bands generates the mauvish colour in other bands. There is no clear indication whether the hematite formed synchronously with the sericite, or as a later near-surface weathering phenomenon.

U 2500
Th 10
Au 2400 ppb

SAMPLE : 79400 South Horn

SECTION NO. : 79400 (C67124)

HAND SPECIMEN : The surface rock sample represents a quartzo-feldspathic rock cut by a quartz-filled comb-textured vein ~1-2 cm thick. Weathering has generated a dull orange-brown ferruginous discolouration throughout the wall rock, especially along the vein margins.

ROCK NAME : **Weathered, veined, altered micrographic granite**

PETROGRAPHY AND MINERAGRAPHY :

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

Mineral	**Vol.%**	**Origin**
Altered micrographic granite		
Quartz	69	Relict igneous / alteration
Apatite	Tr	Relict igneous
Sericite	20	Alteration
Leucoxene / rutile	1	Alteration (after Fe-Ti oxides)
Iron oxides (goethite, incl. clays)	10	Alteration (weathering)
Quartz vein		
Quartz	100	Vein filling

[Note: XRD of vein has identified quartz only.]

In polished thin section, this sample retains a poorly-preserved massive micrographic granitoid texture, modified by veining and alteration including weathering.

Altered micrographic granite is dominated by quartz, which occurs as large equant grains ~1-2 mm in size and as fine-grained granular mosaics. The former represent relict igneous quartz, and the latter represent completely altered precursor mineral sites (probably feldspar). Some of the coarse clean grains retain evidence of micrographic texture, but all intergrown feldspar has been completely replaced by fine-grained sericite and intergrown reddish brown goethite and clays. In places, dense clay aggregates have pseudomorphously replaced blocky to tabular crystals (probably feldspars).

Scattered through the rock are large equant and lath-like crystals composed of latticeworks of leucoxene and/or rutile. These represent altered primary Fe-Ti oxide crystals (?magnetite, ?ilmenite).

Apatite is uncommon, forming acicular crystals within the large equant quartz grains.

Quartz vein is composed almost entirely of large subhedral quartz crystals that have grown inwards from the walls. Tiny two-phase fluid inclusions ~2-5 μm in size are concentrated in dense clouds and along thin sealed microcracks.

Dense, fine-grained aggregates of hydrated iron oxides(goethite) are concentrated along the vein margins, where they tend to form thick diffuse bands. In places, the iron oxide is intergrown with patches of green to yellow clays of indeterminate nature. (U Mins?)

INTERPRETATION:

This sample represents a micrographic granitic igneous rock, originally composed of quartz, feldspar, minor mica, and accessory Fe-Ti oxides and apatite. Subsequent fracturing allowed deposition of a space-filling vein of quartz, and wall rock may have suffered phyllic-type alteration at this time (quartz + sericite + accessory leucoxene/rutile). Subsequent near-surface oxidation generated clays + iron oxides, which has obscured many of the earlier textural and mineralogical features

This sample is similar in all ways with sample 77702: similar micrographic granitic host rock (including similar primary accessory phases), similar space-filling quartz-rich veining, similar phyllic wall rock alteration, and similar surface oxidation.

4. QUALITATIVE ELECTRON-PROBE MICROANALYSIS

Four grains in sample 79396 were identified as containing heavy elements of interest (Table 3).

TABLE 3: QUALITATIVE ELECTRON-PROBE MICROANALYSIS

GRAIN	ELEMENTS IDENTIFIED	PHASE INFERRED
1	U(,Pb)	Uraninite
2	Au	Native gold
3	Th,P(,U,Ca)	Th-phosphate (?monazite, ?brabantite, ?grayite)
4	Zr,Si(,U,Fe)	U-bearing zircon

The presence of essential U with minor Pb in Grain 1 is consistent with uraninite (Plate 1). This grain is closely associated with a similarly small grain of K-feldspar (essential Al, Si, K), and both grains are enclosed within quartz (essential Si only).

Only Au has been detected in Grain 2 (Plate 2). This represents a small grain of native gold, which lies in a thin irregular solution cavity or crack within a quartz grain (essential Si only).

The identification of Grain 3 (Plate 3) is somewhat less certain. It contains essential Th and P, with minor U and Ca, and the grain lies adjacent to a small zircon crystal, enclosed within quartz. It may be monazite, or possibly brabantite or grayite, viz.:

- monazite, $(Ce,La,Nb,Th)PO_4$
- brabantite, $CaTh(PO_4)_2$
- grayite, $(Th,Pb,Ca)PO_4H_2O$

Grain 4 (Plate 4) contains essential Zr and Si, with minor U and Fe. It most likely represents U-bearing zircon, and it occurs within quartz.

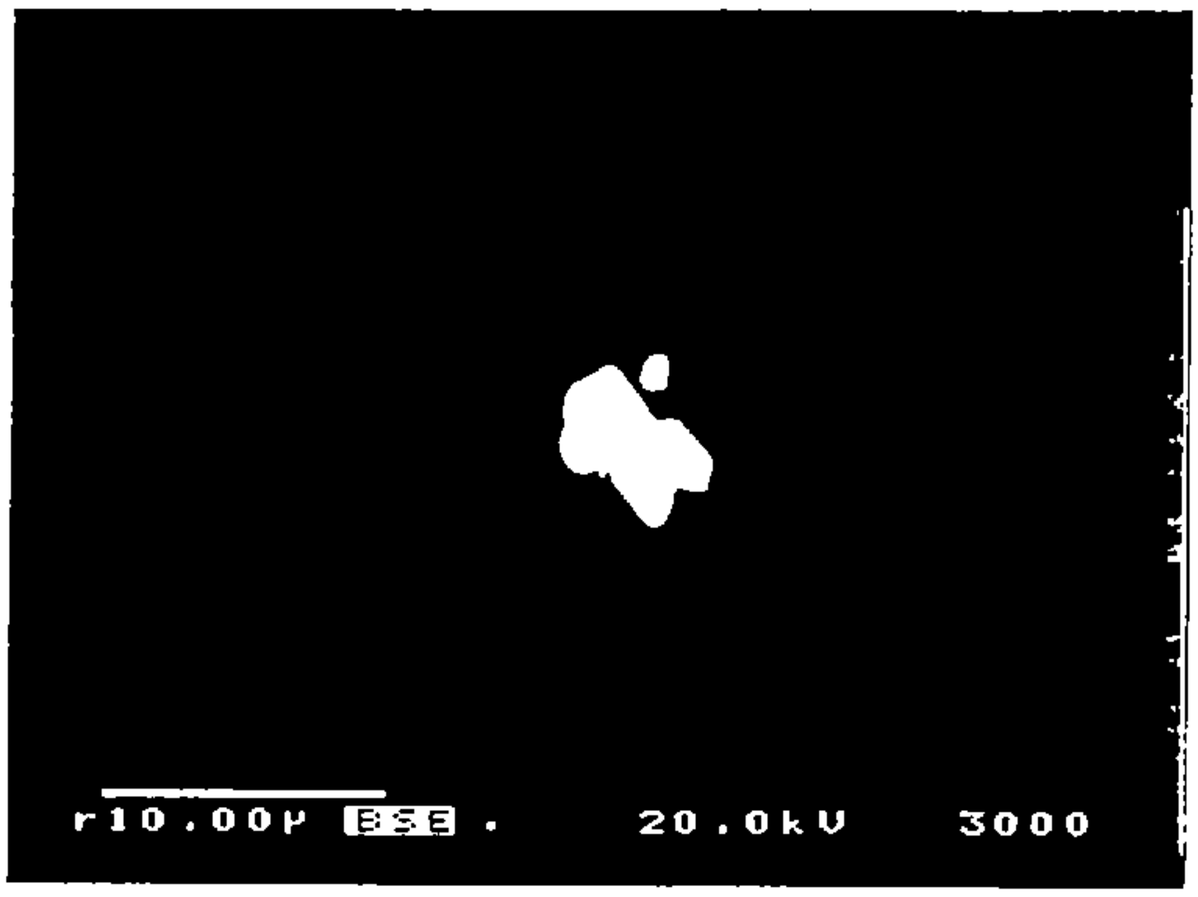

Plate 1: Sample 79396 (BSE image, 10 μm white bar for scale)
A small grain of uraninite (essential U, minor Pb; bright white grain, Grain 1, centre) lies adjacent to a small K-feldspar grain (essential Al, Si, K) within a large grain of quartz (essential Si only).

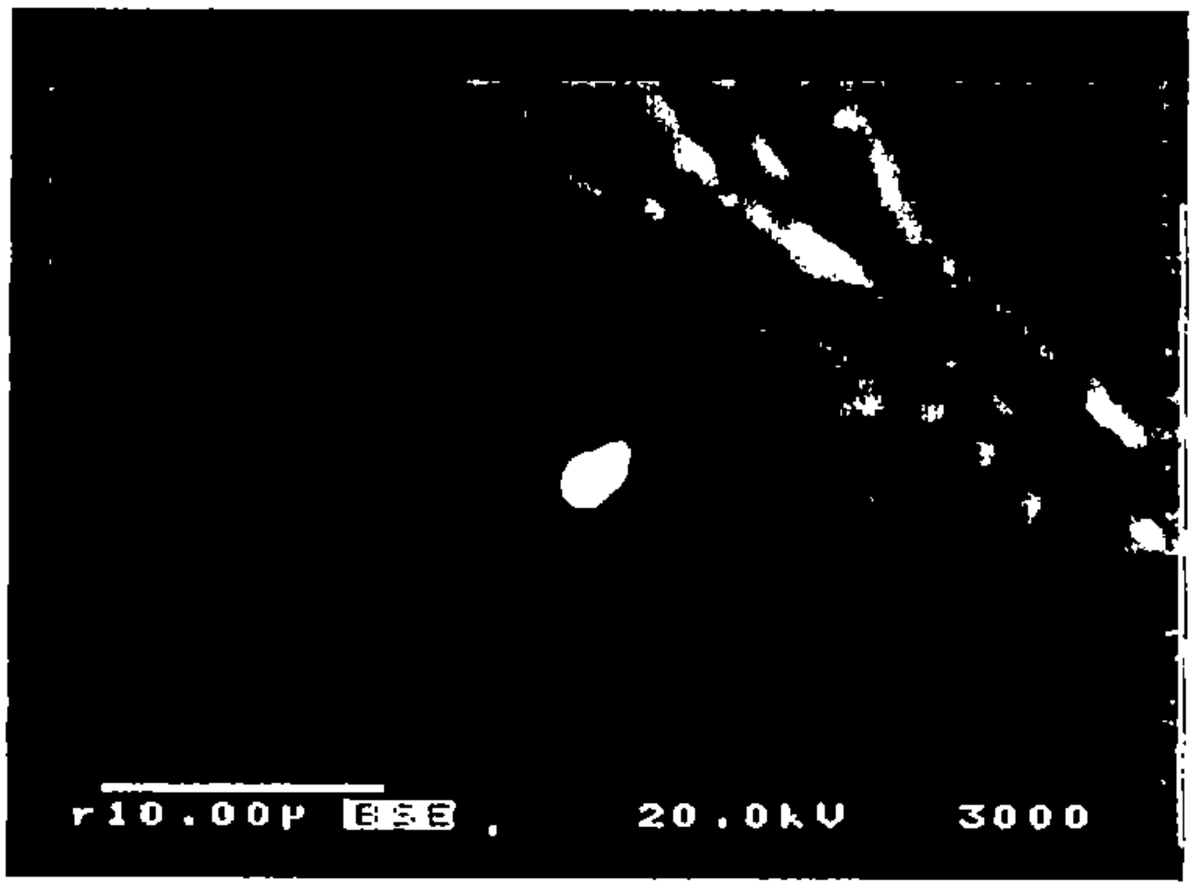

Plate 2: Sample 79396 (BSE image, 10 μm white bar for scale)
A small grain of native gold (essential Au, bright white, centre) lies in a small solution crack within a large grain of quartz (essential Si only, pale grey phase occupying most of field of view).

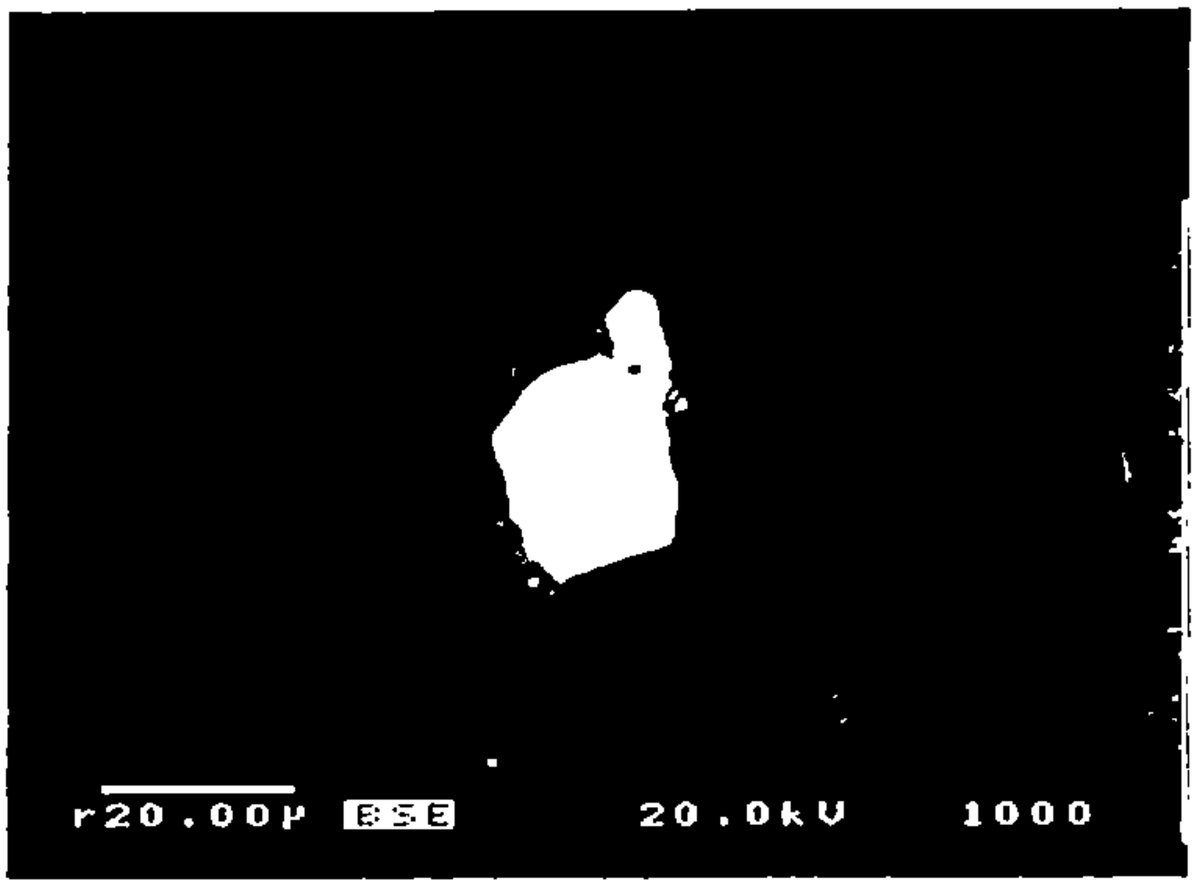

Plate 3: Sample 79396 (BSE image, 20 μm white bar for scale)
The bright white patch in the centre is composed of a larger equant euhedral crystal of zircon (essential Zr,Si) and a smaller grain of ?monazite (Grain 3, essential P,Th, minor U,Ca) located at its top right corner. Both grains lie within quartz (dull grey, essential Si only).

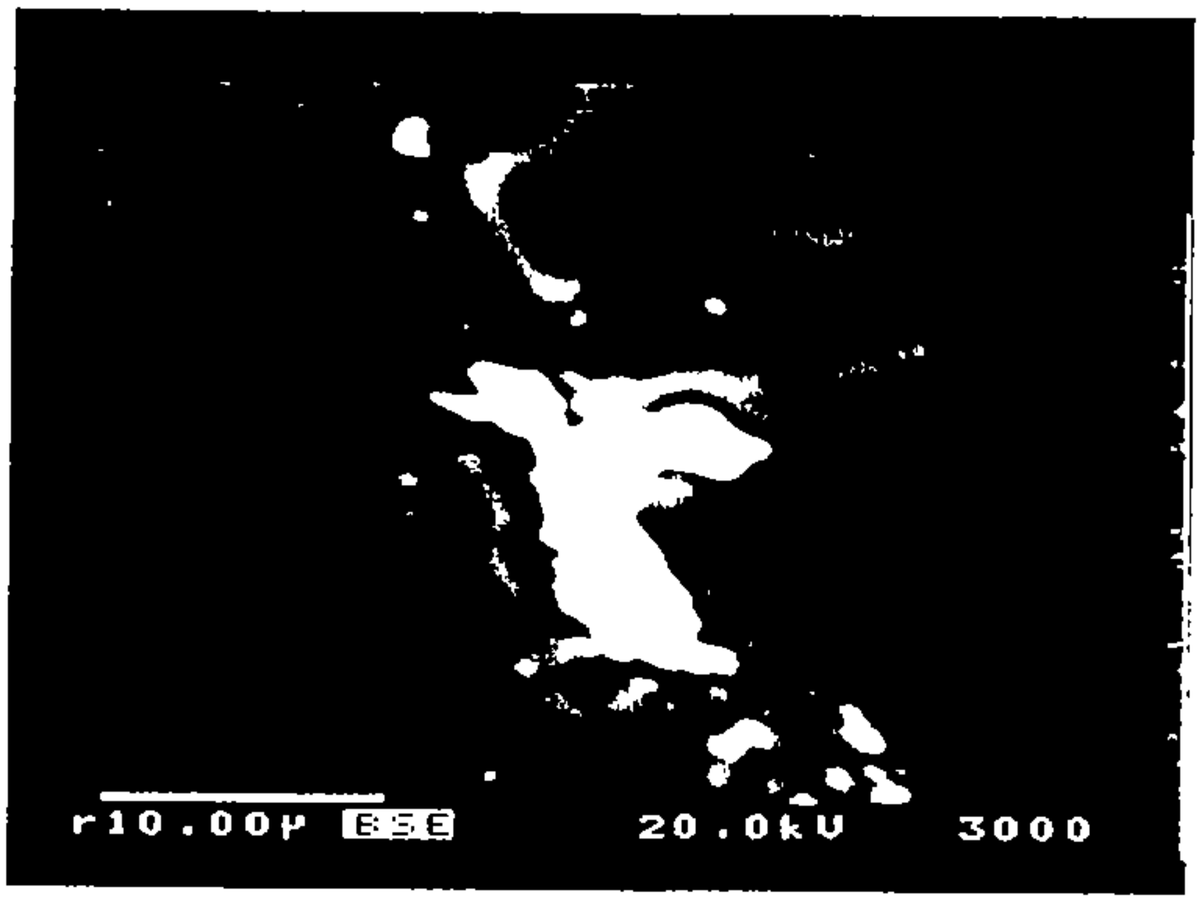

Plate 4: Sample 79396 (BSE image, 10 μm white bar for scale)
A ragged grain (bright white, centre, Grain 4) is composed of essential Zr and Si, with minor Fe, U. It may be U-bearing zircon. It lies within a large grain of quartz (essential Si only)

APPENDIX 1: Autoradiograph and XRD report

The full report from Amdel Limited is provided in the following pages.

amdel

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11 November 1996

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Attn: Dr D R Mason

REPORT G657500G/96

SECTION PREPARATION

YOUR REFERENCE:	Letter dated 21 October 1996
SAMPLE IDENTIFICATION:	77702 to 79400
MATERIAL:	6 rock samples
DATE SAMPLES RECEIVED:	22 October 1996
DATE AUTHORISATION RECEIVED:	22 October 1996
WORK REQUIRED:	Thin section (3) and polished thin section (3) preparation. X-ray diffraction analysis (1) and autoradiograph preparation (1).
INVESTIGATION AND REPORT BY:	Michael Till

Dr Keith J Henley
Manager, Mineralogical Services

cjc

SECTION PREPARATION

1. INTRODUCTION

Samples were received from Dr D R Mason of Mason Geoscience Pty Ltd with a request for section preparation, X-ray diffraction analysis and autoradiograph preparation.

