APPENDIX 3

PETROGRAPHIC REPORTS

Mason Geoscience Pty. Ltd.

ACN 063 539 686

Petrological Services for the
Minerals Exploration and Mining Industry

PO Box 78, Glenside SA 5065, Australia
141 Yarrabee Road, Greenhill SA 5140, Australia
Ph: +61-8-8390-1507 Fax: +61-8-8390-1194
e-mail :drmason@interconnect.com.au

REPORT TITLE	**Petrographic Descriptions for Drill Core Rock Samples, Northern Territory**
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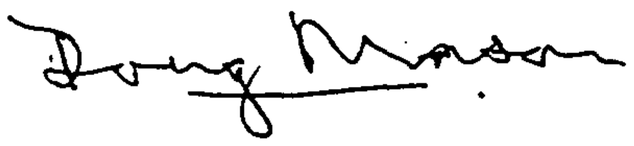
CLIENT	AFmeco Mining and EXploration Pty Ltd
ORDER NO.	3672
CONTACT	Mr John Fabray
REPORT BY	Dr Douglas R. Mason
SIGNED	

for Mason Geoscience Pty. Ltd.

DATE 13 November 1998

Petrographic Descriptions for Drill Core Rock Samples, Northern Territory

SUMMARY

1. Rock Samples

- drill core rock samples from the Northern Territory have been studied using standard petrographic methods (TABLE 1).

2. Brief Results

- Primary rock types

  - Most samples represent precursor rocks of inferred sedimentary origin, including quartzose, quartzo-feldspathic, and pelitic compositions.

    one sample (SHRD 20, 92.5m) represents an intrusive quartz dolerite.

- Metamorphism

  - The sedimentary rock sequence suffered complete recrystallisation under amphibolite facies regional metamorphic conditions, generating new foliated granoblastic assemblages that reflected their primary bulk compositions. Many of these assemblages are now obscured by subsequent alteration (see below), but they included mineral assemblages of plagioclase, quartz, K-feldspar, biotite, muscovite, garnet and sillimanite.

  - The quartz dolerite samples did not suffer the regional metamorphic event, and therefore are inferred to be much younger than the sedimentary sequence.

- Alteration

  - All samples have suffered selective pervasive hydrothermal alteration, ranging from low-intensity (partial to good preservation of primary minerals and good preservation of primary textures) to medium-intensity (complete loss of primary minerals but partial preservation of primary texture).

  - In most samples the alteration is of chlorite-sericite±hematite type

  - In drill hole SHRD 20, alteration intensity is highest in the sericite-chlorite altered quartz dolerite.

  - Veins of space-filling type are observed in some samples. In SHRD 20 (227.9m), a vein is filled by quartz + chlorite and is assumed to have formed synchronously with the pervasive wall rock chlorite-sericite-quartz alteration assemblage.

TABLE 1: SUMMARY OF ROCK NAMES AND MINERALOGY

SAMPLE	ROCK NAME	MINERALOGY*		
		Primary**	Metamorphic/alteration***	Veins
SHRD 20, 92.5m	High-intensity sericite-chlorite altered quartz dolerite	Qtz,bio,apa	Ser,chl,opq(?hem),rut	Opq(?hem)
SHRD 20, 174.0m	Chlorite-sericite altered quartz-?garnet gneiss	?Zir	Qtz,zir; Chl,ser,opq(?hem)	-
SHRD 20, 192.9m	Chlorite-sericite altered layered gneiss	-	Qtz; Chl,ser,rut	-
SHRD 20, 227.9m	Quartz-chlorite veined, chlorite-sericite altered gneiss	-	Qtz,bio; Chl,ser,qtz,rut,opq	Chl,qtz
SHRD 24, 188.8m	Sericite altered quartz-'biotite'-sillimanite gneiss	-	Qtz,sill,opq(?grp); Ser,chl,rut	-
SHRD 25, 151.5m	Layered biotite quartzo-feldspathic gneiss	-	Pla,qtz,Kf,bio,mus; Ser	-
SHRD 25, 191.0m	Low-intensity sericite-chlorite altered podiform banded biotite-sillimanite gneiss:			
"	- Biotite-sillimanite gneiss	-	Bio,sill; Chl,ser	-
"	- Felsic pods	-	Qtz,bio; Ser,chl	-

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:
Apa = apatite; bio = biotite; chl = chlorite; grp = graphite; hem = hematite; ill = illitic clay; Kf = K-feldspar; leu = leucoxene; mon = monazite; mus = muscovite; opq = opaque phas
pla = plagioclase; qtz = quartz; rut = rutile; ser = sericite; sill = sillimanite; spn = sphene; zir = zircon; ? = uncertain paragenesis or mineral identification.

1. INTRODUCTION

drill core rock samples were received from Mr John Fabray (AFmeco Mining and EXploration Pty Ltd, Winnellie, Northern Territory) on 19 October 1998.

Particular requests were:

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

ii) To provide a macrophotograph and photomicrograph for each sample (as per previous batches).

This report contains the full results of this work.

2. METHODS

The drill core samples were examined in hand specimen and marked for section preparation. Standard thin sections were obtained from an external commercial laboratory (Amdel Limited, Thebarton, South Australia).

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

Macrophotographs were taken from each drill core sample using 35mm photography including camera stand and ring flash to provide even lighting conditions. Photomicrographs were taken using standard 35mm photomicrographic equipment attached to the petrographic microscope.

3. PETROGRAPHIC DESCRIPTIONS

The petrographic descriptions are provided in the following pages.

SAMPLE : SHRD 20, 92.5m (Northern Territory)

SECTION NO. : SHRD 20, 92.5m (C71069)

HAND SPECIMEN : The drill core sample represents a massive dark green rock in which darker green patches fill interstices between slightly paler drab green patches. Scattered through the rock are minor small pale pinkish cream Ti-phase grains, and uncommon thin fractures filled by dark pink material.