2. PROCEDURE AND RESULTS

2.1 Section Preparation

The sections (TS 67118 - 67124) were prepared. They were collected by the client on 25 October 1996

2.2 XRD Analysis

A portion of the vein material from sample 79400 was pulverised and then analysed by XRD. The only mineral detected was quartz.

2.3 Autoradiograph

The section offcut from sample 79396 was smoothed and then placed on X-ray film in darkness for approximately 6 days. No black spots, indicating exposure of the film by radioactivity emanating from particles, were detected. The offcut and film were forwarded to the client.

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REPORT TITLE	**Petrographic Descriptions for a suite of Twenty Five Rock Samples, Northern Territory**
REPORT #	2270
CLIENT	Queensland Mines Pty Ltd
ORDER NO.	21061
CONTACT	John Thevissen
REPORT BY	Dr Douglas R. Mason

SIGNED

for Mason Geoscience Pty. Ltd.

DATE 20 December 1996

Petrographic Descriptions for a suite of Twenty Five Rock Samples, Northern Territory

SUMMARY

1. Rock Samples

- A suite of twenty five (25) surface and drill core rock samples from the Northern Territory has been studied using petrographic and limited X-ray diffraction methods.

2. Brief Results

- Rock names and mineralogy are summarised in Table 1.

- Cemented quartzose sandstone

  - This rock type is represented by one sample (77708).

  - It was a very mature, well-sorted quartzose sandstone that remains unmetamorphosed.

  - It has been cemented by dense goethite in dark brown portions of the rock, and by opaline silica + goethite in cream portions of the rock.

- Differentiated basic intrusion

  - Four samples represent parts of a differentiated basic intrusion (samples 77712-77715).

  - One sample (77715) represents a fine-grained olivine-bearing dolerite which may represent the parental magma of the intrusion (e.g. quickly cooled margin).

  - Other samples represent leuco-dolerites and granophyres that represent the upper, felsic parts of a differentiated tholeiitic basic intrusion.

- Altered gneisses

  - Twenty samples represent altered gneissic metamorphic rocks (samples 77709-77711; 77716-77735).

  - They were composed of assemblages dominated by quartz, feldspar (microcline, plagioclase), biotite and muscovite, with minor to accessory amounts of apatite, rutile, monazite, xenotime, and zircon. Sillimanite may have been present in some rocks. The inferred mineral assemblages and their medium-grained, foliated granoblastic metamorphic textures are consistent with medium grade (amphibolite facies) dynamic regional metamorphism of sedimentary rocks of quartzo-feldspathic to pelitic bulk composition.

  - Except for foliation of metamorphic phyllosilicates, the samples display little evidence of deformation. Quartz commonly is virtually free of strain effects, and primary spheroidal shapes of inferred siliceous clay balls (see next) are preserved.

  - Most samples appear to have been compositionally uniform, but some samples display mineralogical layering that may reflect primary sedimentary layering. Two samples (77717, 77723) contain podiform patches of quartz + muscovite + trace

?sillimanite, which are interpreted to represent non-planar primary bodies (e.g. siliceous clay balls or lenticles) in the precursor sediment.

- Hydrothermal alteration has caused selective pervasive alteration of most samples, generating assemblages of chlorite, sericite, hematite, quartz and accessory leucoxene/rutile. Metamorphic quartz, apatite, and non-reactive heavy minerals (zircon, monazite, xenotime) survived the event, and microcline was partly preserved in some rocks. Biotite commonly suffered complete replacement by chlorite ± leucoxene/rutile, but tiny flakes were preserved where enclosed in single quartz grains. Feldspar commonly was completely replaced by assemblages of sericite, chlorite and opaques (hematite).

• X-ray diffraction study of sample 77716

- As requested, XRD study of this sample was undertaken.

- Two types of white mica were identified in this sericite-altered metamorphic rock: unstable 1M-type muscovite ('sericite') is abundant, and the more stable 2M1-type muscovite (relict metamorphic muscovite) is less abundant. No other minerals were identified by XRD. Petrography identified accessory leucoxene/rutile and monazite.

TABLE 1: SUMMARY OF ROCK NAMES AND MINERALOGY

SAMPLE	ROCK NAME	MINERALOGY*			
		Primary**	Metamorphic/alteration***	Veins	Weathering
77708	Fractured, silica-goethite-cemented quartzose sandstone	Qtz,zir,rut	-	-	Sil,goe
77709	Veined, fractured, altered quartzo-feldspathic gneiss	-	Qtz,mus,zir; Alb,chl,ser,hem	Qtz,chl,hem	-
77710	Altered quartzo-feldspathic gneiss	-	Qtz,mus,bio,apa,rut; Chl,ser,opq	-	-
77711	Heavy-mineral-bearing quartzo-feldspathic gneiss	Zir	Qtz,Kf,mus,bio,rut,xen,zir,apa; Chl,ser	-	-
77712	Hornblende granophyre	Pla,qtz,hbl,bio,opq,apa,all	Ser,chl,cal	-	Goe
77713	Leuco-quartz gabbro	Pla,aug,hbl,bio,opq,qtz,Kf,apa	Ser,chl	-	-
77714	Altered leuco-quartz dolerite	Pla,aug,hbl,opq,qtz,Kf,bio,apa	Ser,?pre,act,chl,leu	Act	-
77715	Olivine dolerite	Pla,aug,ol,opq,qtz,bio,apa	Ser,chl,opq	-	-
77716	Sericitised altered gneiss	Qtz,mus	Ser,rut/leu,mon	-	-
77717	Sericite-hematite-altered podiform gneiss	-	Qtz,mus,sil,mon; Ser,hem	-	-
77718	Sericite-chlorite-quartz altered quartzo-feldspathic gneiss	-	Qtz,mus,mon,bio; Ser,chl,qtz,opq	-	-
77719	Sericite-chlorite-quartz altered quartzo-feldspathic gneiss	-	Qtz,mus,bio,zir; Ser,chl,qtz,opq,rut	-	-
77720	Sericite-chlorite altered quartzo-feldspathic gneiss	-	Qtz,Kf,mus,bio,zir; Ser,chl	-	-
77721	Sericite altered siliceous quartzo-feldspathic gneiss	-	Qtz,mus,rut,bio,zir; Ser,opq	-	-
77722	Chlorite-sericite-hematite altered layered quartzo-feldspathic gneiss	-	Qtz,apa,zir; Chl,ser,opq,qtz	-	-
77723	Sericite-chlorite altered podiform quartzo-feldspathic gneiss	-	Qtz,mus,?sil; Ser,chl	-	-
77724	Chlorite-quartz-hematite altered quartzo-feldspathic gneiss	-	Qtz,rut,tou,apa,zir; Chl,qtz,ser,opq	-	-
77725	Chlorite altered layered quartzo-feldspathic gneiss	-	Qtz,Kf,mus,apa; Chl,opq,ser	-	-
77726	Sericite-chlorite-hematite altered quartzo-feldspathic gneiss	-	Qtz,Kf,mus,rut,zir,bio,tou; Ser,chl,opq	Ser	-
77727	Chlorite-sericite-hematite altered micaceous gneiss	-	Qtz,bio; Chl,ser,opq,leu/rut	-	-
77730	Chlorite altered micaceous gneiss	-	Qtz,apa; Chl,qtz,opq,leu	-	-
77732	Chlorite altered micaceous gneiss	-	Qtz,apa,zir; Chl,leu	-	-
77733	Chlorite altered quartzo-?feldspathic gneiss	-	Qtz,mus,apa; Chl,leu	-	-
77734	Veined, chlorite-sericite-quartz altered micaceous gneiss	-	Qtz,mus,bio,apa,zir; Chl,qtz,ser,opq,leu	Qtz,chl,opq	-
77735	Chlorite altered micaceous gneiss	-	Apa,zir; Chl,leu/rut	-	-

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. Act = actinolite, alb = albite, all = allanite; apa = apatite, aug = augite, bio = biotite; cal = calcite; chl = chlorite; goe = goethite; hbl = hornblende, hem = hematite, Kf = K-feldspar; leu = leucoxene; mon = monazite, mus = muscovite, ol = olivine; opq = undifferentiated opaques; pla = plagioclase; pre = prehnite; qtz = quartz; rut = rutile, ser = sericite; sil = sillimanite; tou = tourmaline; xen = xenotime; zir = zircon; ? = uncertain identification.

1. INTRODUCTION

A suite of twenty five (25) rock samples was received from Mr John Thevissen (Queensland Mines Pty Ltd., Darwin, Northern Territory) on 29 November 1996.

Particular requests were:

i) To prepare a thin section and routine petrographic description for each rock sample (service code PETRO 2.1).

ii) To provide mineral identification by X-ray diffraction methods for those samples marked for this service.

This report contains the full results for this work.

2. METHODS

The samples were examined in hand specimen and marked for section preparation. Standard thin sections were obtained from an external laboratory (T. & S. Bradley, Eastwood, NSW).

At Mason Geoscience Pty Ltd, conventional transmitted light microscopy was used to prepare the routine petrographic descriptions.

One sample was submitted for mineral identification by whole-rock X-ray diffraction methods. The full report from Amdel Limited is provided as APPENDIX 1 of this report.

3. PETROGRAPHIC DESCRIPTIONS

The petrographic descriptions are provided in the following pages.

SAMPLE : 77708

SECTION NO. : 77708

HAND SPECIMEN : The drill core rock sample is composed of even-grained cream-coloured quartzose sandstone, partly invaded by massive matrix alteration of dark brown iron oxide. Shapes of the contact between the dark brown and paler portions of the rock suggest that the brown material has invaded the cream material (i.e. contact is convex toward the brown material).

ROCK NAME : **Fractured, silica-goethite-cemented quartzose sandstone**

PETROGRAPHY :

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

Mineral	**Vol.%**	**Origin**
Silicified quartzose sandstone		
Quartz	80	Clastic particles
Opaline silica	15	Cement
Iron oxide	5	Cement
Ferruginised quartzose sandstone		
Quartz	80	Clastic particles
Zircon	Tr	Clastic particles
Rutile	Tr	Clastic particles
Iron oxide (goethite)	20	Cement

In thin section, this sample displays a well-sorted grain-supported arenaceous clastic sedimentary texture, modified by cementation.

Quartz dominates the rock, occurring as rounded particles mostly ~0.4-1.0 mm in size. Some smaller particles ~0.1 mm in size occur in interstices. The particles are almost entirely fragments of single crystals, but a few polycrystalline fragments are also present.

Rare small clastic particles of zoned zircon and subhedral rutile crystals are identified.

The cement is composed of colloform to botryoidal materials that are cryptocrystalline to amorphous. Although structurally similar throughout the rock, the composition of the cement differs in the two differently coloured portions:

i) In the paler cream portion, the cement is composed of cryptocrystalline to amorphous colourless opaline silica, through which are distributed very fine patches of dark brown iron oxide (probably the hydrated iron oxide, goethite).

ii) In the dark brown portion, the cement is composed of dense dark reddish brown cryptocrystalline to amorphous iron oxide (probably mostly goethite).

Cutting the rock is a single planar fracture. It is filled by dense dark reddish brown iron oxide (goethite), and quartz particles have suffered brittle fracturing and local brecciation in the vicinity of the fracture.

INTERPRETATION:

This sample represents a well-sorted arenaceous clastic sedimentary rock. It was originally composed of abundant well-sorted, closely packed, well-rounded quartz particles, with rare zircon and rutile particles. The sediment was compositionally very mature, and had been transported over a considerable distance.

Subsequent infilling of interparticle pore spaces generated the cement. Two phases of infilling may have occurred:

i) Initial infilling generated opaline silica + minor goethite, as observed in the cream portion.

ii) Further invasion by fluids generated more abundant goethite in the darker portions of the rock.

Widely-spaced fracturing of the rock body may have occurred during this event, as the fracture plane is filled by iron oxides similar to that which fills interparticle pores.

SAMPLE : 77709

SECTION NO. : 77709

HAND SPECIMEN : The drill core rock sample represents a pale pink felsic crystalline rock that is cut by a thin fracture set and thicker grey quartz-rich veins.

ROCK NAME : **Veined, fractured, altered quartzo-feldspathic gneiss**

PETROGRAPHY :

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

Mineral	Vol.%	Origin
Quartz	74	Metamorphic / vein filling
Muscovite	2	Relict metamorphic
Zircon	Tr	?Relict metamorphic
Biotite	Tr	Relict metamorphic
Albite (after K-feldspar)	20	Alteration
Chlorite	2	Alteration / vein filling
Sericite	1	Alteration
Hematite	1	Alteration / vein filling

In thin section, this sample displays a gneissic crystalline metamorphic texture that has been modified by fracturing, veining and retrogressive alteration.

Quartz dominates the rock. Most occurs as large anhedral grains ~1-2 mm in size distributed throughout the rock. It is the sole mineral in quartz-rich veins, but there is no textural difference between vein quartz and wall rock quartz except for somewhat larger vein crystals and more planar quartz-quartz grain boundaries. Finer-grained quartz fills some discontinuous veins.

Small fluid inclusions ~2-5 μm in size occur abundantly in clouds in the vein quartz, and in wall rock quartz they are restricted to trails along thin parallel sealed microcracks that lie subparallel to the main quartz veining.

Feldspar is moderately abundant. It occurs as anhedral grains distributed throughout the rock. All display the combined albite and pericline twinning typical of microcline, but all grains appear to have been completely replaced by optically continuous albite. The feldspar is more abundant in some areas than in others, suggesting the rock may be mineralogically banded.

Muscovite occurs in minor amount as ragged flakes. Tiny sericite flecks are sprinkled through albitised feldspar grains, and also occurs elsewhere through the rock.

Chlorite occurs in two sites:

i) Some forms pleochroic green replacements of precursor biotite. Confirmation of the precursor is provided by the presence of rare tiny brown biotite flakes which are preserved in some large quartz grains.

ii) Chlorite also occurs as exceptionally fine-grained, green, massive aggregates that fill small patches in some discontinuous vein-like structures.

Hematite occurs in minor amount as small acicular crystals confined to some thin discontinuous veins.

Zircon occurs as small subhedral crystals in large quartz grains.

INTERPRETATION:

This sample represents a gneissic rock, originally composed of abundant quartz, lesser feldspar (probably microcline), and minor biotite, muscovite and zircon. Its mineralogy and texture suggest if formed by medium-grade regional metamorphism of a quartzo-feldspathic precursor rock of uncertain origin.

The rock body suffered strong fracturing and invasion by hydrothermal fluids. This resulted in filling of fractures by quartz + minor chlorite + hematite. Abundant tiny fluid inclusions were trapped in vein quartz, and along sealed microcracks in wall rock quartz. Broadly mesothermal conditions are inferred for the hydrothermal event, as supported by the similar grain size of wall rock and vein quartz and optical continuity between wall rock and vein quartz.

SAMPLE : 77710

SECTION NO. : 77710

HAND SPECIMEN : The drill core rock sample represents an even-grained, medium-grained felsic crystalline rock, in which layering is defined by subtle colour differences (paler grey, pale pink).

ROCK NAME : **Altered quartzo-feldspathic gneiss**

PETROGRAPHY :

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

Mineral	Vol.%	Origin
Quartz	75	Metamorphic
Muscovite	2	Metamorphic
Apatite	<1	Metamorphic
Rutile	Tr	Metamorphic
Biotite	Tr	Relict metamorphic
Chlorite	20	Alteration
Sericite	1	Alteration
Opaques (incl. hematite)	<1	Alteration

In thin section, this sample displays a granoblastic weakly foliated metamorphic texture with indistinct mineralogical layering, modified by selective alteration.

Quartz dominates the rock, occurring as anhedral grains ~0.4-1.0 mm in size. More elongate grains lie subparallel to weak mineralogical layering and foliation. Indistinct trails of fluid inclusions traverse the rock. Most of the inclusions appear to be filled by a dark vapour bubble, suggestive of a CO_2-rich composition.

Chlorite occurs in significant amount in two sites:

i) Most occurs as very fine-grained dense massive aggregates that have pseudomorphously replaced anhedral precursor grains, most likely feldspar but none is preserved. This chlorite is virtually colourless.

ii) A smaller amount of chlorite occurs as pleochroic pale green replacements of precursor biotite flakes whose preferred orientation contributed to a moderate metamorphic foliation. Rare small tan brown biotite flakes are preserved where enclosed by single large quartz grains.