ROCK NAME : **High-intensity sericite-chlorite altered quartz dolerite**

PETROGRAPHY :

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

Mineral	Vol.%	Origin
Quartz	1	Igneous
Biotite	Tr	Igneous
Apatite	Tr	Igneous
Chlorite	35	Alteration (after ?pyroxene)
Sericite	60	Alteration (after plagioclase)
Opaques (?hematite)	2	Alteration (fracture-filling and pervasive)
Rutile	2	Alteration (after Fe-Ti oxide)

In thin section, this sample displays a partly-preserved massive doleritic igneous texture, modified by selective pervasive alteration.

Sericite is abundant, occurring as tiny flakes that have pseudomorphously replaced randomly oriented small prismatic crystals ~0.6 mm long and scattered larger crystals ~2-4 mm long. All of these crystals are inferred to represent precursor plagioclase crystals, but none is preserved for confirmation. Some sericite also occurs as ragged small patches scattered elsewhere through the rock.

Chlorite occurs as optically continuous plates that have pseudomorphously replaced precursor ferromagnesian grains up to several millimetres in size (probably pyroxene, but none is preserved for confirmation). The chlorite displays a dull green pleochroism. Some of the chloritised pyroxene sites enclose smaller randomly oriented plagioclase crystal sites (now sericitised) in relatively well-preserved primary ophitic texture.

Opaques occur in moderate amount as dense fine-grained aggregates, concentrated as fracture fillings and alteration of nearby wall rock. The dark reddish brown colour of some of the 'opaques' suggests it is mainly hematite, but other phases may be present.

Scattered through the rock are relatively coarse granular aggregates of rutile which have formed by pseudomorphous replacement of a precursor Ti-phase (probably ilmenite or magnetite or both).

Quartz occurs in minor amount as small clear angular interstitial grains and poikilitic pools. They tend to contain small acicular apatite crystals.

Biotite occurs in trace amount as small angular interstitial flakes, pleochroic in reddish browns.

INTERPRETATION:

This sample represents a medium to coarse-grained doleritic intrusive igneous rock. It was originally composed of a massive ophitic to subophitic assemblage of plagioclase + pyroxene + minor Fe-Ti oxide/s + quartz + apatite. The presence of interstitial quartz confirms that the dolerite crystallised from silica-oversaturated magma of probable quartz tholeiitic magmatic affinity.

The rock has suffered selective pervasive hydrothermal alteration, generating the new assemblage sericite + chlorite + rutile + opaques (?hematite). In particular, plagioclase was replaced by sericite, pyroxene by chlorite, and primary Fe-Ti oxide/s by rutile. Minor ?hematite formed as fine-grained fracture fillings and alteration of adjacent wall rock.

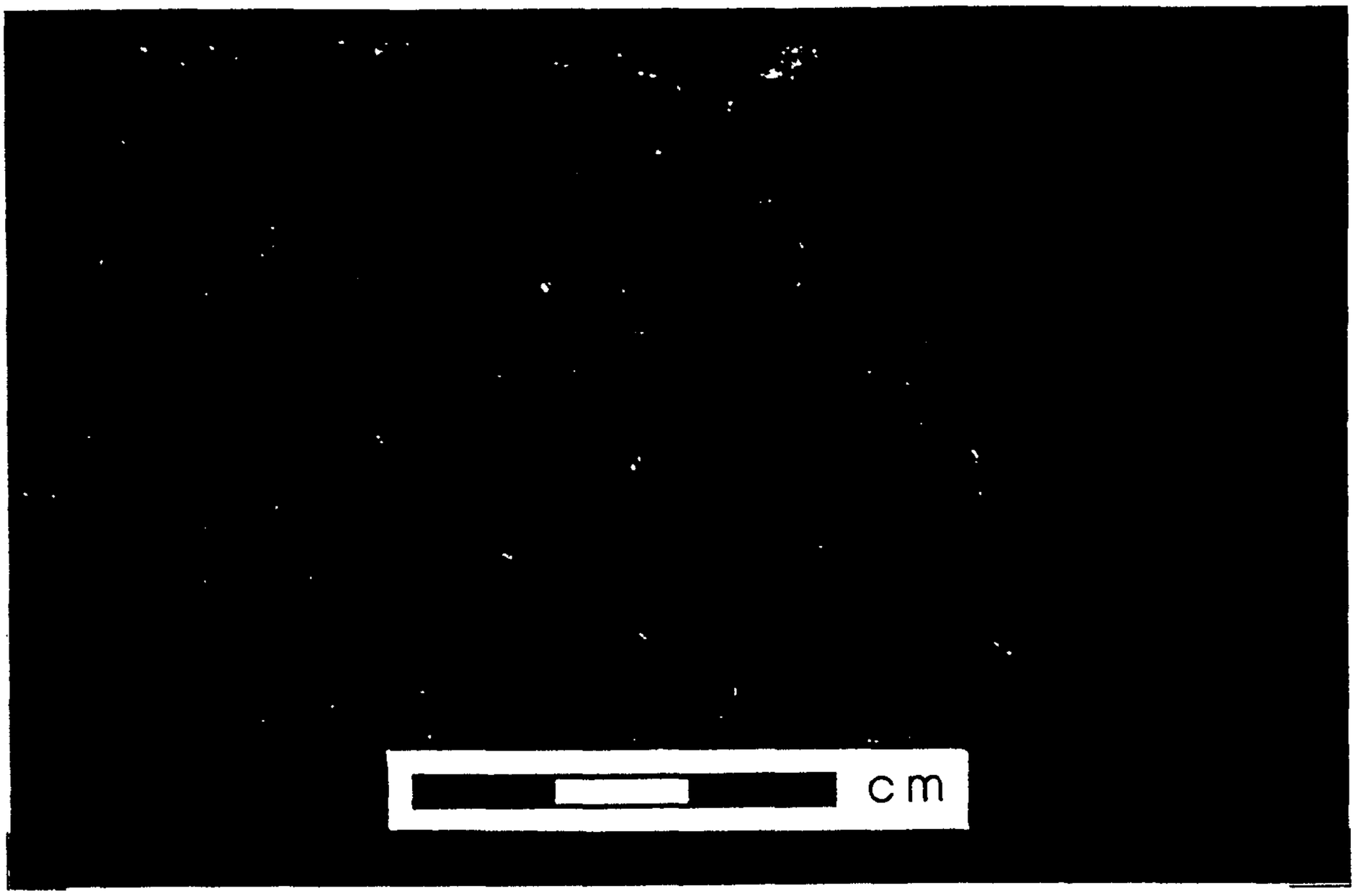


PLATE 18: SAMPLE SHRD 20, 174.0m (Macrophotograph, sawn drill core, wet. Film 1 Frame 14) Compositional layering in this altered gneissic rock is defined by chlorite altered ?garnet grains (dark green to black equant to round grains, right), quartz (translucent grey) and foliae or layers richer in alteration sericite

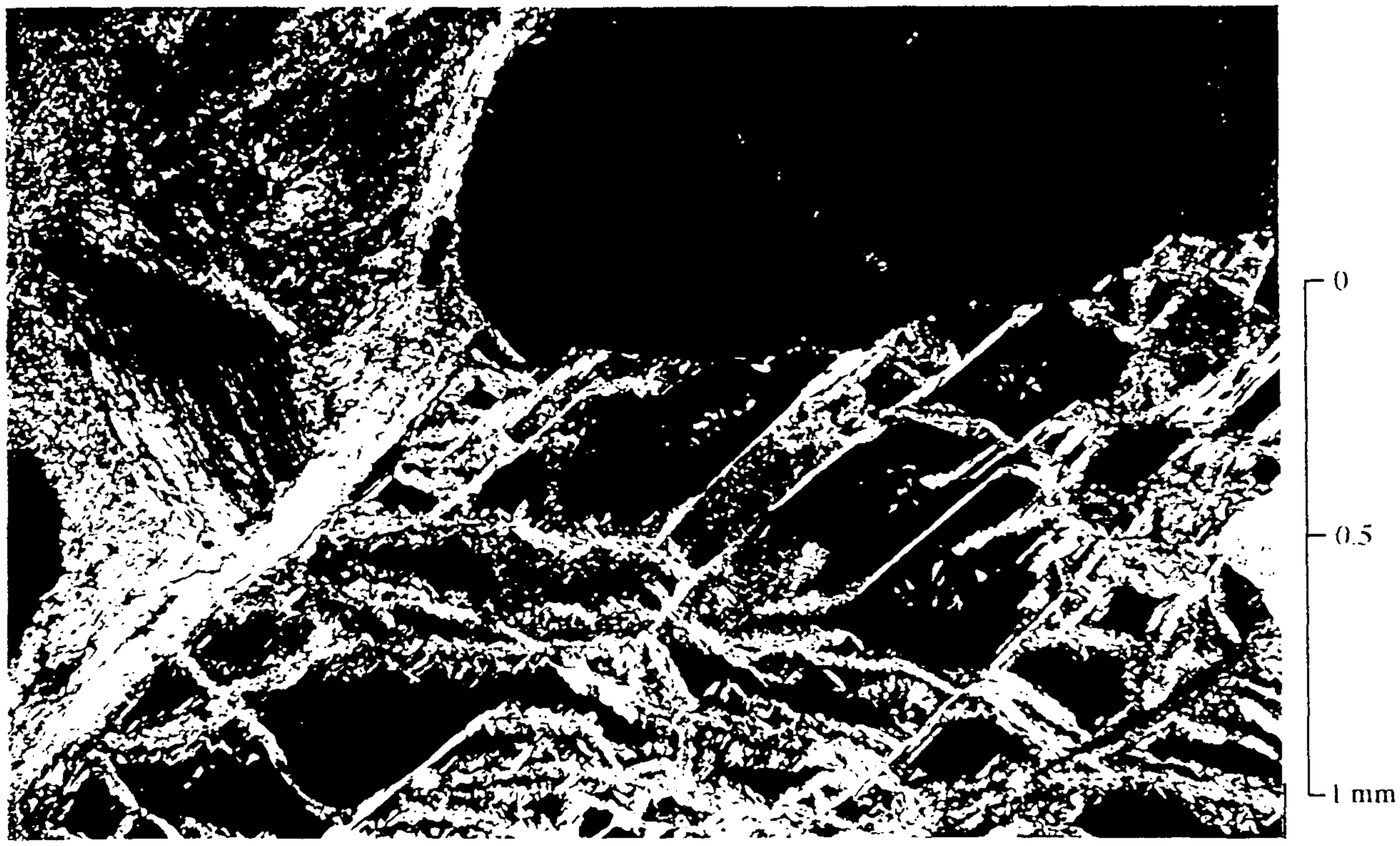


PLATE 19: SAMPLE SHRD 20, 174.0m (Photomicrograph, transmitted light, crossed polarisers, x5. Film 2 Frame 11) This view of altered gneiss shows preserved metamorphic quartz (grey, top), part of a large ?garnet grain (bottom) replaced by a sericite latticework and kernels of dark chlorite, and sericite-altered biotite flakes (top left)

SAMPLE : SHRD 20, 174.0m (Northern Territory)

SECTION NO. : SHRD 20, 174.0m (C71070)

HAND SPECIMEN : The drill core sample represents a coarse-grained pale grey siliceous crystalline rock laced with diffuse pale green phyllosilicate flakes. Dark greenish black ovoid to blocky euhedral altered crystals, several millimetres to ~1 cm in size, are loosely confined to an indistinct horizon (?layer). The section has captured several of the large dark altered crystals.

ROCK NAME : **Chlorite-sericite altered quartz-?garnet gneiss**

PETROGRAPHY :

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

Mineral	Vol.%	Origin
Quartz	60	Metamorphic
Zircon	Tr	Metamorphic / ?relict primary
Chlorite	20	Alteration (after ?garnet)
Sericite	20	Alteration
Opaques (mainly ?hematite)	Tr	Alteration

In thin section, this sample displays a relict coarsely porphyroblastic metamorphic texture, modified by selective pervasive alteration. The mode given above refers to the thin section only; mineral abundances most probably differ in the rock as a whole (more quartz-rich, less sericite and chlorite).