Muscovite occurs as ragged plates up to ~0.5 mm in size. They tend to be concentrated most abundantly in a single thick band where altered feldspar grains are virtually absent.

Apatite occurs in minor amount as small equant but anhedral grains, with typical lack of colour and moderate relief. They tend to be concentrated loosely in particular horizons.

Opaques occur as tiny specks and small dark aggregates that are concentrated in, and around margins of, chlorite-altered feldspar grain sites.

Rutile is rare, forming small subhedral crystals.

INTERPRETATION:

This sample represents a quartzo-feldspathic gneiss, originally composed of the medium-grade metamorphic assemblage of quartz, feldspar, minor biotite, muscovite, and accessory apatite and rutile. The rock was weakly mineralogically layered, and a foliation was developed subparallel to the layering. There are few clues as to the nature of the precursor rock. However, the mineralogy (including- high abundance of quartz) is consistent with a quartz-rich quartzo-feldspathic sediment.

Subsequent low-grade hydrothermal alteration resulted in selective replacement of feldspar by chlorite + trace sericite + hematite, and replacement of biotite by chlorite.

SAMPLE : 77711

SECTION NO. : 77711

HAND SPECIMEN : The drill core rock sample represents a pale grey quartzo-feldspathic crystalline rock, in which weak mineralogical layering is defined by variable abundance of pale pink feldspar and finer-grained brownish layers.

ROCK NAME : **Heavy-mineral-bearing quartzo-feldspathic gneiss**

PETROGRAPHY :

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

Mineral	**Vol.%**	**Origin**
Quartz	65	Metamorphic
K-feldspar (microcline)	25	Metamorphic
Muscovite	3	Metamorphic
Biotite	Tr	Metamorphic
Rutile	2	Metamorphic
Xenotime	2	Metamorphic
Zircon	<1	Relict clastic / metamorphic
Apatite	Tr	Metamorphic
Chlorite	1	Alteration
Sericite	1	Alteration

In thin section, this sample displays a foliated granoblastic metamorphic texture with indistinct mineralogical layering, with only slight alteration.

Quartz is abundant, forming anhedral grains ~0.4-3.0 mm in size. It is distributed throughout the rock.

K-feldspar (microcline) is the other principal mineral. It occurs as anhedral grains of variable size, ~0.4-3.0 mm. They display the combined albite and pericline twinning typical of microcline, and are quite fresh.

Both muscovite and biotite occur in minor amount. Muscovite forms ragged plates up to ~0.5 mm in size. It tends to be concentrated in particular poorly-defined horizons. Biotite forms better-crystallised flakes, but most have suffered replacement by pale green chlorite. Some biotite flakes enclosed in quartz are preserved, and display pleochroism from dark tan brown to pale yellow.

Small crystals of heavy minerals are concentrated in poorly-defined horizons. Rutile forms angular equant dark reddish brown crystals. It tends to be intergrown with small prismatic clear to very pale yellowish crystals of xenotime (uniaxial positive optic figures obtained), but xenotime also occurs as discrete crystals. Zircon forms small, more turbid grains that display truncated zoning, confirming their primary clastic origin. Some zircons contain thin overgrowths of probable metamorphic origin.

Apatite occurs as small subhedral colourless grains.

Sericite occurs in trace amount as massive, cryptocrystalline replacements of anhedral grains that in places are weakly porphyroblastic. Their identity remains uncertain: possible phases are plagioclase and cordierite.

INTERPRETATION:

This sample represents a quartzo-feldspathic gneiss composed of weakly layered assemblages of quartz and microcline, minor biotite and muscovite, and accessory rutile, xenotime, zircon and apatite. It formed by medium-grade regional metamorphism of a quartzo-feldspathic rock, possibly a feldspathic sandstone. The heavy mineral concentrations may represent recrystallised sedimentary heavy mineral lag laminae. The significant abundance of xenotime and zircon may be responsible for any radioactive signal from the rock.

Weak retrogressive alteration has caused sericitic replacement of a minor metamorphic phase, possibly plagioclase or cordierite.

SAMPLE : 77712

SECTION NO. : 77712

HAND SPECIMEN : The surface rock sample represents a massive coarse-grained mesocratic igneous rock, composed of randomly oriented bladed dark green ferromagnesian crystals and interstitial pink felsic grains.

The sample responds weakly to the hand magnet, suggesting minor magnetite is present.

ROCK NAME : **Hornblende granophyre**

PETROGRAPHY :

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

Mineral	**Vol.%**	**Origin**
Plagioclase	43	Igneous
K-feldspar	15	Igneous
Quartz	20	Igneous
Hornblende	8	Igneous
Apatite	Tr	Igneous
Opaques (incl. magnetite)	2	Igneous
Allanite	Tr	Relict igneous
Chlorite (incl. biotite)	10	Alteration (incl. igneous)
Calcite	Tr	Alteration
Sericite	1	Alteration
Goethite	1	Alteration (weathering)

In thin section, this sample displays a massive micrographic granitoid texture, modified by mild alteration.

Plagioclase occurs as large randomly oriented prisms ~1-3 mm long. Most have suffered partial replacement by small wisps of sericite.

Large interstitial areas are filled by equant subhedral quartz crystals which grow in optical continuity into micrographic intergrowths of quartz and turbid brownish K-feldspar. The K-feldspar also forms overgrowths on plagioclase prisms.

Hornblende forms anhedral ragged grains, pleochroic in deep greens, moulded on plagioclase crystals. It tends to form in the interstitial areas. Most of the hornblende grains have suffered partial replacement by ragged calcite patches and deep red iron oxide patches.

Biotite occurs in some abundance in the interstitial areas, where it forms fibrous curved aggregates variably pleochroic in reddish browns and greens. Some of the biotite has been replaced by paler green chlorite.

Opaques occur in significant amount, forming angular equant grains (probably magnetite, possibly partly hematised). Minor thin opaque blades may be late-forming ilmenite, and are intergrown with interstitial micrographic quartz and K-feldspar.

Apatite occurs as acicular colourless crystals in interstitial areas.

Allanite forms uncommon subhedral blocky prisms, pleochroic in dark browns and displaying growth zoning.

INTERPRETATION:

This sample represents a mesocratic granitic rock composed of plagioclase, quartz, K-feldspar, hornblende, biotite, and minor opaques (magnetite, ilmenite), apatite and allanite. The presence of micrographic interstitial intergrowths of quartz and K-feldspar, and acicular apatite, suggest that the magma crystallised relatively quickly at final stages of consolidation.

It is likely that this rock formed as part of the final fractionate of a differentiated mafic intrusion. This interpretation is supported by the abundance of micrographic intergrowths and the abundance of hornblende, biotite, and opaques.

SAMPLE : 77713

SECTION NO. : 77713

HAND SPECIMEN : The surface rock sample represents a massive, coarse-grained leuco-gabbroic igneous rock, composed of abundant dark waxy grey feldspar, scattered black ferromagnesian grains, and minor interstitial pink K-feldspar.

The rock responds strongly to the hand magnet, suggesting magnetite is moderately abundant.

ROCK NAME : **Leuco-quartz gabbro**

PETROGRAPHY :

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

Mineral	**Vol.%**	**Origin**
Plagioclase (incl. sericite)	57	Igneous (incl. alteration)
Clinopyroxene (augite)	20	Igneous
Hornblende	5	Igneous
Micrographic intergrowths (qtz + Kf)	8	Igneous
Opaques (incl. magnetite)	5	Igneous
Biotite (incl. chlorite)	5	Igneous (incl. alteration)
Apatite	Tr	Igneous

In thin section, this sample displays a gabbroic igneous texture, with large ophitic pyroxene crystals and interstitial micrographic intergrowths.

Plagioclase is abundant, forming randomly oriented prismatic crystals ~1 mm long. Most have suffered partial replacement by wispy patches of sericite. Some smaller plagioclase crystals are enclosed in large augite plates.

Clinopyroxene (augite) is moderately abundant, forming large anhedral plates that have enclosed smaller plagioclase prisms (ophitic texture commonly observed in basic igneous rocks). Hornblende commonly forms pleochroic green overgrowths on some pyroxene crystals.

Interstitial micrographic intergrowths of clear quartz and turbid brownish K-feldspar are scattered through the rock. They are the pink patches observed in hand specimen.

Opaques are moderately abundant, occurring as large angular grains and aggregates intergrown with pyroxene and plagioclase. The forms and magnetic response of the hand specimen suggest that most of the opaque material is magnetite.

Interstitial patches are filled by fine-grained green chlorite and larger flakes of biotite that are variably pleochroic in browns and greens. In places, distinction between green biotite and chlorite is difficult.

Apatite occurs in accessory amount as small acicular crystals in the micrographic interstitial areas.

INTERPRETATION:

This sample represents a felsic gabbroic igneous rock, composed mainly of abundant plagioclase and lesser augite, with minor hornblende, opaques (mainly magnetite), biotite, interstitial micrographic quartz and K-feldspar, and accessory apatite.

The mineralogy and texture of the rock are consistent with development by crystallisation differentiation of a basic intrusive body. The sample represents part of the more differentiated, upper part of the main body of the intrusion. The presence of interstitial micrographic intergrowths indicates that the magma developed from a tholeiitic (silica-saturated to oversaturated) basic magma. Note that this sample is less differentiated than the previous sample, 77712, to which it is genetically related.

SAMPLE : 77714

SECTION NO. : 77714

HAND SPECIMEN : The surface rock sample represents a massive grey crystalline rock through which are scattered larger cream feldspar grains and black ferromagnesian grains.

The sample fails to respond to the hand magnet, suggesting magnetite is absent.

ROCK NAME : **Altered leuco-quartz dolerite**

PETROGRAPHY :

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

Mineral	Vol.%	Origin
Plagioclase (incl. sericite, ?prehnite)	63	Igneous (incl. alteration)
Clinopyroxene (augite)	20	Igneous
Hornblende	5	Igneous
Opaques (incl. leucoxene)	3	Igneous (incl. alteration)
Biotite	1	Igneous
Quartz	3	Igneous
K-feldspar	1	Igneous
Apatite	Tr	Igneous
Actinolite	1	Alteration / vein filling
Chlorite	2	Alteration

In thin section, this sample displays an ophitic, subporphyritic igneous texture that has been modified by mild selective pervasive alteration and weak veining.

Plagioclase is abundant, forming randomly oriented small prisms ~0.4 mm long, with some larger crystals ranging up to ~1 mm. Some are poikilitically enclosed in large augite crystals. Most plagioclase has suffered partial replacement by fibrous patches of poorly crystallised sericite, and possibly associated prehnite.

Clinopyroxene (augite) is moderately abundant, forming large poikilitic plates ~2-3 mm in size. They display a very pale buff brown colour, and some display weak compositional zoning. They tend to enclose small plagioclase prisms in classic ophitic texture.

Hornblende occurs as pleochroic pale brownish green to green overgrowths on some augite plates, and also as angular interstitial grains. Some hornblende grains display colour zoning, from darker brown to green.

Opaques occur as large angular grains that tend to be moulded on plagioclase prisms. Many display incipient replacement by turbid dark brownish leucoxene. This alteration, together with the lack of magnetic response of the hand specimen, suggests that most of the opaque phase was magnetite.

Biotite is present in minor amount as small ragged flakes, pleochroic from reddish tan brown to pale yellow. Many are closely associated with margins of the opaque grains.

Clear quartz occurs in minor amount as angular interstitial fillings, scattered through the rock. In places, the quartz is associated with angular grains of turbid K-feldspar, and some interstitial areas display micrographic intergrowths of quartz and K-feldspar.

Apatite forms acicular clear crystals, commonly located in the interstitial areas composed of quartz and K-feldspar.

Chlorite occurs in minor amount as dense green aggregates that have replaced scattered anhedral ferromagnesian grains (probably augite, inferred from presence of enclosed plagioclase prisms).

Actinolite is present in minor amount as fibrous replacements around margins of some altered pyroxene grains, and as sheaves of crystals in one thin vein that cuts the rock.

INTERPRETATION:

This sample represents a basic igneous rock, originally composed mainly of plagioclase and augite, with lesser hornblende, opaques (magnetite), and minor biotite, quartz, K-feldspar and apatite. The mineralogy and texture are consistent with development of the rock by crystallisation of the relatively differentiated (upper) part of a basic intrusion. The primary basaltic magma was tholeiitic in magmatic affinity, as confirmed by the presence of primary quartz in the interstitial residuum.

This sample is similar mineralogically to the previous sample (77713), but is less evolved and finer-grained.

Subsequent weak alteration affected the rock body, generating sericite + ?prehnite + actinolite by partial replacement of plagioclase and augite. A small amount of actinolite filled minor thin fractures.

SAMPLE : 77715

SECTION NO. : 77715

HAND SPECIMEN : The surface rock sample is a fine-grained, massive, dark grey rock with minor scattered pale creamish green altered feldspar crystals.

The sample responds weakly to the hand magnet, suggesting minor magnetite is present.

ROCK NAME : **Olivine dolerite**

PETROGRAPHY :

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

Mineral	**Vol.%**	**Origin**
Plagioclase (incl. sericite)	65	Igneous (incl. alteration)
Sericite	3	Alteration (after igneous phenocrysts)
Olivine (incl. chlorite)	2	Igneous (incl. alteration)
Clinopyroxene (augite)	25	Igneous
Opaques (incl. magnetite)	3	Igneous
Quartz	1	Igneous
Biotite	Tr	Igneous
Apatite	Tr	Igneous

In thin section, this sample displays a massive, sparsely porphyritic, weakly vesicular doleritic igneous texture, modified by slight alteration.

Plagioclase is abundant, and occurs in two forms:

i) Most occurs as small randomly oriented laths ~0.4 mm long. Most have suffered partial replacement by fine flecks and patches of sericite, possibly also including some prehnite.

ii) A small amount of plagioclase occurred as large prismatic phenocrysts ~2-4 mm long. They have been completely replaced by dense fine mats of sericite.

Clinopyroxene (augite) is the other principal phase. It forms small angular pale pinkish brown plates ~0.2-0.4 mm in size that subophitically enclose plagioclase laths. The pyroxene is quite fresh.

Olivine occurs as small subhedral grains ~0.1-0.2 mm in size, sparsely scattered through the rock. Some remain fresh, displaying their typical lack of colour, moderate relief, straight extinction against prism faces, and moderate birefringence. Many have suffered replacement by very fine-grained green to brown-green chloritic material and very fine-grained opaque material.

Opaques occur in three forms:

i) Some occurs as equant blocky grains sparsely but uniformly distributed through the groundmass. This appears to be magnetite.

ii) Some forms small lath-like crystals, also sparsely but uniformly distributed through the rock. This most likely is ilmenite.

iii) A small amount occurs as very fine-grained granules and aggregates, intergrown with chlorite in altered ferromagnesian (mostly olivine) grain sites. This most likely is alteration magnetite.

Quartz occurs in minor amount as small angular clear interstitial patches. Small acicular apatite crystals are intergrown with the quartz.

Biotite is uncommon, forming small pleochroic dark brown flakes in interstitial patches.

Uncommon round structures ~0.5 mm in diameter are filled by dense massive fine-grained chlorite, uncommon well-crystallised biotite flakes, and small quartz grains. These appear to be filled vesicles.

INTERPRETATION:

This sample represents a fine-grained doleritic igneous rock, originally composed of sparsely scattered plagioclase phenocrysts in a finer-grained groundmass of plagioclase laths, augite, minor olivine, and accessory opaques (magnetite, ilmenite), quartz, apatite and biotite.

The primary basaltic magma was of tholeiitic magmatic affinity. Olivine was an early-crystallising phase, and failed to react with silica-oversaturated residual liquid owing to the relatively rapid crystallisation of the magma. This may have occurred at or near the margin of the intrusive body. This sample represents the parent magma from which the differentiated dolerites described elsewhere in this report have evolved. Particular petrographic features of this sample which provide a genetic link to the granophyric dolerites include the form and colour of the augite, and the presence of interstitial late-forming quartz.

Subsequent low-grade alteration generated minor sericite + chlorite, after plagioclase and olivine respectively.

SAMPLE : 77716

SECTION NO. : 77716

HAND SPECIMEN : The drill core rock sample is uniformly very fine-grained and pale yellowish cream in colour. A weak foliation is defined by slightly darker, thin, orange-yellow foliae, giving the impression of a pervasively altered schistose rock. Minor grey quartz-rich patches are elongated within the trace of a precursor foliation.

ROCK NAME : **Sericite altered gneiss**

PETROGRAPHY :

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

Mineral	**Vol.%**	**Origin**
Quartz	5	Relict metamorphic
Muscovite	5	?Relict metamorphic / ?alteration
Rutile (incl. leucoxene)	1	?Relict metamorphic / alteration
Monazite	Tr	?Relict metamorphic
Sericite	90	Alteration

[N.B.: XRD has identified two types of white mica: 1M-type is most abundant, and $2M_1$-type is less abundant.]

In thin section, this sample displays severe pervasive alteration with minor relict metamorphic mineralogical and textural features.

White mica dominates the rock, occurring in two forms:

i) Most of the white mica occurs as tiny ragged flecks (sericite) that form a dense, massive mat throughout the rock. There are few relict textural features to indicate what it has replaced (but see next). This is the 1M-type white mica identified by XRD.

ii) A small amount of white mica occurs as larger, optically continuous flakes up to ~1-2 mm in size. They appear to be relict larger flakes of precursor metamorphic origin. This is the $2M_1$-type mica identified by XRD. In places they have clearly suffered partial replacement by sericite.

Quartz occurs in minor amount as coarse-grained lenticular aggregates. Fluid inclusions are present in moderate amount, mostly entrained along sealed microcracks. Two types are evident: two-phase inclusions almost completely filled by a large dark vapour bubble may be CO_2-rich, but other inclusions containing a small pale vapour bubble appear to be aqueous.

Rutile occurs in minor amount. Some occurs as larger granular aggregates, but some occurs as very fine-grained turbid grains in loose aggregates. Much of the latter fine-grained rutile/leucoxene is concentrated in loose aggregates aligned within the trace of a precursor foliation.

Monazite occurs in trace amount as small subhedral equant crystals.