Quartz is abundant, occurring as large anhedral grains ~1-3 mm in size forming a coarse granoblastic mosaic through most of the rock. The quartz grains display mild shadowy strain extinction. Smaller anhedral to subrounded grains occur as inclusions within the chlorite-sericite altered grain sites.

Chlorite is moderately abundant, and occurs in different sites:

i) Most occurs as tiny randomly oriented flakes that form massive replacements of precursor large grains (most probably garnet, but none is preserved for confirmation).

ii) Some occurs as fine-grained ragged alteration patches scattered through the rock, but they tend to occur in or near sericite-rich alteration patches.

iii) Some occurs as optically continuous replacements of precursor well-crystallised phyllosilicate flakes (biotite) which tend to contain minute turbid Ti-phase granules (?rutile, ?leucoxene).

All of the chlorite displays green pleochroism suggestive of an Fe-rich composition.

Sericite occurs in similar abundance to chlorite, and also occurs in different sites:

i) Some occurs as tiny flecks that are concentrated along fractures cutting the chlorite-altered ?garnet grain sites.

ii) Some occurs as tiny flecks concentrated in ragged replacement patches, locally with chlorite. These may represent thoroughly altered precursor ?feldspar grains, but none is preserved for confirmation.

iii) Some occurs as optically continuous replacements of precursor well-crystallised phyllosilicate flakes (biotite) that were sparsely distributed through the rock and whose preferred orientation defines a foliation through the rock. The aligned biotite flakes in places wrapped around the large ?garnet grain sites.

Opaques occur in minor amount as very fine-grained dark aggregates concentrated in sericite- and chlorite-rich alteration patches. Some of the 'opaque' material displays deep red colours suggestive of hematite.

A trace of zircon occurs as small euhedral crystals and rounded grains. They may be of complex origin (e.g. relict clastic grains and metamorphic crystals).

INTERPRETATION:

This sample represents a porphyroblastic gneissic metamorphic rock, originally composed of a coarse-grained granoblastic mosaic of quartz, large garnet porphyroblasts, minor foliated biotite flakes, and possible minor feldspar. All primary minerals and textures have been destroyed, but the precursor is inferred to have been a sedimentary rock possibly of pelitic or siliceous-pelitic composition.

The rock has suffered selective pervasive hydrothermal alteration, generating the new assemblage of sericite + chlorite + minor opaques (?hematite). In detail:

i) Garnet porphyroblasts were replaced by chlorite + sericite.

ii) Biotite flakes were replaced by sericite, chlorite and tiny Ti-phase granules.

iii) ?Feldspar grains were replaced by sericite ± chlorite ± opaques (?hematite).

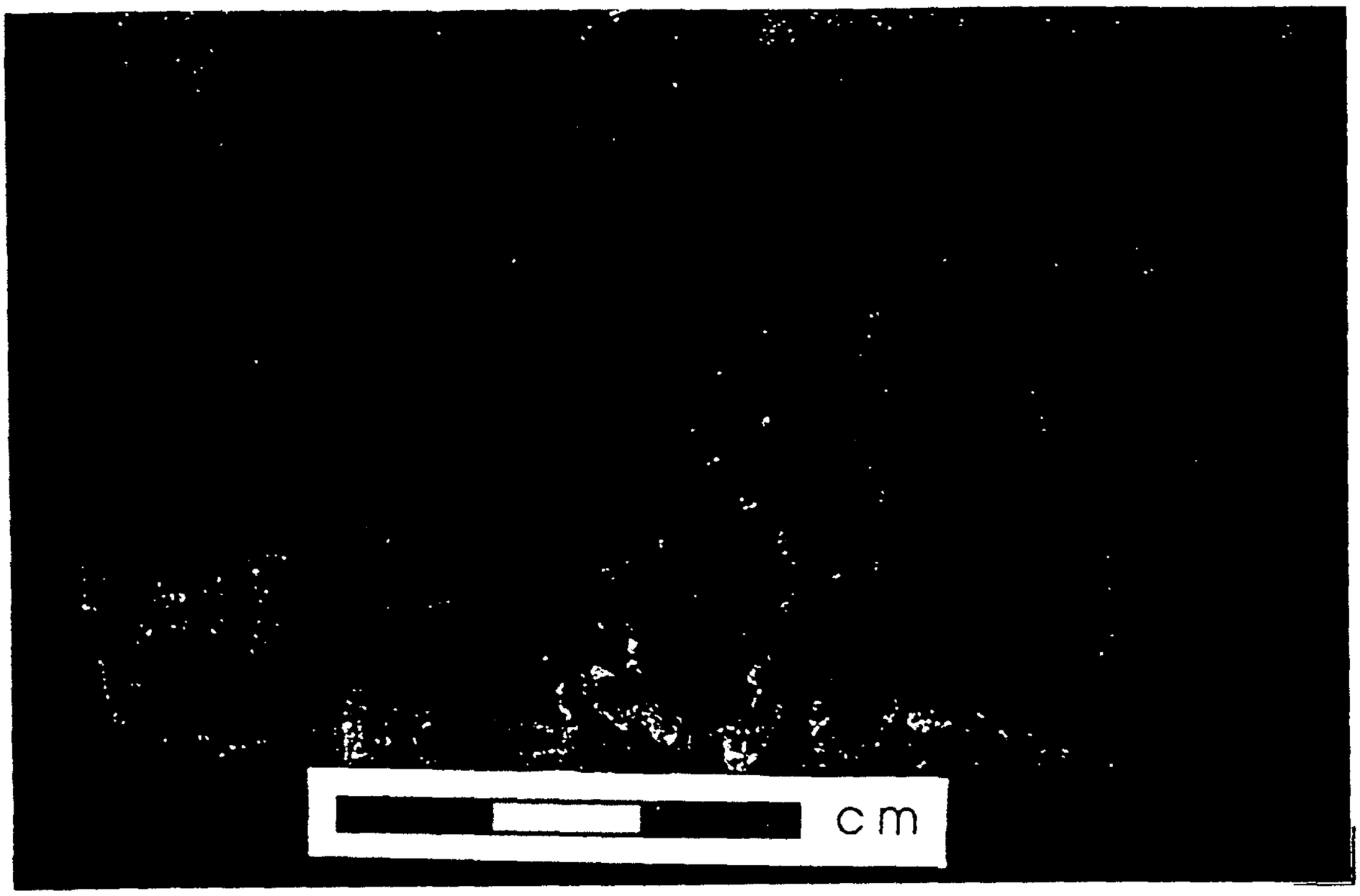


PLATE 20: SAMPLE SHRD 20, 192.9m (Macrophotograph, sawn drill core, wet; Film1 Frame 15) Layering in this gneissic rock is preserved despite strong selective pervasive alteration by chlorite (dark green) and sericite (not distinguishable). Metamorphic quartz (translucent grey to white) is preserved.

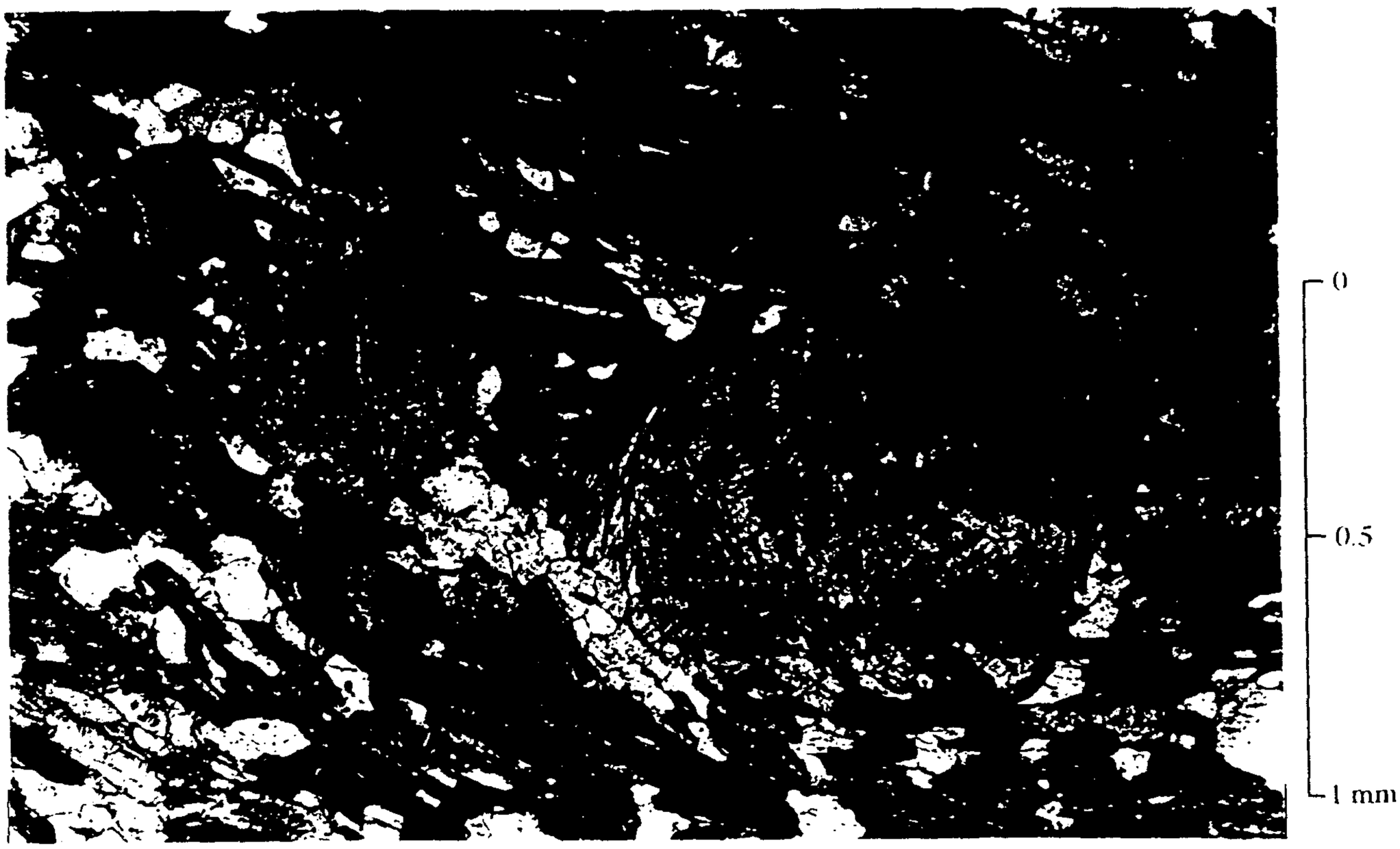


PLATE 21 SAMPLE SHRD 20, 192.9m (Photomicrograph, transmitted plane polarised light, x5. Film 2 Frame 12). This view shows portion of a darker layer, in which equant ?garnet porphyroblasts (lower right, upper left) have been pseudomorphously replaced by chlorite. Foliated biotite flakes (oriented NW-SE) have been partly replaced by chlorite.

SAMPLE : SHRD 20, 192.9m (Northern Territory)

SECTION NO. : SHRD 20, 192.9m (C71071)

HAND SPECIMEN : The drill core sample represents a layered gneissic rock composed of alternating coarser-grained felsic layers and darker greenish grey to yellowish layers.

ROCK NAME : **Chlorite-sericite altered layered gneiss**

PETROGRAPHY :

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

Mineral	Vol.%	Origin
Quartz	40	Metamorphic
Chlorite	50	Alteration
Sericite	10	Alteration
Rutile	Tr	Alteration

In thin section, this sample displays a relatively well-preserved medium to coarse-grained granoblastic metamorphic texture with foliation and mineralogical layering. It has been modified by selective pervasive alteration.