INTERPRETATION:

This sample has suffered intense pervasive alteration, generating a dense fine-grained mat of sericite (relatively unstable 1M-type by XRD). Leucoxene formed fine-grained aggregates aligned within the trace of a precursor foliation, possibly mimicking precursor phyllosilicate flakes (?biotite, ?muscovite). Fluid inclusions trapped along sealed microcracks in quartz probably represent samples of the hydrothermal fluid responsible for alteration: the presence of both vapour-rich and liquid-rich inclusions suggests that the fluids were boiling during alteration.

The nature of the precursor rock has been almost completely obscured by the alteration affects. However, it may have been a phyllosilicate-rich metamorphic rock (schist or gneiss), composed of mica + quartz, and may therefore have been a meta-sediment of pelitic composition.

SAMPLE : 77717

SECTION NO. : 77717

HAND SPECIMEN : The drill core rock sample represents a felsic gneiss in which large paler patches lie in a reddish brown matrix.

ROCK NAME : **Sericite-hematite-altered podiform gneiss**

PETROGRAPHY :

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

Mineral	Vol.%	Origin
Sericite-hematite altered matrix of gneiss		
Quartz	50	Metamorphic
Muscovite	5	Metamorphic
Monazite	Tr	Metamorphic
K-feldspar (microcline)	Tr	Metamorphic (inclusions in quartz)
Sericite	40	Alteration
Opaques (incl. hematite)	5	Alteration
Felsic patches		
Quartz	63	Metamorphic
Muscovite	30	Metamorphic
?Sillimanite	<1	Metamorphic
Sericite	5	Alteration
Hematite	1	Alteration

In thin section, this sample displays a relict granoblastic metamorphic texture, with large relict felsic patches ~2 cm in size, modified by pervasive alteration.

Sericite-hematite altered matrix of gneiss is composed of anhedral grains of clear quartz ~0.5 mm in size which lie in a network of very fine-grained massive sericite. The precursor material replaced by the sericite is uncertain, but feldspar was likely, a suggestion supported by the presence of rare small rounded grains of microcline preserved in single quartz grains. Muscovite flakes occur in minor amount, and appear to represent relict metamorphic flakes.

Opaques (mostly hematite) occur as very fine-grained dense aggregates that are sprinkled through the sericite mats.

Monazite occurs in trace amount as small equant crystals.

Felsic patches are composed mostly of quartz and muscovite. The quartz forms elongate anhedral grains, notably more elongate than the quartz which occurs in the surrounding matrix areas. Tiny acicular crystals (probably sillimanite) are distributed through the quartz. Muscovite occurs as optically continuous patches that appear to have formed around margins of the large elongate quartz grains. Fine-grained dense sericite forms minor replacement patches, and hematite occurs in minor amount as aggregates and angular grains.

INTERPRETATION:

This sample represents a gneissic rock of medium-grained regional metamorphic origin that has suffered pervasive alteration by sericite + hematite. Most of the alteration occurred in the matrix areas of the gneiss, where precursor ?feldspar has been completely replaced by sericite + hematite.

The nature of the gneissic rock has been obscured by the effects of alteration. However, it was essentially quartzo-feldspathic in composition, and contained cm-sized felsic patches. Those patches recrystallised to assemblages of quartz + muscovite + trace sillimanite during metamorphism, suggesting they were peraluminous in composition and therefore possibly aluminous sedimentary materials (compare similar podiform patches, interpreted to have been siliceous clay balls, in sample 77723).

SAMPLE : 77718

SECTION NO. : 77718

HAND SPECIMEN : The drill core rock sample represents a fine- to medium-grained crystalline rock that has suffered pervasive alteration, generating ragged large dark greenish patches and small cream altered grains.

ROCK NAME : **Sericite-chlorite-quartz altered quartzo-feldspathic gneiss**

PETROGRAPHY :

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

Mineral	**Vol.%**	**Origin**
Quartz	35	Metamorphic
Muscovite	<1	Metamorphic
Monazite	Tr	Metamorphic
Biotite	Tr	Metamorphic (inclusions in quartz)
Sericite (incl. ?clays)	25	Alteration
Chlorite	20	Alteration
Quartz	15	Alteration
Opaques (incl. hematite)	2	Alteration

In thin section, this sample displays a poorly-preserved weakly foliated granoblastic metamorphic texture, modified by moderately strong pervasive alteration.

Quartz is abundant, and occurs in two forms:

i) Some occurs as anhedral equant grains ~0.4 mm in size. They are distributed throughout the rock, but tend to be more abundant in particular ill-defined horizons. This quartz is of metamorphic origin. Minor small fluid inclusions are trapped along widely-spaced subparallel microcracks which define a sealed set.

ii) Some occurs as very fine-grained, massive replacement patches. Some are slightly coarser-grained and appear to have formed by replacement of precursor ragged feldspar grains. Elsewhere, very fine-grained microcrystalline quartz forms replacement patches in various sites: around margins and along fractures through quartz grains, in indistinct fracture zones, and in altered ?feldspar grains.

White mica occurs in two forms:

i) Most occurs as tiny randomly oriented flecks that form dense replacement mats in altered ?feldspar grain sites. In places, these mats display a more turbid appearance that is suggestive of poorly-crystallised clay.

ii) A small amount of muscovite occurs as large flakes up to ~1 mm in size. This appears to be a relict metamorphic phase.

Chlorite is moderately abundant, occurring as tiny flecks concentrated in large diffuse areas. It is very pale green to colourless, suggestive of an Mg-rich composition. There is no evidence of the nature of the phase or phases that chlorite has replaced.

Biotite is rare, forming small well-crystallised pleochroic brown flakes located in single quartz grains. Biotite most likely was more abundant in the precursor metamorphic rock.

Opaques occur in minor amount as fine-gained dense aggregates scattered through the rock. Some of the aggregates appear to have formed by replacement of precursor small phyllosilicate flakes, probably biotite.

Monazite is rare, occurring as tiny equant turbid crystals within sericite mats.

INTERPRETATION:

This sample has suffered quite severe pervasive alteration, generating the assemblage sericite + chlorite + quartz + opaques (hematite). The mineral assemblage and its fine grain size confirm that the alteration occurred under relatively low-temperature conditions.

The nature of the precursor rock has been obscured by the effects of alteration. It appears to have been a quartzo-feldspathic gneiss, composed of feldspar, quartz, micas and trace monazite, and presumably formed by medium-grade regional metamorphism of a quartzo-feldspathic primary rock.

SAMPLE : 77719

SECTION NO. : 77719

HAND SPECIMEN : The drill core rock sample represents an even-grained, fine- to medium-grained gneissic rock composed mostly of pale grey-green altered feldspar through which aligned thin dark foliae define a relict foliation.

ROCK NAME : **Sericite-chlorite-quartz altered quartzo-feldspathic gneiss**

PETROGRAPHY :

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

Mineral	**Vol.%**	**Origin**
Quartz	40	Metamorphic
Muscovite	1	Metamorphic
Biotite	Tr	Metamorphic (inclusions in quartz)
Zircon	Tr	Metamorphic (inclus. in altered biotite)
Sericite	25	Alteration
Chlorite (green)	3	Alteration (after biotite flakes)
Chlorite (very pale brown-green)	18	Alteration
Quartz	10	Alteration
Opaques (hematite)	2	Alteration
Rutile	Tr	Alteration

In thin section, this sample displays a weakly foliated granoblastic metamorphic texture, modified by strong selective pervasive alteration.

Quartz is moderately abundant, and occurs in two sites:

i) Most occurs as anhedral equant unstrained grains ~0.2-1.0 mm in size (average ~0.4 mm). They are distributed more-or-less uniformly through the rock.

ii) A smaller amount occurs as small anhedral grains that have pseudomorphously replaced precursor blocky to anhedral grains of uncertain origin. They may have been metamorphic amphibole.

Other metamorphic minerals are preserved in only trace amount. Biotite occurs as small pleochroic brown flakes enclosed in single quartz grains. Muscovite forms well-crystallised flakes sparsely scattered through the rock. Small equant zircon crystals may occur in altered biotite sites, and enclosed in quartz.

Two types of chlorite are identified:

i) Some occurs as pleochroic green aggregates that have more-or-less pseudomorphously replaced sparsely scattered biotite flakes. Fine-grained opaques (including dark red hematite) are intimately intergrown with the chlorite, and minor small rutile crystals also occur within the chlorite.

ii) Paler brownish green chlorite has replaced large ragged grains ~1-2 mm in size. Their identity remains unknowns. Small quartz grains and minor fine-grained opaques are distributed through the chlorite.

Sericite forms tiny ragged flecks that are concentrated in dense mats that have formed by pseudomorphous replacement of anhedral grains (probably feldspar, but none is preserved).

INTERPRETATION:

This sample represents a quartzo-feldspathic gneiss. It contained a significant amount of quartz, minor biotite, accessory zircon, and significant abundances of unidentified phases (probably feldspar, and perhaps amphibole). The rock presumably formed by medium-grade regional metamorphism of a quartzo-feldspathic precursor rock.

The metamorphic rock body was invaded by hydrothermal fluids which caused moderately strong pervasive selective replacement, generating the assemblage chlorite + sericite + quartz + hematite + rutile.

SAMPLE : 77720

SECTION NO. : 77720

HAND SPECIMEN : The drill core rock sample represents an even-grained, medium-grained gneissic rock composed of uniformly distributed waxy grey quartz grains, greenish altered grains (plagioclase), pale pinkish cream K-feldspar grains, and minor foliated dark mica flakes.

ROCK NAME : **Sericite-chlorite altered quartzo-feldspathic gneiss**

PETROGRAPHY :

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

Mineral	Vol.%	Origin
Quartz	35	Metamorphic
K-feldspar (microcline)	25	Metamorphic
Muscovite	2	Metamorphic
Zircon	Tr	Metamorphic
Chlorite (incl. trace biotite)	5	Alteration (incl. relict biotite)
Sericite	33	Alteration (after plagioclase)

In thin section, this sample displays a weakly foliated granoblastic metamorphic texture, modified by selective alteration.

Quartz is moderately abundant, forming anhedral grains ~0.4-1.0 mm in size. All are clear and quite unstrained.

K-feldspar is moderately abundant, distributed throughout the rock as anhedral ragged grains and larger poikiloblastic plates that enclose smaller quartz grains. All grains contain combined albite and pericline twinning ("tartan twinning"), confirming the identification of microcline.

Muscovite occurs in minor amount as well-crystallised flakes that were intergrown with quartz, biotite and plagioclase.

Biotite was moderately abundant, forming well-crystallised flakes ~0.4-0.8 mm in size. They are distributed more-or-less uniformly through the rock, and their slight preferred orientation defines the metamorphic foliation through the rock. All flakes have suffered complete replacement by drab green chlorite, but rare small biotite flakes enclosed in single quartz grains are preserved.

Sericite is moderately abundant, occurring as dense fine-grained replacement mats pseudomorphous after anhedral grains and aggregates. No precursor mineral is preserved, but it most likely was plagioclase.

Zircon forms uncommon small prisms, enclosed in altered plagioclase and biotite crystals, and also in quartz grains.

INTERPRETATION:

This sample represents a quartzo-feldspathic rock that has suffered medium-grade regional metamorphism, generating the weakly foliated granoblastic assemblage of quartz + plagioclase

+ K-feldspar + minor biotite + muscovite + zircon. The nature of the primary rock has been obscured.

Invasion by hydrothermal fluids resulted in complete replacement of plagioclase by sericite, and replacement of biotite by chlorite.

SAMPLE : 77721

SECTION NO. : 77721

HAND SPECIMEN : The drill core rock sample represents an even-grained, fine- to medium-grained crystalline rock composed mostly of translucent grey quartz grains, scattered grains of white altered feldspar, and tiny black specks. Indistinct layering is defined by variation in abundance of darker components.

ROCK NAME : **Sericite altered siliceous quartzo-feldspathic gneiss**

PETROGRAPHY :

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

Mineral	**Vol.%**	**Origin**
Quartz	70	Metamorphic
Zircon	Tr	Metamorphic
Muscovite	2	Metamorphic
Rutile	Tr	Metamorphic
Biotite	Tr	Metamorphic (inclusions in quartz)
Sericite (incl. ?clay)	25	Alteration
Opaques (incl. hematite)	1	Alteration

In thin section, this sample displays a massive equigranular granoblastic metamorphic texture, modified by selective alteration.

Quartz is abundant, occurring as anhedral grains ~0.4-1.0 mm in size. They are quite clear, and display little or no strain extinction.

Feldspar was the other principal phase, forming anhedral grains similar in size to quartz. It was distributed more or less uniformly through the rock. All grains have suffered complete replacement by very fine-grained dense phyllosilicates and small aggregates of opaque grains and laths. Some of the latter display the typical dark red colour of hematite. The identity of the feldspar remains uncertain, owing to lack of any relict primary grains. The identity of the replacement phyllosilicate also remains uncertain: some of the material displays typical optical characteristics of white mica (i.e. sericite), but some is darker, more turbid, and less birefringent, suggesting it may be a clay.

Muscovite occurs as small but well-crystallised flakes sparsely scattered through the rock.

Rutile occurs as small but well-crystallised turbid dark brown grains, sparsely scattered through the rock.

Biotite occurs in trace amount as small flakes enclosed in quartz. They are pleochroic from tan brown to very pale yellow. No larger flakes or sites of flakes have been identified.

Zircon occurs in trace amount as small equant prisms, some with growth zoning.

INTERPRETATION:

This sample represents a siliceous quartzo-feldspathic rock that has suffered medium-grade regional metamorphism, generating the granoblastic assemblage of quartz + feldspar + minor

muscovite + biotite + rutile + zircon. There are no preserved primary textures to aid identification of the precursor, but the mineralogy is consistent with a quartz-rich quartzo-feldspathic sediment (e.g. feldspathic sandstone).

Subsequent hydrothermal alteration caused complete replacement of feldspar by sericite + ?clay + opaques (including hematite).

SAMPLE : 77722

SECTION NO. : 77722

HAND SPECIMEN : The drill core rock sample represents a uniformly fine-grained pale greenish grey crystalline rock, in which layering is defined by thin darker laminae.

ROCK NAME : **Chlorite-sericite-hematite altered layered quartzo-feldspathic gneiss**

PETROGRAPHY :

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

Mineral	**Vol.%**	**Origin**
Quartz	60	Metamorphic
Apatite	<1	Metamorphic
Zircon	Tr	?Metamorphic / ?relict clastic
Sericite	8	Alteration (after ?feldspar, ?mica)
Chlorite (green)	1	Alteration (after biotite)
Chlorite (v. pale green-brown)	26	Alteration (after ?feldspar)
Quartz	1	Alteration (after ?feldspar)
Opaques (incl. hematite)	3	Alteration

In thin section, this sample displays an even-grained granoblastic metamorphic texture, with indistinct mineralogical layering defined by variable mineral abundance and variable average grain size between layers.

Quartz is abundant, forming equant anhedral grains ~0.2-0.4 mm in size in most horizons. Larger grains ~1 mm in size are abundant in quartz-rich layers. Most of the quartz is clear and unstrained (i.e. no shadowy strain extinction).

Other principal minerals have been completely replaced. The most abundant mineral probably was feldspar, but none is preserved. It has been replaced by very fine-grained massive chlorite, with very pale green-brown colour. Minor small ragged aggregates of replacement quartz also occur in these alteration sites. The feldspar varied in abundance from layer to layer. Sericite occurs mostly as fibrous replacements of precursor phyllosilicate flakes, probably biotite, that tended to form small aggregates in feldspar-rich layers.

Opaques form small, randomly oriented lath-like crystals and aggregates of crystals and grains. It tends to be concentrated in chlorite-altered feldspar grains, and layers rich in those grains. The presence of some dark blood red colours in the opaque grains suggests that at least some is hematite.

Green chlorite occurs in minor amount as replacements of small precursor phyllosilicate flakes, probably biotite.

A small amount of apatite occurs as small equant colourless crystals which tend to be weakly concentrated in particular horizons.

Zircon occurs in trace amount as small euhedral crystals.

INTERPRETATION:

This sample represents a granoblastic metamorphic rock, originally composed of quartz and feldspar, with minor muscovite, biotite, apatite and zircon. The mineralogy and texture suggest recrystallisation under medium-grade regional metamorphic conditions.

Mineral and grain size variation defines layering, which is considered to reflect primary sedimentary layering in a feldspathic sand. This is supported by the lack of deformation of the rock, as indicated by the lack of strain in the quartz.

Invasion by hydrothermal fluids generated chlorite + opaques (hematite), presumably by replacement of feldspar and biotite.

SAMPLE : 77723

SECTION NO. : 77723

HAND SPECIMEN : The drill core rock sample is composed of equigranular greenish grey crystalline rock, through which are distributed coalesced pale pink crystalline spheroidal patches and misshapen pods several centimetres in size.

ROCK NAME : **Sericite-chlorite altered podiform quartzo-feldspathic gneiss**

PETROGRAPHY :

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

Mineral	**Vol.%**	**Origin**
Quartzo-feldspathic gneiss		
Quartz	55	Metamorphic
Muscovite	5	Metamorphic
Chlorite (green; incl. trace biotite)	3	Alteration (after biotite)
Chlorite (pale brown)	17	Alteration (after feldspar)
Sericite	20	Alteration (after feldspar)
Quartz-muscovite(-?sillimanite) pods		
Quartz	50	Metamorphic
Muscovite	50	Metamorphic
?Sillimanite	<1	Metamorphic

In thin section, this sample displays a foliated granoblastic metamorphic texture that is medium-grained in the darker green portion and coarse-grained in the pale pink pods.

Quartzo-feldspathic gneiss contains abundant quartz, which occurs as anhedral unstrained equant grains ~0.4-0.6 mm in size. They are in granoblastic relationship with lesser feldspar which formed ragged grains, but has been completely replaced by very fine-grained massive mats of sericite and very pale brownish chlorite.

Mica flakes occur in minor amount. Muscovite forms well-crystallised flakes, and biotite formed similarly well-crystallised flakes but has been almost completely replaced by pleochroic green chlorite.