Quartz is abundant. Most occurs in the more mafic layers as small equant anhedral grains ~0.2-0.4 mm in size. Some quartz occurs as larger anhedral grains that form a coarse-grained mosaic in quartz-rich layers.

Chlorite is abundant, and occurs in different sites:

i) Some occurs as fine-grained massive green replacements of equant subhedral to anhedral grains ~0.4-1.0 mm in size, with minor small rounded quartz inclusions. These grains were concentrated in particular layers, and they may have been garnet grains but none is preserved for positive identification.

ii) Most chlorite occurs as fine-grained massive green replacements of precursor anhedral grains that formed a granoblastic mosaic in many layers of the rock. None of the precursor phase or phases has been preserved, but much may have been feldspar.

iii) Some occurs as optically continuous replacements of precursor well-crystallised phyllosilicate flakes ~0.4-1.0 mm long. These clearly were biotite flakes: they were concentrated in particular layers, and their preferred orientation subparallel to layering contributed to the structure through the rock. Identification as biotite is supported by the presence of tiny Ti-phase granules peppered through the altered flake sites, and also the presence of drab brownish colour in some slightly less-altered flakes.

Sericite occurs in moderate amount, mostly as replacements of precursor biotite flakes, with associated tiny Ti-phase granules. Some occurs elsewhere through the rock as ragged replacement patches.

Rutile occurs as tiny granules in altered biotite flake sites, and also as coarser granular aggregates (possibly alteration of precursor metamorphic ?ilmenite) sparsely scattered through the rock.

INTERPRETATION:

This sample represents a gneissic metamorphic rock which formed by complete recrystallisation of an unknown precursor rock (possibly of pelitic composition) under conditions of regional metamorphism in the amphibolite facies. This generated the layered foliated granoblastic assemblage of unknown minerals (?feldspar, ?others) + quartz + ?garnet + biotite + trace Ti-phase (?ilmenite).

Subsequent invasion by hydrothermal fluids caused severe selective replacement:

i) ?Feldspars ± ?others were completely replaced by chlorite + sericite.

ii) ?Garnet was completely replaced by chlorite.

iii) Biotite was completely replaced by chlorite or sericite + Ti-phase.

Metamorphic quartz and the layered granoblastic metamorphic texture were preserved through this event.

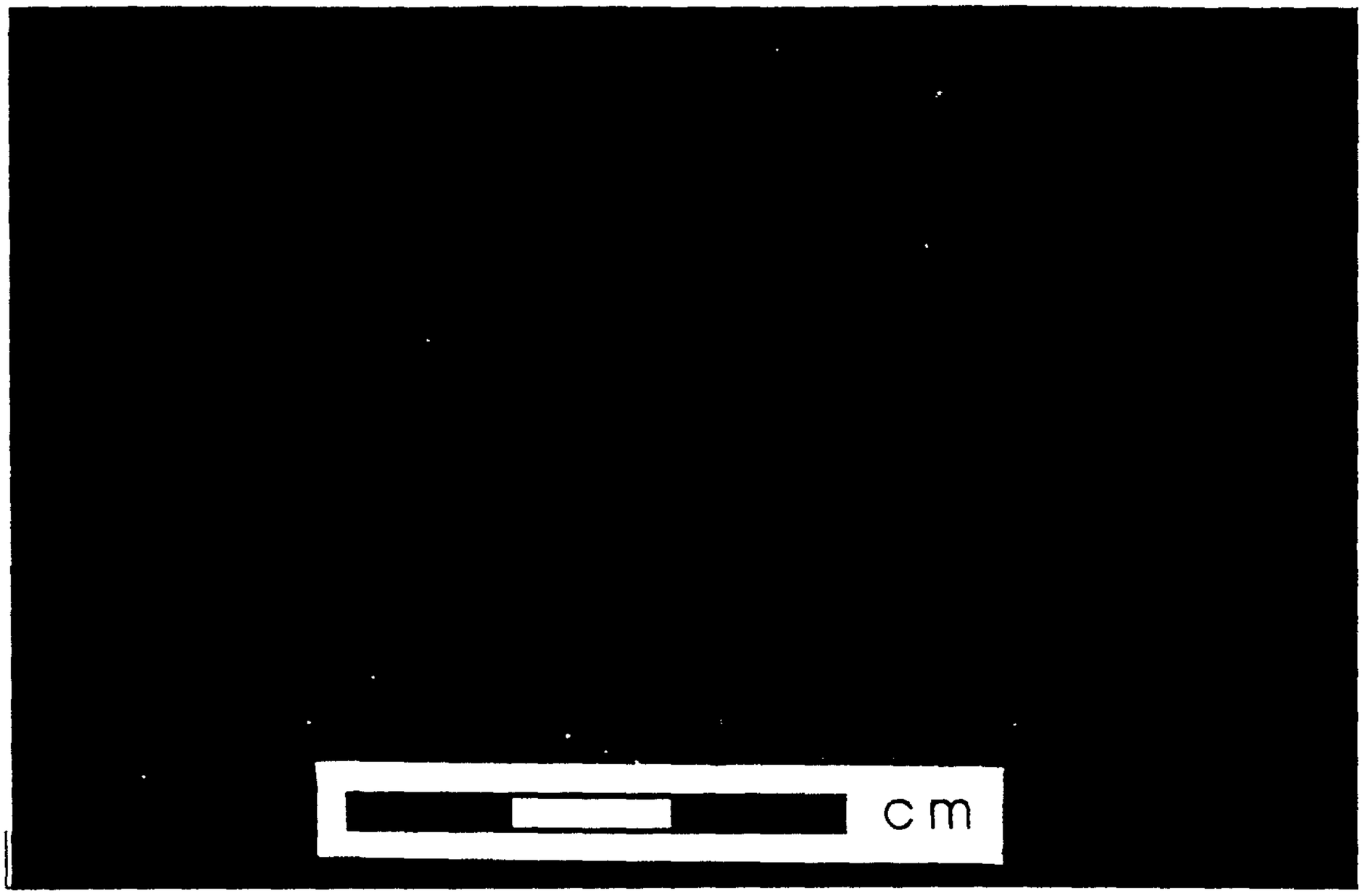


PLATE 22: SAMPLE SHRD 20, 227.9m (Macrophotograph, sawn drill core, wet, Film 1 Frame 16) Relict metamorphic foliation (E-W) is retained despite strong pervasive alteration by chlorite and sericite. A single foliation parallel fracture has been filled by chlorite (dark green, along margins) and quartz (pale grey, centre of vein).