Quartz-muscovite(-?sillimanite) pods are composed of subequal amounts of quartz and muscovite. The quartz occurs as large anhedral grains ~0.6-1.0 mm in size, partly enclosed by very large poikiloblastic plates of slightly deformed muscovite. Tiny acicular crystals (probably sillimanite) are laced through the quartz. It is notable that these acicular crystals are entirely absent from quartz in the surrounding quartzo-feldspathic host rock.

INTERPRETATION:

This sample represents a quartzo-feldspathic sediment that has suffered medium-grade regional metamorphism, generating the granoblastic metamorphic assemblage of quartz + feldspar + minor muscovite + biotite.

The podiform patches recrystallised under the same metamorphic conditions, generating a coarse-grained assemblage of quartz + muscovite + minor ?sillimanite. The pods are interpreted as primary siliceous clay balls in the primary sediment. There is no scope to interpret them as retrogressive alteration patches, because they display a similar metamorphic texture as their quartzo-feldspathic host. They simply were more siliceous and aluminous in composition. Note that the pale patches in sample 77717 display identical metamorphic mineralogy and texture to the spheroidal podiform patches in this sample.

Subsequent alteration resulted in complete replacement of feldspar by sericite + chlorite (pale brown), and replacement of biotite by chlorite (green). The podiform patches were unaffected by this alteration event.

SAMPLE : 77724

SECTION NO. : 77724

HAND SPECIMEN : The drill core rock sample has the appearance of an altered medium-grained felsic crystalline rock. It is composed of abundant waxy grey quartz, lesser pale green alteration patches, and minor tiny reddish hematite patches.

ROCK NAME : **Chlorite-quartz-hematite altered quartzo-feldspathic gneiss**

PETROGRAPHY :

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

Mineral	**Vol.%**	**Origin**
Quartz	72	Relict metamorphic / alteration
Rutile	Tr	Metamorphic
Tourmaline	Tr	Metamorphic
Zircon	Tr	Metamorphic
Apatite	Tr	Metamorphic
Phyllosilicate (chlorite, ?clay)	20	Alteration
Opaques (incl. hematite)	4	Alteration
Sericite	2	Alteration

In thin section, this sample displays a weakly foliated granoblastic metamorphic texture, modified by strong selective pervasive alteration.

Quartz dominates the rock. Most occurs as large unstrained anhedral grains ~0.4-1.0 mm in size with a tendency to be elongated within the trace of the foliation. Most grain boundaries are irregularly sutured, and local finer-grained replacement patches are evident.

Fine-grained phyllosilicate materials are abundant. They form very fine-grained, massive, dense replacement mats after anhedral precursor grains of uncertain identity (possibly feldspar or ferromagnesian grains). They are colourless to very pale drab green, and have low birefringence; these optical features suggest that the phase is chlorite, a suggestion supported by the green colour of the alteration patches in hand specimen.

Sericite occurs in minor amount as fine replacement aggregates, pseudomorphous after precursor small phyllosilicate plates (probably biotite). The preferred orientation of the plates contributed to definition of the metamorphic foliation.

Opaques occur as tiny ragged grains that tend to form loose aggregates and patches in the chloritic alteration sites. Some grains display deep red colours appropriate for hematite.

Two subhedral crystals of tourmaline have been observed. They are weakly pleochroic in drab greens, and were in granoblastic relationship with larger quartz grains.

Rutile occurs as rare angular grains. Zircon forms small subhedral zoned crystals. Apatite occurs as rare equant colourless grains.

INTERPRETATION:

This sample represents a medium-grained granoblastic metamorphic rock that has suffered moderately severe pervasive alteration, generating the assemblage chlorite + quartz + hematite + sericite. Sufficient of the precursor rock has been preserved to indicate that it was a medium-grained, weakly foliated granoblastic rock composed of quartz, feldspar and/or ferromagnesian minerals, biotite, and accessory rutile, apatite, and zircon.

SAMPLE : 77725

SECTION NO. : 77725

HAND SPECIMEN : The drill core rock sample represents a layered medium-grained crystalline rock, in which layers several mm to ~1 cm thick are composed of variable proportions of pink grains and drab dark green patches.

ROCK NAME : **Chlorite altered layered quartzo-feldspathic gneiss**

PETROGRAPHY :

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

Mineral	Vol.%	Origin
Quartz	60	Metamorphic
K-feldspar (microcline)	20	Metamorphic
Muscovite	<1	Relict metamorphic
Apatite	Tr	Metamorphic
Phyllosilicate (?chlorite, ?clays)	15	Alteration
Chlorite (green)	<1	Alteration
Sericite	2	Alteration
Opaques (incl. hematite)	2	Alteration

In thin section, this sample displays an inequigranular medium-grained granoblastic metamorphic texture, with indistinct layering defined by variable abundances of quartz, K-feldspar and an altered phase.

Quartz is abundant, forming clear anhedral grains of variable size, from ~0.2 mm up to ~1 mm in size. They display only weak shadowy strain extinction.

K-feldspar occurs as anhedral grains, mostly ~0.2-0.4 mm in size but uncommon larger grains range up to ~1 mm. They display the typical combined albite and pericline twinning ('tartan' twinning) that is typical of microcline. Most grains display incipient dull buff-coloured alteration . The K-feldspar varies in abundance from layer to layer, and one particular layer is very rich in K-feldspar.

Another moderately abundant metamorphic phase formed anhedral grains, some quite large. They have been completely replaced by very fine-grained massive phyllosilicate, probably a chlorite but possibly containing clays or some sericite. The precursor phase may have been plagioclase, but none remains for positive identification.

Tiny ragged opaque grains and aggregates are distributed through the chloritic alteration sites. Most are truly opaque, but some grains display deep red colour of hematite.

Biotite formed well-crystallised small flakes scattered through the rock. They have been replaced by pleochroic green chlorite, and tend to be associated with muscovite flakes which appear to be a relict metamorphic phase.

Apatite occurs in trace amount as equant anhedral colourless grains with typical moderately high relief. They are sparsely and irregularly scattered through the rock.

INTERPRETATION:

This sample represents a mineralogically layered granoblastic metamorphic rock. It was composed of quartz, K-feldspar, possibly plagioclase, minor biotite and muscovite, and accessory apatite. There are no textural or other features to confirm the origin of the layering, but it is possible that it represents relict primary layering in a precursor sediment. Regional metamorphism of medium grade caused complete recrystallisation.

Subsequent low-temperature hydrothermal alteration generated fine-grained ?chlorite + opaques (hematite) + sericite. It is likely that most of the ?chlorite formed by replacement of metamorphic plagioclase.

SAMPLE : 77726

SECTION NO. : 77726

HAND SPECIMEN : The drill core rock sample represents a medium-grained pink crystalline rock, composed mostly of pale pink feldspar and waxy grey quartz. Layering is defined by darker reddish brown material concentrated in particular horizons.

ROCK NAME : **Sericite-chlorite-hematite altered quartzo-feldspathic gneiss**

PETROGRAPHY :

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

Mineral	Vol.%	Origin
Quartz	63	Metamorphic
K-feldspar (microcline)	25	Metamorphic
Muscovite	2	Metamorphic
Rutile	Tr	Metamorphic
Zircon	Tr	Metamorphic
Biotite	Tr	Metamorphic (inclusions in quartz)
Tourmaline	Tr	Metamorphic
Sericite	5	Alteration
Chlorite	2	Alteration
Opaques (mainly hematite)	1	Alteration

In thin section, this sample displays an inequigranular granoblastic metamorphic texture, with indistinct layering defined by alignment of granular K-feldspar aggregates.

Quartz is abundant, occurring as anhedral clear grains mostly ~1-2 mm in size. Most grains display only very slight shadowy strain extinction.

K-feldspar is moderately abundant, forming anhedral grains that range widely in size, from ~0.2 mm up to ~4 mm (mostly ~0.2-1.0 mm). They are distributed throughout the rock, but in places they tend to be weakly concentrated in granular aggregates whose alignment defines a weak layering. All the K-feldspar displays 'tartan' twinning, confirming identification of microcline.

Two types of white mica are identified:

i) Some occurs as well-crystallised large plates up to ~1 mm in size, intergrown with K-feldspar and quartz. They represent primary metamorphic muscovite.

ii) Fine-grained flecks of sericite occupy dense, massive replacement patches which appear to have formed by replacement of a precursor minor phase. None is preserved for positive identification, but it may have been plagioclase. Similar fine-grained sericite fills one tortuous (i.e. non-planar) vein. One ragged patch of drab green tourmaline is intergrown with the sericite in the vein.

Chlorite occurs in minor amount in two forms:

i) Some occurs as pleochroic green pseudomorphous replacements of precursor biotite. The primary forms of the biotite flakes are well-preserved, but pleochroic brown biotite is preserved only as rare small flakes where enclosed in single quartz grains.

ii) A small amount of very fine-grained drab greenish brown chlorite occurs as dense replacement patches in some K-feldspar grains.

Opaques occur as tiny grains and small aggregates sprinkled through the sericitic alteration patches. Dark red colours in some of the opaques suggests that most is hematite, a suggestion supported by the reddish mauve colour of some altered bands in the hand specimen.

Small equant heavy minerals (turbid dark brown rutile, small equant zircon crystals) occur in trace amount. They tend to be loosely concentrated in particular laminae, suggestive of heavy mineral concentration in precursor clastic sedimentary rock.

INTERPRETATION:

This sample represents a medium-grained quartzo-feldspathic gneiss, originally composed of quartz, K-feldspar, possible minor plagioclase, biotite, muscovite, and accessory rutile, zircon, and tourmaline. The grain size and mineralogy are consistent with medium-grade (amphibolite facies) regional metamorphism of a quartzo-feldspathic sedimentary precursor, which may have contained thin heavy mineral bearing laminae.

Subsequent alteration generated minor sericite + chlorite + hematite. ?Plagioclase was replaced by sericite + hematite, biotite was replaced by biotite, and K-feldspar also suffered incipient replacement by chlorite.

SAMPLE : 77727

SECTION NO. : 77727

HAND SPECIMEN : The drill core rock sample represents a coarse-grained dark green foliated phyllosilicate-rich rock, with a reddish brown hematitic stain in small patches throughout. A coarse-grained quartz-rich lens has been captured in the section.

ROCK NAME : **Chlorite-sericite-hematite altered micaceous gneiss**

PETROGRAPHY :

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

Mineral	Vol.%	Origin
Quartz	25	Metamorphic
Biotite	Tr	Metamorphic (inclusions in quartz)
Chlorite	39	Alteration
Sericite	30	Alteration
Opaques (incl. hematite)	5	Alteration
Leucoxene/rutile	<1	Alteration

In thin section, this sample displays a well-preserved strongly foliated granoblastic metamorphic texture, modified by selective pervasive alteration.

Quartz is moderately abundant, occurring mostly as anhedral grains ~0.2-0.4 mm in size. Smaller quartz grains tend to be intergrown with a sericite-altered phase (possibly feldspar). Quartz also occurs as very large anhedral grains of centimetre size that fill the large lens observed in hand specimen.

Biotite was abundant, forming large plates ~1 mm long. Their strong preferred orientation defined a strong foliation through the rock. All have suffered complete replacement by pale green chlorite, fine-grained opaques (possibly mainly hematite), and tiny granules of leucoxene and/or better-crystallised rutile. Uncommon small biotite flakes are preserved in quartz grains, where they display their primary strong dark brown to very pale yellow pleochroism.

Sericite is moderately abundant, and occurs in two sites:

i) Most occurs as very fine-grained, dense, massive, turbid pale brown replacements of small anhedral grains. They may have been feldspar, but none is preserved. In places, small ?feldspar grains were intergrown with similarly small quartz grains, forming poorly-defined lenses between coarser foliated biotite-rich portions of the rock.

ii) Some occurs as flakes intergrown with chlorite in altered biotite crystal sites. It is possible that some of this is relict minor primary metamorphic muscovite.

Opaques occur in two forms:

i) Most occurs as tiny dark specks sprinkled through chloritised biotite flakes. In places, these form dense clouds. Most may be hematite.

ii) Some occurs as large, well-crystallised grains up to ~1 mm in size. They appear to represent hematite-altered magnetite crystals.

INTERPRETATION:

This sample represents a mica-rich gneissic rock, originally composed of biotite + ?feldspar + quartz + minor ?magnetite. It most likely was a pelitic sediment that suffered medium-grade dynamic regional metamorphism.

Subsequent alteration generated the assemblage chlorite + sericite + opaques (hematite) + leucoxene/rutile. Biotite was replaced by chlorite + opaques, and ?feldspar was replaced by sericite.

SAMPLE : 77730

SECTION NO. : 77730

HAND SPECIMEN : The drill core rock sample grades from a very dark green foliated rock into a rock composed of subequal abundances of dark green patches and grey quartz.

ROCK NAME : **Chlorite altered micaceous gneiss**

PETROGRAPHY :

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

Mineral	Vol.%	Origin
Quartz	30	Metamorphic
Apatite	Tr	Metamorphic
Chlorite	65	Alteration
Quartz	3	Alteration
Opaques (incl. hematite)	<1	Alteration
Leucoxene	Tr	Alteration

In thin section, this sample displays a relict foliated granoblastic metamorphic texture, in which mineral abundance varied from mica-rich to quartz-rich. Selective pervasive alteration has severely modified the rock.

Mica was abundant. It most likely was biotite, forming plates ~0.2-1.0 mm in size, but it has been completely replaced by dark green chlorite and minute dark specks of leucoxene. The biotite flakes formed a dense, strongly foliated mat. In places, the chlorite occurs as finer-grained, denser masses in which no precursor texture is evident: these areas may have been another mineral (e.g. feldspar), but there is no clear evidence to support this.

Quartz was the other principal metamorphic mineral. It formed large anhedral grains ~1 mm in size that were abundant in parts of the rock, but were virtually absent in the biotite-rich horizons. In places, quartz-quartz grain margins display suturing, suggesting some alteration of the metamorphic quartz has occurred, and a small amount of fine-grained alteration quartz also occurs in some of the chloritised areas.

Leucoxene occurs in two forms. Some occurs as minute specks distributed through altered biotite, but some occurs as fine-grained turbid granular aggregates scattered through the chloritised biotite.

Apatite is rare, occurring as large equant crystals in the biotite-rich areas.

INTERPRETATION:

This sample represents a biotite-rich gneissic rock. It most likely formed by medium-grade dynamic regional metamorphism of a pelitic sediment, generating the assemblage biotite + quartz + accessory apatite + Ti-phase. Feldspar may have been present in the assemblage. Mineralogical variation in the metamorphic rock (i.e. variation in biotite and quartz abundances) may reflect primary compositional variation in the precursor sediment.

Pervasive alteration of the schist resulted in complete replacement of biotite (and ?feldspar) by chlorite + trace leucoxene.

SAMPLE : 77732

SECTION NO. : 77732

HAND SPECIMEN : The drill core rock sample represents a dark green schistose rock through which are scattered small grey to white grains and aggregates aligned within the foliation.

ROCK NAME : **Chlorite altered micaceous gneiss**

PETROGRAPHY :

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

Mineral	Vol.%	Origin
Quartz	15	Metamorphic
Apatite	Tr	Metamorphic
Zircon	Tr	Metamorphic
Chlorite	40	Alteration (after phyllosilicate flakes)
Chlorite	45	Alteration (after unknown precursor)
Leucoxene	Tr	Alteration

In thin section, this sample displays a poorly-preserved foliated granoblastic metamorphic texture, modified by strong pervasive alteration.

Quartz is the only abundant preserved primary metamorphic mineral. It occurs as anhedral grains ~0.4-1.0 mm in size, commonly elongated within the trace of the foliation. The quartz is irregularly distributed through the rock: it is moderately abundant in some horizons, but is absent elsewhere.

Apatite occurs in trace amount as equant subhedral grains ~0.2 mm in size. They tend to occur in particular horizons.

Zircon is rare, forming small subhedral prisms with growth zoning.

Chlorite occurs as pleochroic green flakes, in two different sites:

i) Some occurs as optically continuous replacements that are pseudomorphous after precursor phyllosilicate flakes, most probably biotite. The flakes were concentrated in particular horizons, where they composed almost 100% of the horizon.

ii) Some occurs as very fine-grained, dense, massive replacements of a precursor phase or phases. None is preserved, and no textures are preserved, but it is possible it was feldspar (e.g. plagioclase).

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

INTERPRETATION:

This sample has suffered intense pervasive alteration, generating abundant chlorite with trace leucoxene. The nature of the precursor rock has been obscured by the intensity of the alteration, but particular aspects can be recognised:

i) It was a medium-grained foliated granoblastic metamorphic rock.

ii) It contained moderately abundant phyllosilicate (probably biotite), possibly another moderately abundant phase such as feldspar, and lesser quartz.

iii) It contained accessory apatite and zircon.

The rock is inferred to have been a micaceous gneiss, possibly of pelitic sedimentary origin.

SAMPLE : 77733

SECTION NO. : 77733

HAND SPECIMEN : The drill core rock sample represents a foliated altered gneissic rock, composed of small dark green flakes and aggregates irregularly distributed through a waxy grey siliceous matrix.

ROCK NAME : **Chlorite altered quartzo-?feldspathic gneiss**

PETROGRAPHY :

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

Mineral	Vol.%	Origin
Quartz	61	Metamorphic
Muscovite	3	Metamorphic
Apatite	Tr	Metamorphic
Chlorite	35	Alteration
Leucoxene	Tr	Alteration

In thin section, this sample displays a relict foliated granoblastic metamorphic texture, modified by complete replacement of some of the metamorphic phases.

Quartz is abundant, occurring as anhedral grains that range widely in size, from ~0.2 mm up to ~2 mm. It is somewhat variable in abundance from horizon to horizon through the rock.

Muscovite occurs in minor amount as well-crystallised flakes up to ~1 mm long. They are in granoblastic relationship with quartz and other metamorphic minerals (?biotite, ?feldspar).

Apatite is rare, forming equant anhedral clear grains within quartz.

Chlorite is moderately abundant, and appears to occur in two forms:

i) Some occurs as optically continuous replacements of precursor phyllosilicate flakes up to ~1 mm long. They most likely were biotite, but none is preserved. Tiny dark turbid leucoxene granules may occur in these sites, supporting the suggestion that biotite was the precursor phase.

ii) A significant amount of chlorite occurs as fine-grained, dense, massive replacements of an unidentified precursor metamorphic phase. It may have been feldspar, but none is preserved and crystal forms have been destroyed. In places, it is difficult to distinguish between this chlorite and that of i) above.

INTERPRETATION:

This sample represents a gneissic metamorphic rock which appears to have been composed of quartz, ?feldspar, biotite, muscovite, and trace apatite. The inferred mineralogy and texture are consistent with recrystallisation of a quartzo-feldspathic rock (possibly a sedimentary rock) under medium-grade regional metamorphic conditions.

Subsequent invasion by hydrothermal fluids resulted in complete replacement of biotite by chlorite + trace leucoxene, and complete replacement of ?feldspar by chlorite.

SAMPLE : 77734

SECTION NO. : 77734

HAND SPECIMEN : The drill core rock sample represents a dark green schistose rock cut by a 5 mm-wide vein filled by layers of cream and green coloured materials with small pink patches.

ROCK NAME : **Veined, chlorite-sericite-quartz altered micaceous gneiss**

PETROGRAPHY :

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

Mineral	**Vol.%**	**Origin**
Altered micaceous gneiss		
Quartz	15	Metamorphic
Muscovite	Tr	Metamorphic
Biotite	Tr	Metamorphic (inclusions in quartz)
Apatite	Tr	Metamorphic
Zircon	Tr	Metamorphic
Chlorite	48	Alteration
Sericite	15	Alteration
Quartz	20	Alteration
Opaques (incl. hematite)	<1	Alteration
Leucoxene	Tr	Alteration
Quartz-chlorite vein		
Quartz	45	Vein filling
Chlorite (pale brown)	30	Vein filling
Chlorite (colourless)	20	Vein filling
Opaques (incl. hematite)	5	Vein filling

In thin section, this sample displays a relict foliated granoblastic metamorphic texture, modified by moderately strong selective pervasive alteration and veining.

Altered micaceous gneiss is dominated by chlorite, which occurs in two forms:

i) Some occurs as pleochroic drab green, optically continuous plates that are pseudomorphous after precursor phyllosilicate flakes (biotite, as supported by the presence of tiny turbid leucoxene granules in the chlorite, and the presence of small pleochroic tan brown biotite flakes preserved in single quartz grains). The preferred alignment of the moderately abundant biotite flakes defined the metamorphic foliation.

ii) Some chlorite occurs as dense, fine-grained aggregates which appear to have replaced an unknown precursor phase (possibly feldspar). This chlorite may form a matrix around the better-preserved chloritised biotite flakes.

Quartz also occurs in two forms:

i) Some occurs as clear anhedral grains ~0.2-0.6 mm in size. They are distributed throughout the rock, and clearly represent relict metamorphic quartz.

ii) Some occurs as anhedral grains ~0.1-0.2 mm in size, in places forming small aggregates. They are distributed throughout the rock, and are distinguished from the metamorphic quartz by the presence of tiny turbid specks (mainly fluid inclusions).

Sericite occurs in two forms:

i) Some occurs as tiny, randomly oriented flecks that form pseudomorphous replacement aggregates after a precursor metamorphic phase (possibly feldspar). A small amount of this fine-grained sericite also occurs intergrown with chlorite.

ii) Some occurs as large, dense foliated sheaves of sericite. They are scattered irregularly and sparsely through the rock, they are several millimetres long, and are aligned in the trace of the foliation. They have the appearance of sericitised fibrolitic sillimanite sheaves, but no relict sillimanite can be positively identified.

Opaques occur as ragged small aggregates intergrown with chlorite. Some margins and flakes within the aggregates display the deep red colour of hematite.

Muscovite occurs in minor amount, forming well-crystallised plates up to ~0.6 mm in size, in limited horizons in the rock. Other phases also occur in trace amount: apatite occurs as anhedral equant grains, and zircon forms small equant to anhedral grains of high birefringence.

Quartz-chlorite vein is composed mostly of quartz and chlorite. The quartz occurs as anhedral, subradiating grains in poorly-defined layers. Chlorite occurs in two forms that contribute to a poorly-defined colloform layering: pale brown cryptocrystalline chlorite which forms optically continuous sheaves, and fine-grained colourless chlorite which forms subradiating aggregates. Sprinkled through the brownish chlorite are small ragged patches of hematite.

INTERPRETATION:

This sample represents a foliated granoblastic metamorphic rock, originally composed of mica (biotite >> muscovite), possibly a significant amount of feldspar, and quartz. Sparsely scattered large sheaves of sillimanite may have been present, and apatite and zircon occurred in trace amounts. The inferred metamorphic mineral assemblage suggests that the precursor rock was a pelitic sediment, recrystallised by dynamic regional metamorphism of medium grade.

The rock body suffered moderately intense hydrothermal alteration, generating the alteration assemblage of chlorite + quartz + sericite + hematite + trace leucoxene. During this event, open fractures were filled by colloform vein assemblages of quartz + chlorite + minor hematite.

SAMPLE : 77735

SECTION NO. : 77735

HAND SPECIMEN : The drill core rock sample represents a dark green schistose rock with minor small pale grains and aggregates aligned in the foliation.

ROCK NAME : **Chlorite altered micaceous gneiss**

PETROGRAPHY :

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

Mineral	**Vol.%**	**Origin**
Apatite	2	Metamorphic
Zircon	<1	?Relict clastic / ?metamorphic
Chlorite (pale green to colourless)	57	Alteration (after biotite)
Chlorite (dark drab green)	40	Alteration
Leucoxene/rutile	Tr	Alteration

In thin section, this sample displays a relict foliated metamorphic texture, strongly modified by selective pervasive alteration.

Chlorite dominates the rock, and two types are distinguished:

i) Some occurs as pleochroic, somewhat variegated, pale drab green to colourless flakes ~0.4-0.6 mm long. Their optical continuity defines the shapes of precursor phyllosilicate flakes (biotite, as inferred from the presence of leucoxene granules and intergrown sagenitic acicular rutile). Although somewhat misoriented, the broad preferred alignment of the flakes defines a moderately strong foliation through the rock. The pale colour of the chlorite suggests it may be Mg-rich.

ii) A similar amount of chlorite occurs as fine-grained, dense aggregates composed of darker drab green, randomly oriented flakes. No precursor minerals or textures are preserved in these areas, which generally occupy interstices between laminae of paler chlorite flakes. It may have been feldspar. The dark colour of the chlorite suggests it is relatively Fe-rich.

Apatite occurs in minor amount. It forms anhedral equant grains ~0.2-0.4 mm in size, in places forming granular aggregates. Although sparsely disseminated through the rock, it tends to be loosely concentrated in horizons several mm thick in the plane of the foliation.

Zircon occurs in significant amount for an accessory phase. Numerous small rounded to subangular grains ~0.05-0.1 mm in size tend to be concentrated in particular laminae <0.4 mm thick and several mm long. These have the appearance of relict heavy mineral lag laminae in a precursor sediment. Some angular grains display truncated growth zoning, supporting a clastic origin for the grains. A trace of rutile may occur with the zircon, forming small subhedral turbid grains moulded on the zircon.

INTERPRETATION:

This sample represents a foliated mica-rich gneissic rock composed of biotite, possibly feldspar, minor apatite, and accessory zircon and rutile. It is considered to have formed by

medium-grade dynamic regional metamorphism of a pelitic sedimentary precursor rock. Minor heavy mineral lag deposits of zircon and Ti-minerals may have been present in the sediment.

Subsequent to the metamorphic event, the rock body was invaded by hydrothermal fluids. This caused severe pervasive replacement by chlorite of two types: biotite was replaced by pale ?Mg-rich chlorite ± leucoxene/rutile, and ?feldspar was replaced by darker ?Fe-rich chlorite. No biotite or ?feldspar was preserved. The metamorphic apatite and ?clastic zircon survived the event.

APPENDIX 1: X-RAY DIFFRACTION STUDY OF SAMPLE 77716

amdel

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5 December 1996

Mason Geoscience Pty Ltd
P O Box 78
GLENSIDE SA 5065

Attn: Dr D.R. Mason

REPORT G931/96

IDENTIFICATION OF MINERALS IN 77716

YOUR REFERENCE:	Letter dated 29/11/96
SAMPLE IDENTIFICATION:	77716
MATERIAL:	One rock sample
DATE SAMPLES RECEIVED:	2 December 1996
DATE AUTHORISATION RECEIVED:	2 December 1996
WORK REQUIRED:	Mineral identification by X-ray diffraction
INVESTIGATION AND REPORT BY:	Michael Till

Keith Henley

Dr Keith J Henley
Manager, Mineralogical Services

fws

IDENTIFICATION OF MINERALS IN 77716

1. INTRODUCTION

A rock sample was received from Dr D.R. Mason of Mason Geoscience Pty Ltd with a request for mineral identification.

2. PROCEDURE

The sample was pulverised then analysed by X-ray diffraction.

3. RESULTS

The sample consists of muscovite only. Two types of muscovite are present, with the 1M-type apparently more abundant than the more stable, more commonly-occurring $2M_1$-type.

Mason Geoscience Pty. Ltd.

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REPORT TITLE	**Autoradiography and Electron Microprobe Studies of Rock Samples 77702 and 79400**
REPORT #	2282
CLIENT	Queensland Mines Pty Ltd
ORDER NO.	21069
CONTACT	John Thevissen

REPORT BY Dr Douglas R. Mason

SIGNED

for Mason Geoscience Pty. Ltd.

DATE 31 January 1997

QMPL 1997/2

CONTENTS

Autoradiography and Electron Microprobe Studies of Rock Samples 77702 and 79400

SUMMARY

1. Rock Samples

- Polished thin sections of two rock samples (sample 77702, section number C67119; sample 79400, section number C67124) have been studied using autoradiographic and electron-probe microanalytical methods.

2. Results

- Autoradiography

  - In sample 77702, radioactive material occurs as small diffuse patches in the general vicinity of a thin quartz-rich vein, and also as thin discontinuous linings along the margin of the vein.

  - In sample 79400, abundant radioactive material occurs as dense linings in ferruginous weathering products along the margins of a thick quartz-rich vein, and also as ragged patches irregularly scattered through nearby host rock.

- Electron-probe microanalysis

  - A single U-P(-Cu-Fe)-bearing phase has been detected in significant abundance in both samples. It occurs as ragged grains and thin microcrack fillings, intimately intergrown with iron oxide. The phase is inferred to belong to the autunite or meta-autunite group.

  - Native gold occurs as tiny equant grains ~1-5 μm in size, intimately associated with the U-bearing and ferruginous minerals.

1. INTRODUCTION

Two polished thin sections (labelled 77702 and 79400) were received from Mr John Thevissen (Queensland Mines Pty Ltd, Darwin, Northern Territory). Petrographic descriptions had previously been provided for these and other associated samples (see Mason Geoscience Report No. 2259, 9 December 1996).

Particular requests were:

i) To investigate the distribution of radioactive minerals in the sections by acquiring an autoradiograph of each.

ii) To investigate the nature of U-bearing and Au-bearing minerals in the two samples, using electron-probe microanalytical methods.

The preliminary results were provided to Mr Thevissen by telephone on 23 January 1997. This report contains the full results of this work.

2. METHODS

The two polished thin sections were delivered to Mineral Services Division of Amdel Limited (Thebarton, South Australia) where autoradiographs were prepared.

The sections were collected from Amdel on 20 January 1997, and delivered to the Centre for Electron Microscopy and Microstructural Analysis at the University of Adelaide for carbon coating prior to analysis on 23 January 1997. The instrument used was a Cameca SX51 SEM-probe, running at 20 kV, with attached energy-dispersive microanalyser to allow spectrum collection and element identification. Each section was visually scanned using the back-scattered electron image, seeking 'bright' grains which indicate relatively high 'average atomic number' (i.e. potential U- or Au-bearing phases). Where bright grains were observed, their spectrum was collected, and elements present were identified using computer-assisted methods. Black-and-white photographs were taken of U- and Au-bearing grains, where found.

3. RESULTS

3.1 Autoradiography

The full autoradiograph report is provided as APPENDIX 2.

Particular results include the following:

i) In sample 77702 (section C67119), small ragged radioactive patches are detected sparsely and irregularly scattered through the rock in the vicinity of a thin quartz-rich vein, and also as minor thin discontinuous linings along a thin quartz vein.

ii) In sample 79400 (section C67124), fine-grained radioactive material is densely concentrated within dark brown ferruginous margins of the thick vein. Minor radioactive materials also occur as sparsely scattered ragged patches through the rock.

3.2. Electron Probe Microanalysis

Numerous spots were analysed for their contained elements (Table 1). Note that only qualitative elemental analyses were obtained, which do not uniquely identify the mineral.

TABLE 1: IDENTIFIED ELEMENTS AND INFERRED MINERALS

SAMPLE-#	ELEMENTS*	INFERRED MINERAL	OCCURRENCE
77702-1	U,P,(Cu,Fe)	Autunite / meta-autunite	Ragged small grain
77702-2	U,P,(Cu,Fe)	Autunite / meta-autunite	Ragged small grain
77702-3	U,P,(Cu,Fe)	Autunite / meta-autunite	Ragged small grain
77702-4	U,P,(Cu,Fe)	Autunite / meta-autunite	Small grain in aggregate
77702-5	U,P,(Cu)	Autunite / meta-autunite	Cleaved filling in microcrack
77702-6	Ca,P	Apatite	Large primary prismatic crystal
77702-7	U,P,(Cu)	Autunite / meta-autunite	Cleaved filling in microcrack
77702-8	Si	Quartz	Large primary grain hosting microcracks
77702-9	Si,Al,K	K-feldspar	Large grain intergrown with quartz
77702-10	Ti	Rutile	In aggregate with U-bearing grains
77702-11	Ti,Fe	Ilmenite	Relict primary grain, altered to rutile
77702-12	U,P, (Cu)	Autunite / meta-autunite	Bladed filling in microcrack
79400-1	U,P,(Fe)	Autunite / meta-autunite	Filling in microcrack
79400-2	U,P,(Fe)	Autunite / meta-autunite	Ragged grain in aggregate
79400-3	U,P	Autunite / meta-autunite	Ragged tiny grain intergrown with Fe oxide
79400-4	Fe	Iron oxide (?goethite)	Ragged overgrowths with #3
79400-5	U,P,(Fe)	Autunite / meta-autunite	Ragged tiny grain with Fe oxide
79400-6	Fe	Iron oxide (?goethite)	Overgrowths associated with #5
79400-7	U,P	Autunite / meta-autunite	Filling in microcrack in vein quartz
79400-8	Fe	Iron oxide (?goethite)	In same microcrack as #7
79400-9	U,P	Autunite / meta-autunite	Ragged patch in margin of quartz vein
79400-10	Fe	Iron oxide (?goethite)	Intergrown with #9
79400-11	U,P	Autunite / meta-autunite	Bladed aggregate in patch
79400-12	Au	Native gold	Small equant grain in U-P-Fe aggregate
79400-13	Au	Native gold	Tiny equant grain in U-P-Fe aggregate
79400-14	Au	Native gold	Tiny equant grain in U-P-Fe aggregate
79400-15	U,P	Autunite / meta-autunite	Ragged patches associated with gold
79400-16	Fe	Iron oxide (?goethite)	Ragged matrix containing U-P and Au
79400-17	U,P,(Fe)	Autunite / meta-autunite	Ragged patch in granitoid host rock
79400-18	U,P,(Fe)	Autunite / meta-autunite	Another ragged patch in granitoid
79400-19	Si	Quartz	Large quartz grain host to #17, #18.

*: Major elements (minor elements in brackets)

Inferred minerals include the following:

i) Autunite / meta-autunite

A U-P-bearing phase has been identified in both samples 77702 and 79400. It may or may not contain minor amounts of Cu, or Fe, or both Cu and Fe. The composition may vary over distances of a few tens of microns (compare analyses 77702-4 and 77702-5). The mineral is likely to belong to the autunite group

$(Ba,Ca,Cu,Fe^{2+},(HAl)_{0.5},Mg,Mn^{2+},Na_2,(UO_2))(UO_2)_2((As,P,V)O_4)_2 \cdot 8\text{-}12H_2O$

or the meta-autunite group

$(Ba,Ca,Co,Cu^{2+},Fe^{2+},K_2,Mg,(NH_4)_2)(UO_2)_2((As,P)O_4)_2 \cdot 4\text{-}8H_2O$.

This mineral occurs as fillings in thin microcracks, and as small ragged grains and aggregates of grains intimately intergrown with iron oxide. It may occur along margins of the quartz-rich veins that occur in both samples, but it also occurs distributed through the granitic host rock in microcracks and intergrown with rutile in altered ilmenite crystal sites.

ii) Iron oxide

An Fe-bearing phase has been identified, and most likely belongs to the hydrated iron oxides such as goethite or lepidocrocite. It occurs abundantly as fine-grained dense alteration patches and fillings in microcracks.

iii) Quartz

Quartz has been identified by its elemental composition of Si. It occurs as large grains in granitic wall rock and in quartz-rich veins.

iv) K-feldspar

K-feldspar has been identified from its elemental association, and its occurrence with quartz. It occurs in close association with coarse-grained quartz in the granitic host rock.

v) Ilmenite and rutile

Ilmenite (Ti- and Fe- bearing) has been identified as small ragged grains that are mantled and partly replaced by rutile (Ti only). The ilmenite is inferred to represent a relict primary igneous accessory phase, partly to completely altered to rutile (and other associated minerals including iron oxide and autunite / meta-autunite).

vi) Native gold

Tiny grains of native gold (Au only) have been identified. They occur intimately associated with the autunite / meta-autunite phase and iron oxide. They are much less common than the U-bearing and Fe-bearing phases. Native gold has only been identified in sample 79400.

4. DISCUSSION

The intimate association of the U-bearing and Au-bearing minerals with iron oxide suggests that they formed more-or-less synchronously. The occurrence of all of these minerals in diffuse aggregates, concentrated along vein / host rock contacts, and in microcracks, strongly suggests that they all formed during the pervasive oxidation event that the rock body has experienced in the zone of weathering. The lack of Ag in the native gold grains provides additional support for

a near-surface weathering origin. Primary hydrothermal gold would most likely contain a significant Ag content.