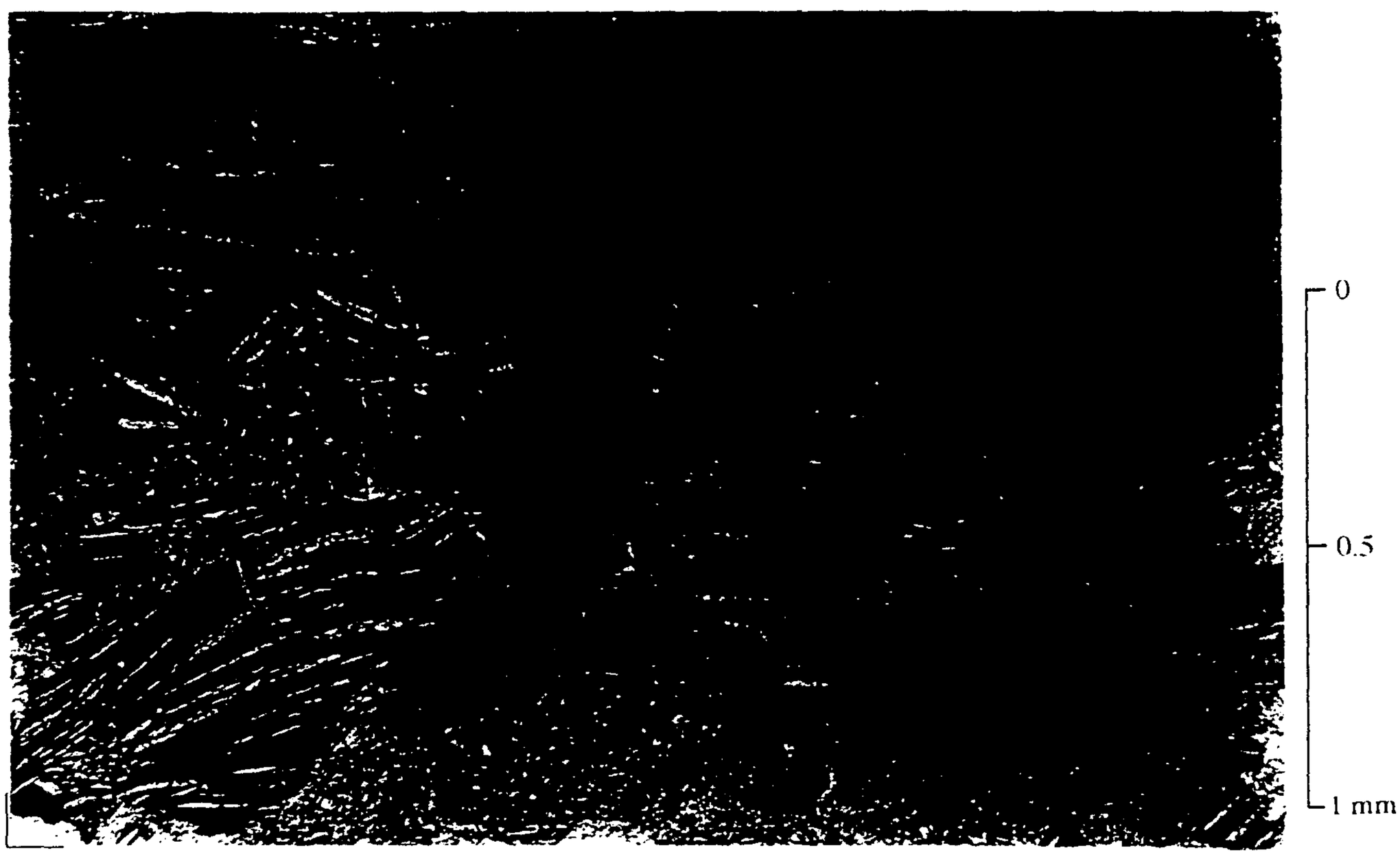


PLATE 23: SAMPLE SHRD 20, 227.9m (Photomicrograph, transmitted plane polarised light, x5, Film 2 Frame 13). Relict foliated flakes of biotite (brown) are partly replaced by cleavage lenses of quartz. They lie in a fine-grained alteration matrix composed mainly of chlorite, sericite and quartz.

SAMPLE : SHRD 20, 227.9m (Northern Territory)

SECTION NO. : SHRD 20, 227.9m (C71072)

HAND SPECIMEN : The drill core rock sample represents a fine-grained grey rock cut by a single vein filled by dark green chlorite at vein margins and central translucent grey quartz.

ROCK NAME : **Quartz-chlorite veined, chlorite-sericite altered gneiss**

PETROGRAPHY :

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

Mineral	Vol.%	Origin
Chlorite-sericite altered gneiss		
Biotite	2	Relict metamorphic
Quartz	10	Metamorphic
Chlorite	63	Alteration
Sericite	20	Alteration
Quartz	5	Alteration
Ti-phase (?rutile, ?leucoxene)	Tr	Alteration
Opaques	Tr	Alteration
Quartz-chlorite vein		
Quartz	50	Vein filling
Chlorite	50	Vein filling

In thin section, this sample displays a fine- to medium-grained foliated granoblastic metamorphic texture, modified by strong selective pervasive alteration.

Chlorite-sericite altered gneiss contains biotite as well-crystallised flakes ~0.4 mm long, pleochroic from tan brown to pale yellow. They are distributed relatively uniformly, and their preferred orientation defines a moderate foliation through the rock. All biotite flakes display alteration in the form of lenticular quartz patches concentrated along swollen cleavage traces. Uncommon larger biotite flakes up to ~2 mm long occur in quartz-rich horizons.