It is considered, therefore, that the present distribution of U- and Au-bearing minerals reflects near-surface weathering processes. This begs the question as to the primary source or sources of the U and Au. No primary U- or Au-bearing phases have been identified to date in the granitic host rocks, although their inferred origin by differentiation from adjacent dolerite would allow concentration of large metal cations. It is noted that a potentially radioactive phase (allanite) has been identified in nearby biotite-hornblende quartzo-feldspathic gneiss (sample 79397, Mason Geoscience Report No. 2259).

APPENDIX 1: PHOTOGRAPHS FROM ELECTRON MICROPROBE

A selection of black-and-white photographs is provided in the following pages. They represent backscattered electron images of fields of view under the electron microprobe. Apparent brightness in these images is directly correlated with 'average atomic number' of the phase. Thus very bright grains have very high average atomic number (e.g. autunite, native gold), paler grey grains have lower average atomic number (e.g. Fe-oxide), and dark grey grains have very low average atomic number (e.g. quartz, K-feldspar). Note that contrast is not consistent between plates, in order to highlight particular features in each plate.

TABLE 2 : KEY TO PLATES

SAMPLE	PLATES
77702	1-4
79400	5-9

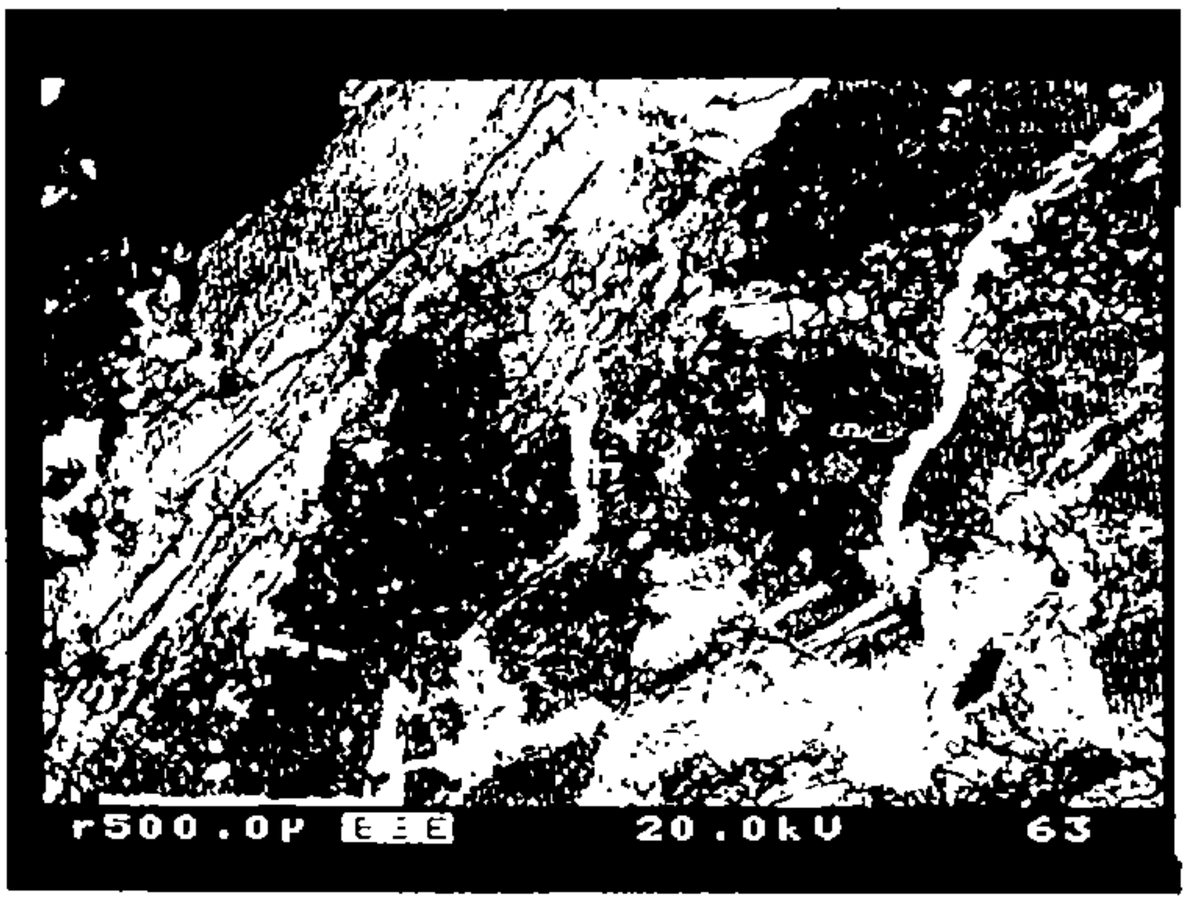

PLATE 1: Sample 77702 (Backscattered electron image, 500μm white bar for scale)
This view shows microcracks (centre, centre right) filled by autunite meta-autunite (white), a large quartz grain (medium grey, occupies most of field of view), and K-feldspar (pale grey, upper left) The diffuse white patch (bottom right) is composed of relict ilmenite, rutile, and autunite meta-autunite.

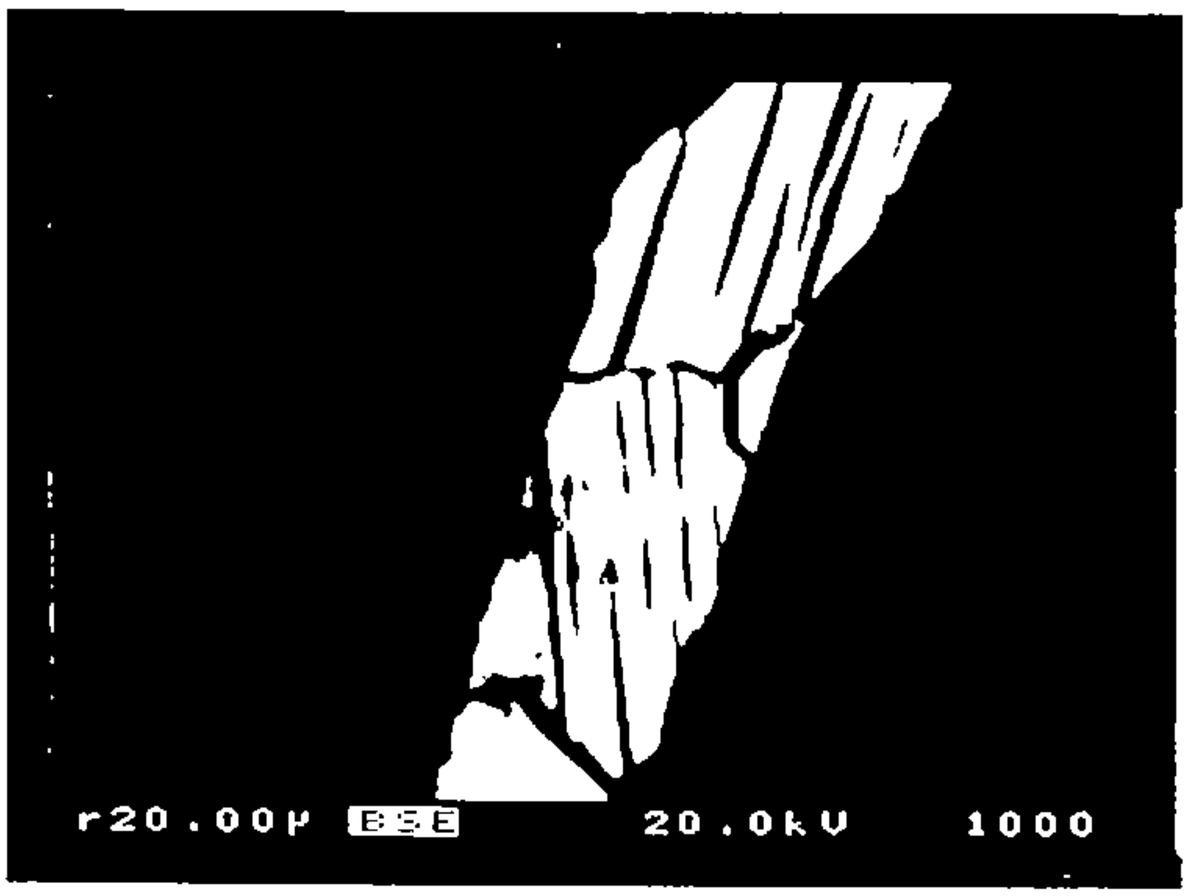

PLATE 2 Sample 77702 (Backscattered electron image, 20μm grey bar for scale)
This view shows portion of a crack-filling of cleaved autunite meta-autunite (analysis 77702-5)

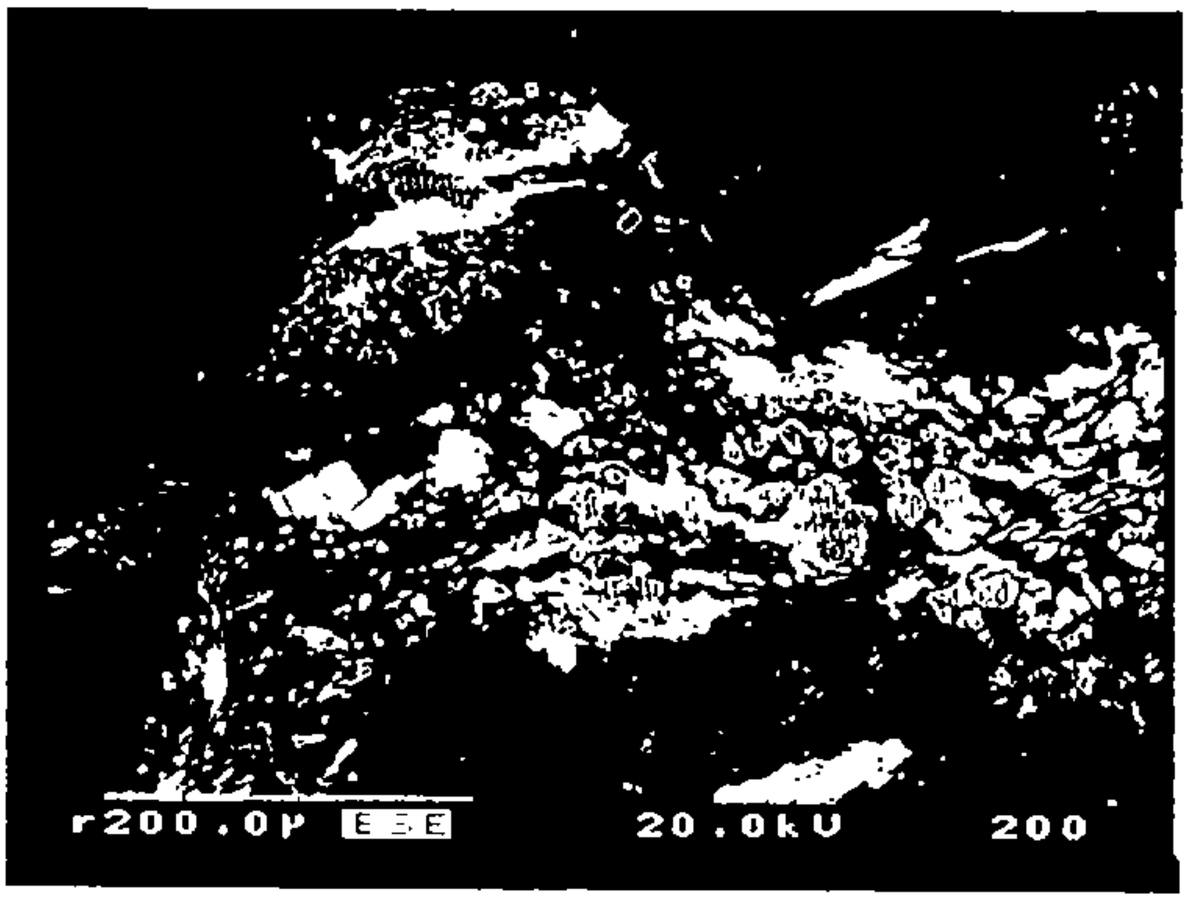

PLATE 3: Sample 77702 (Backscattered electron image, 20μm grey bar for scale)
This view shows a granular alteration aggregate (also see PLATE 1, bottom centre) Small ragged grains of autunite/ meta-autunite (bright white, centre left) are intimately associated with rutile (dull ragged grey grains) that has replaced primary ilmenite (pale grey wispy remnants, analyses 77702-10 and 77702-11)

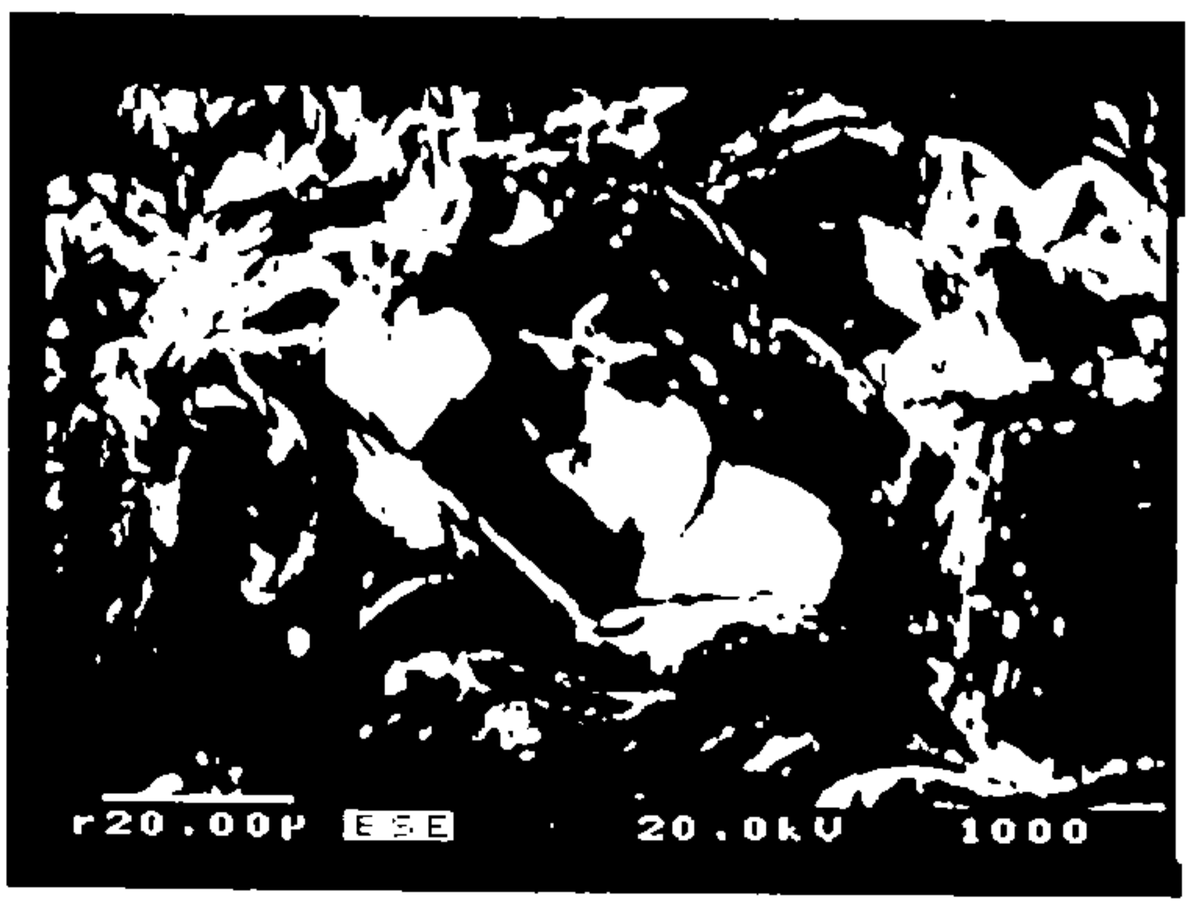

PLATE 4: Sample 77702 (Backscattered electron image, 20μm white bar for scale)
This view illustrates small equant grains of autunite / meta-autunite (white, centre, upper left; analyses 77702-2 and 77702-3) that are associated with patches of iron oxide (duller white, upper left, upper right)

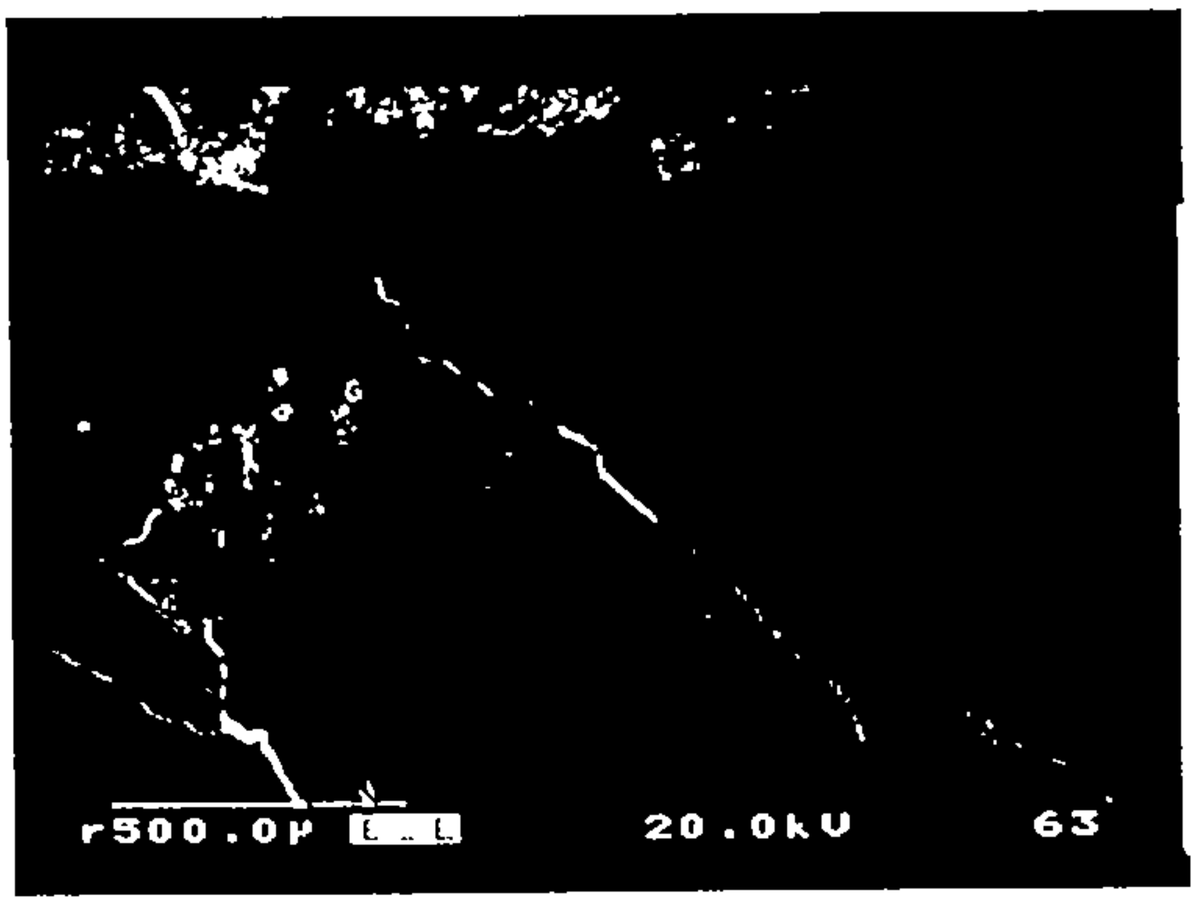

PLATE 5: Sample 79400 (Backscattered electron image, 500μm bar for scale)
Autunite / meta-autunite (bright white) occupies thin microcracks in vein quartz, and also forms tiny ragged aggregates within ferruginous contact (top left) of vein with granitic host rock. Most of the field of view is occupied by vein quartz (black). Paler grey material is iron oxide.

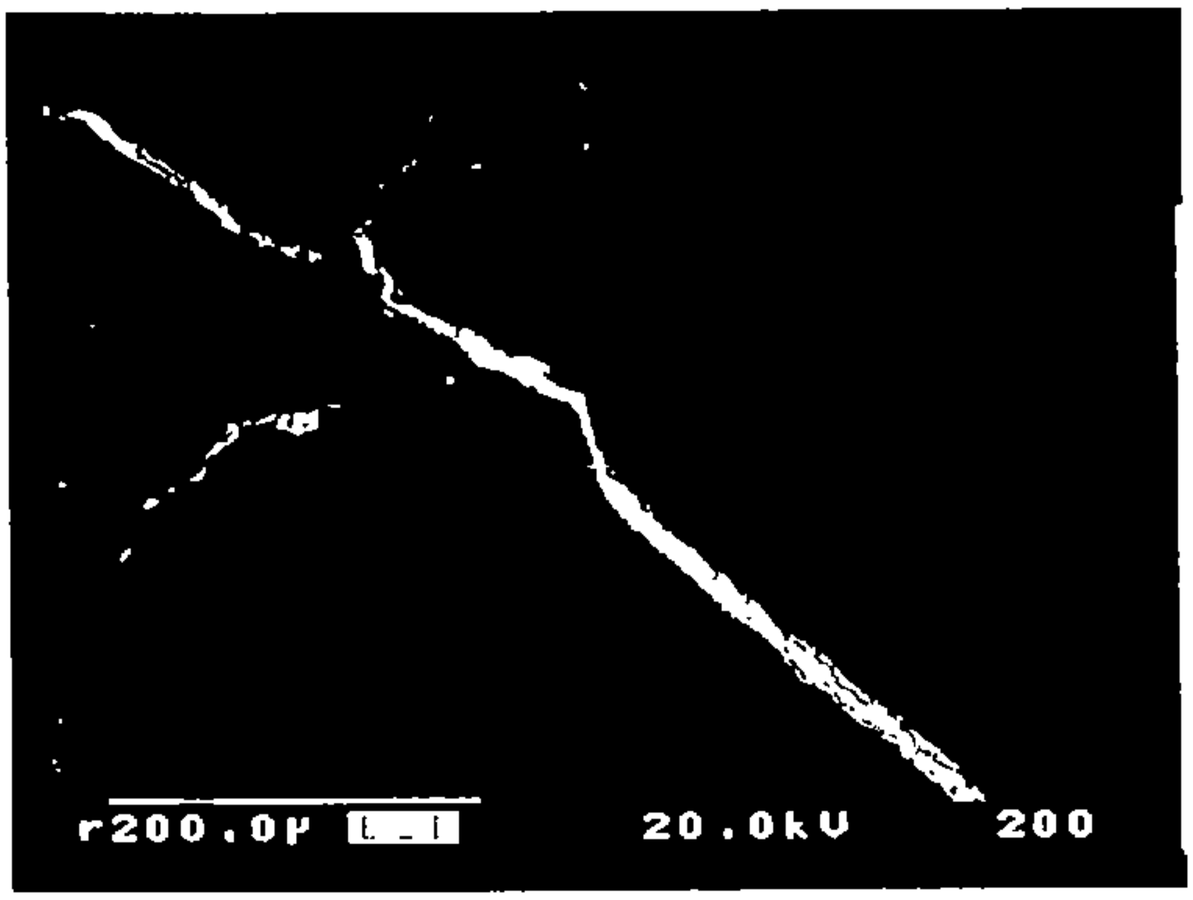

PLATE 6: Sample 79400 (Backscattered electron image, 200μm bar for scale)
This closer view shows a thin microcrack in vein quartz, filled by autunite meta-autunite (bright white, analysis 79400-7) and iron oxide (dull grey; analysis 79400-8).

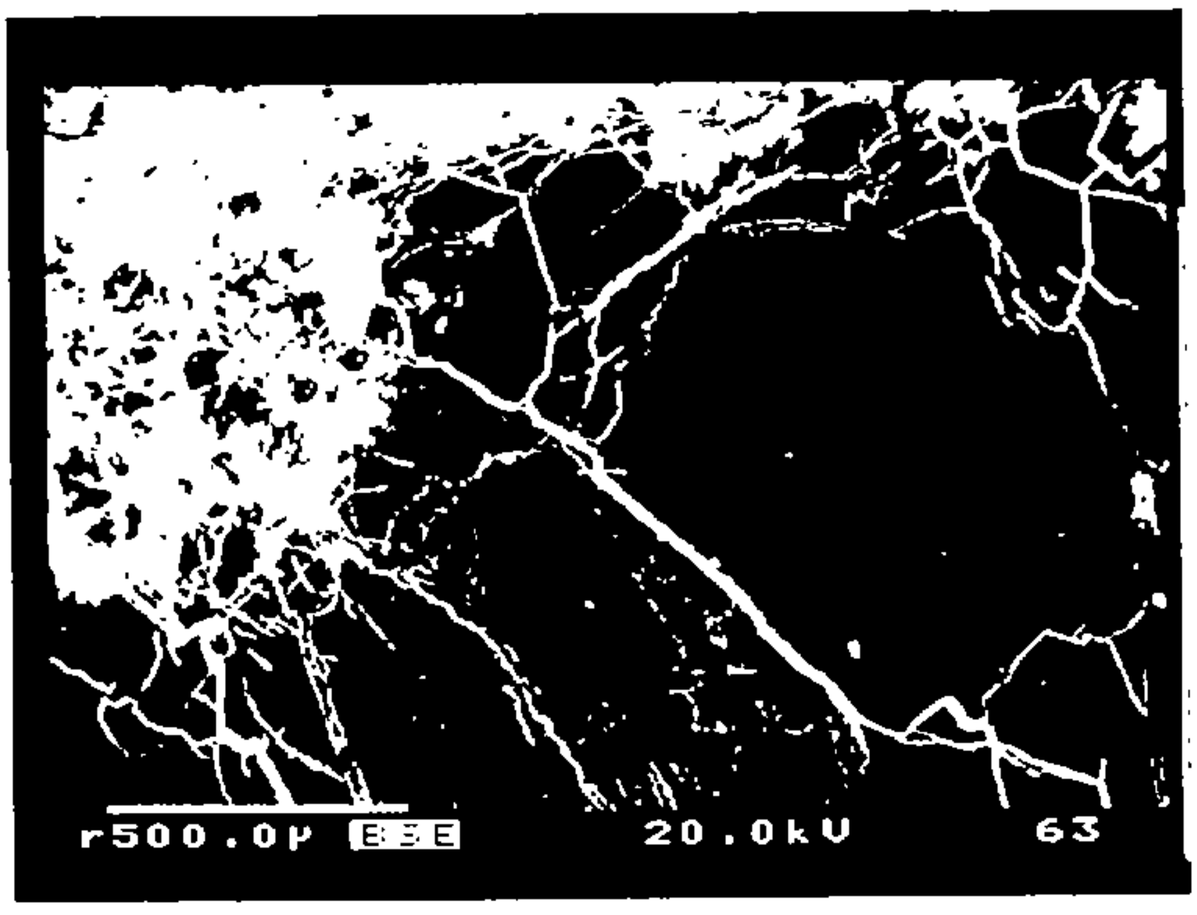

PLATE. 7: Sample 79400 (Backscattered electron image, 500μm bar for scale)
This view shows portion of the contact between vein quartz (bottom, dull grey) and the contact (top) with granitic host rock. The white material filling fractures and densely occupying the contact zone is iron oxide and autunite / meta-autunite.

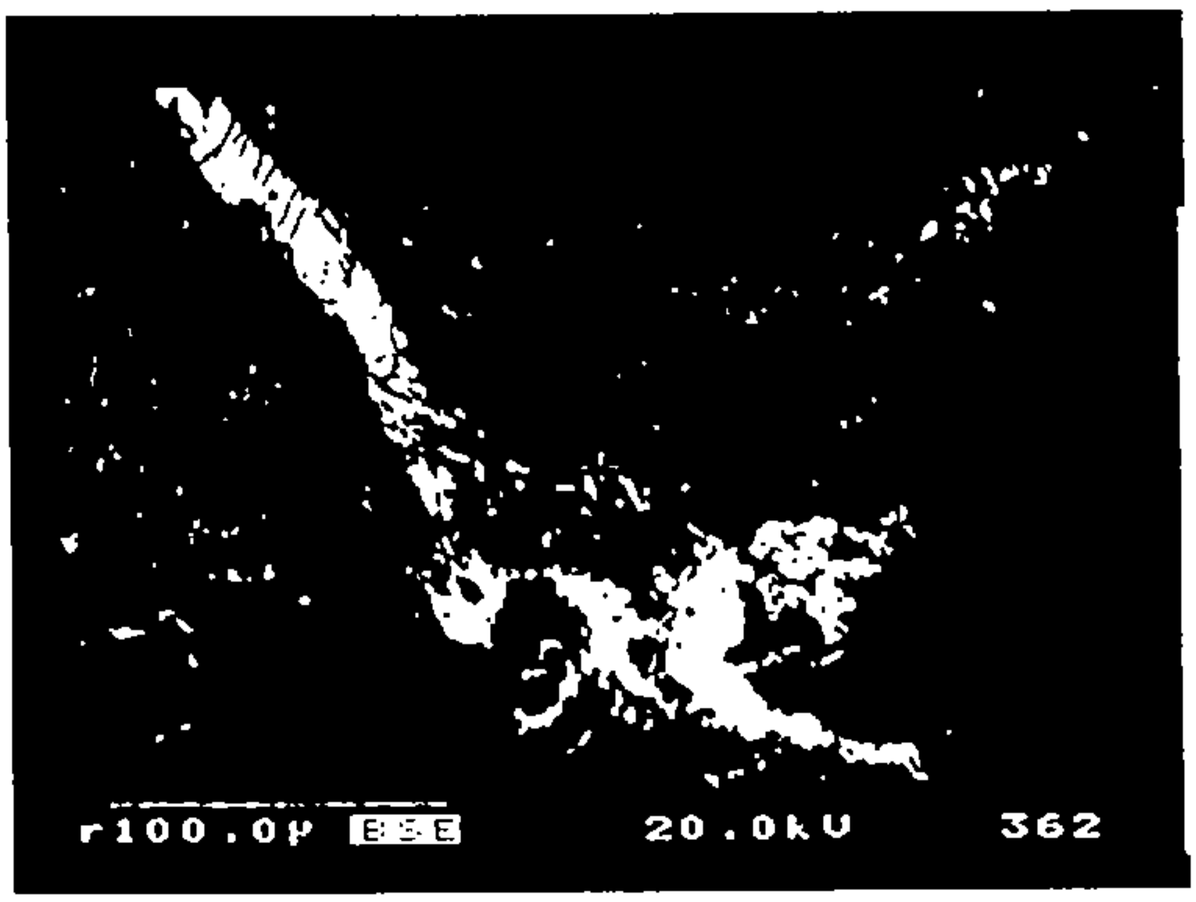

PLATE 8: Sample 79400 (Backscattered electron image, 100μm bar for scale)
This view shows closer detail of an autunite / meta-autunite-bearing microcrack (upper left, analysis 79400-1) and ragged aggregate of the same phase (analysis 79400-2) in the contact zone between the quartz vein and granitic host rock (see top left of PLATE 5 for location)

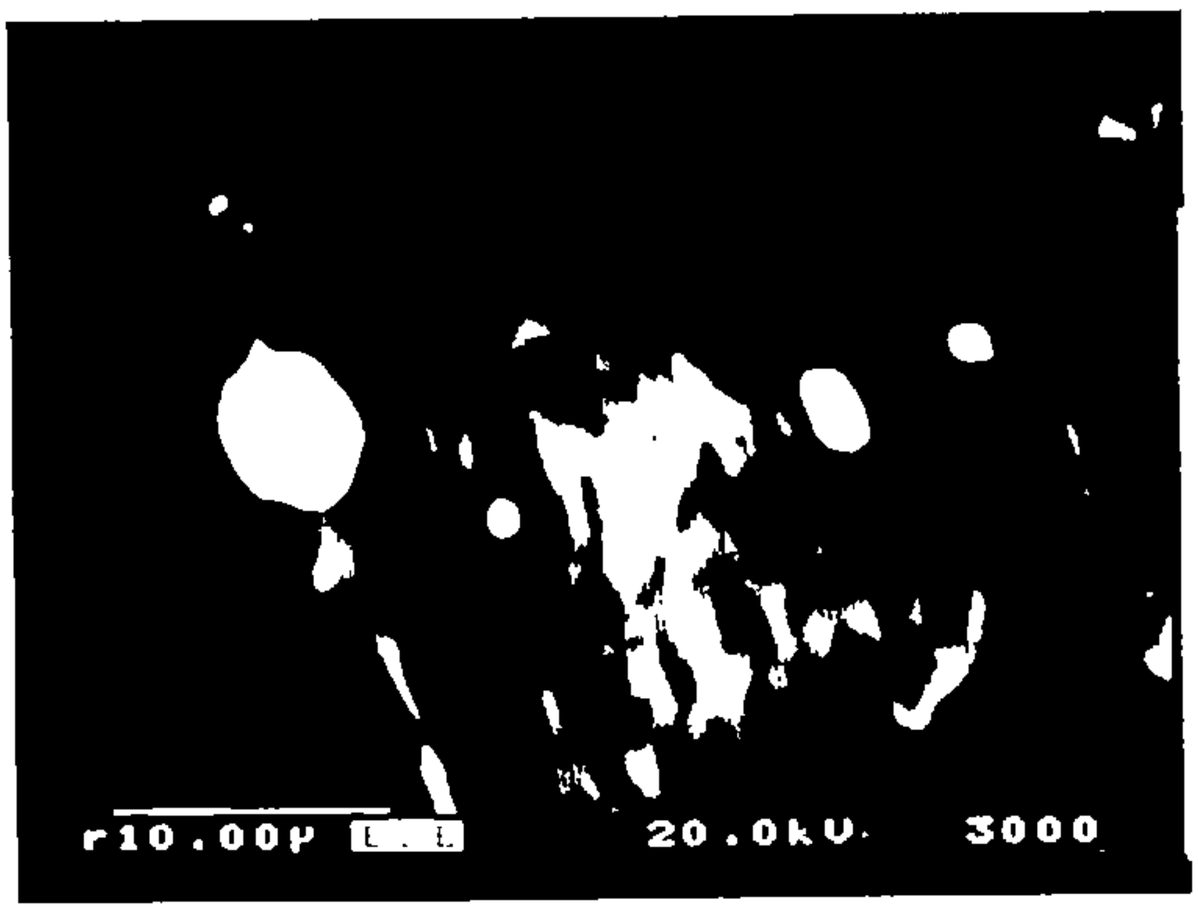

PLATE 9: Sample 79400 (Backscattered electron image, 10μm bar for scale)
Small equant grains of native gold (bright white, centre left, centre right) are associated with ragged patches of autunite / meta-autunite (dull white, lower centre) and iron oxide (black, rest of field of view)

APPENDIX 2: AUTORADIOGRAPH REPORT

The full autoradiograph report from Amdel Limited is provided in the following pages.

Note that the autoradiographs are provided in the first copy of this report, enclosed in a small zip-top plastic bag.

amdel

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23 January 1997

Mason Geoscience Pty Ltd
PO Box 78
GLENSIDE SA 5065

Attn: Dr D Mason

REPORT G27/97

AUTORADIOGRAPHY OF TWO POLISHED THIN SECTIONS

YOUR REFERENCE:	Letter dated 13 January 1997
SAMPLE IDENTIFICATION:	TSC 67119 and TSC 67124
MATERIAL:	2 polished thin sections
DATE SAMPLES RECEIVED:	14 January 1997
DATE AUTHORISATION RECEIVED:	14 January 1997
WORK REQUIRED:	Autoradiography
INVESTIGATION AND REPORT BY:	Frank Radke

Dr Keith J Henley
Manager, Mineralogical Services

cjc

AUTORADIOGRAPHY OF TWO POLISHED THIN SECTIONS

1. INTRODUCTION

Two polished thin sections numbered TSC 67119 and TSC 67124 were submitted by Mason Geoscience Pty Ltd for preparation of autoradiographs. The polished thin sections were collected by Jo Mason on 21 January 1997.

Each polished thin section was notched, with one notch being put in TSC 67119 and two notches in TSC 67124, to aid in orientation of these sections on the autoradiographs. The backs of the polished thin sections were blacked out and the polished surfaces of the polished thin sections placed on X-ray film which was then exposed to light and placed in a lightproof box for six days, after which the film was developed. On the autoradiograph radioactive areas are defined by a darkening of the autoradiograph.

The autoradiographs are returned with this report.