Quartz occurs in moderate amount as large anhedral grains that form coarse granoblastic mosaic concentrated in particular horizons (layers) of the rock. A small amount of quartz occurs as small anhedral grains in other horizons, but most of the rock is free of quartz.

Chlorite is abundant, occurring as fine-grained massive pleochroic green replacements of anhedral grains that contributed to the metamorphic granoblastic mosaic through the rock. No precursor mineral has been preserved to aid identification, but possible phases include plagioclase and hornblende.

Sericite occurs as tiny randomly oriented flakes concentrated in equant anhedral grain sites (possibly ?plagioclase) that were distributed as part of the granoblastic mosaic.

A Ti-phase, either rutile or more poorly-crystallised leucoxene, occurs as tiny granules sprinkled through some of the chlorite-altered grain sites. The presence of a Ti-phase in these sites suggests that the precursor phase was Ti-bearing, and it may have been hornblende.

Opaques are rare, occurring as small anhedral grains in loose aggregates very sparsely scattered through the rock.

Quartz-chlorite vein displays a zoned space-filling texture. Very fine-grained dense pale green chlorite formed a massive lining along both vein walls. The central part of the vein is filled by anhedral but elongate quartz grains that have grown from margins inwards.

INTERPRETATION:

This sample represents a granoblastic gneissic metamorphic rock of uncertain mineralogy. It may have been dominated by feldspar and amphibole, and it certainly contained minor amounts of quartz and biotite. The primary rock therefore may have been a calc-silicate sediment.

The rock has suffered severe selective pervasive alteration in response to fracturing and invasion by hydrothermal fluids. Fractures were filled by the zoned space-filling assemblage of chlorite + quartz, and wall rock suffered severe selective replacement by chlorite + sericite + minor quartz + trace Ti-phase.

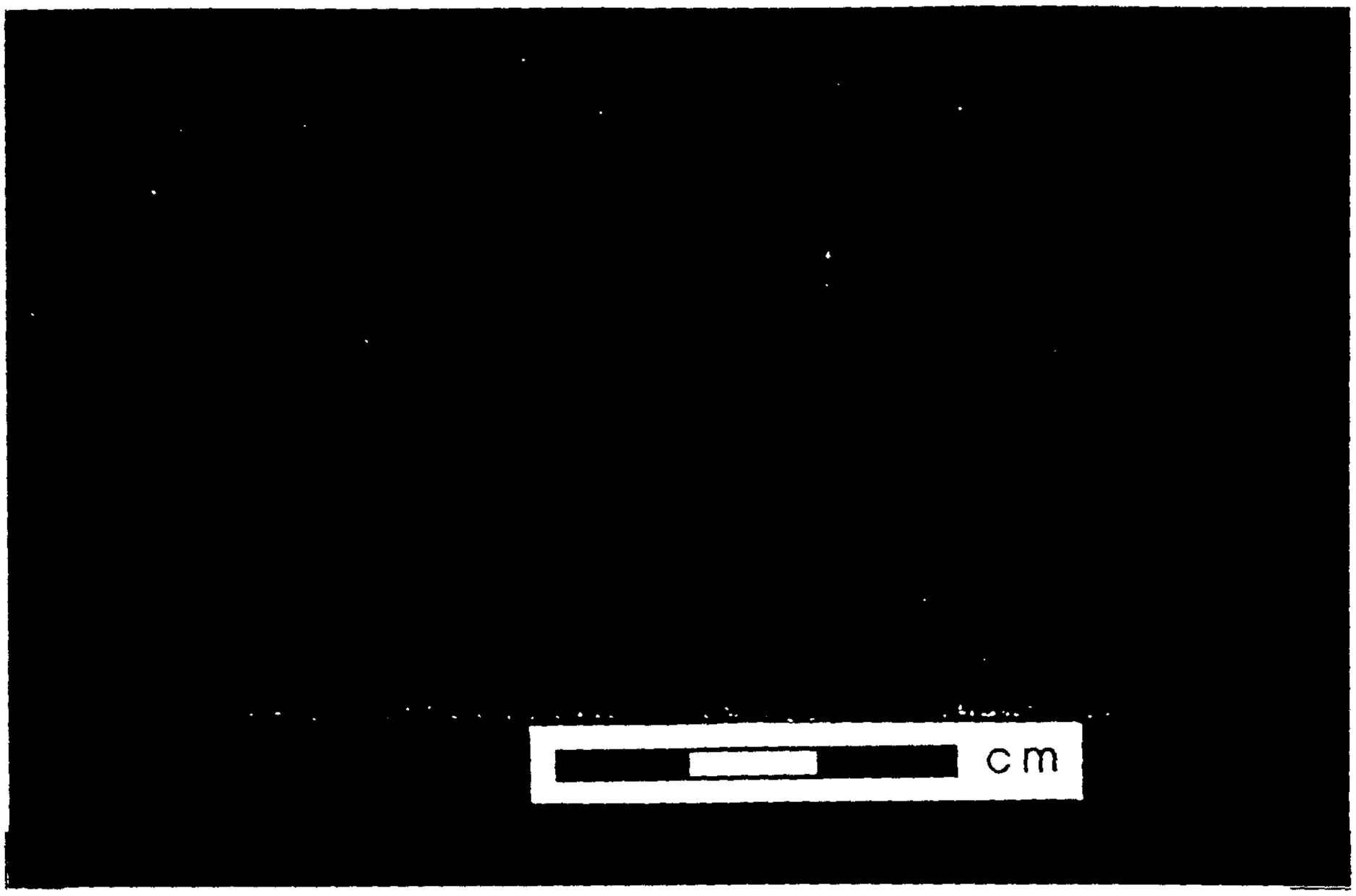


PLATE 24: SAMPLE SHRD 24, 188.8m (Macrophotograph, sawn drill core, wet; Film 1 Frame 18) This view shows the strong foliation (NW-SE) in this gneissic metamorphic rock. The brownish tinge is attributable to biotite flakes partly to severely replaced by sericite

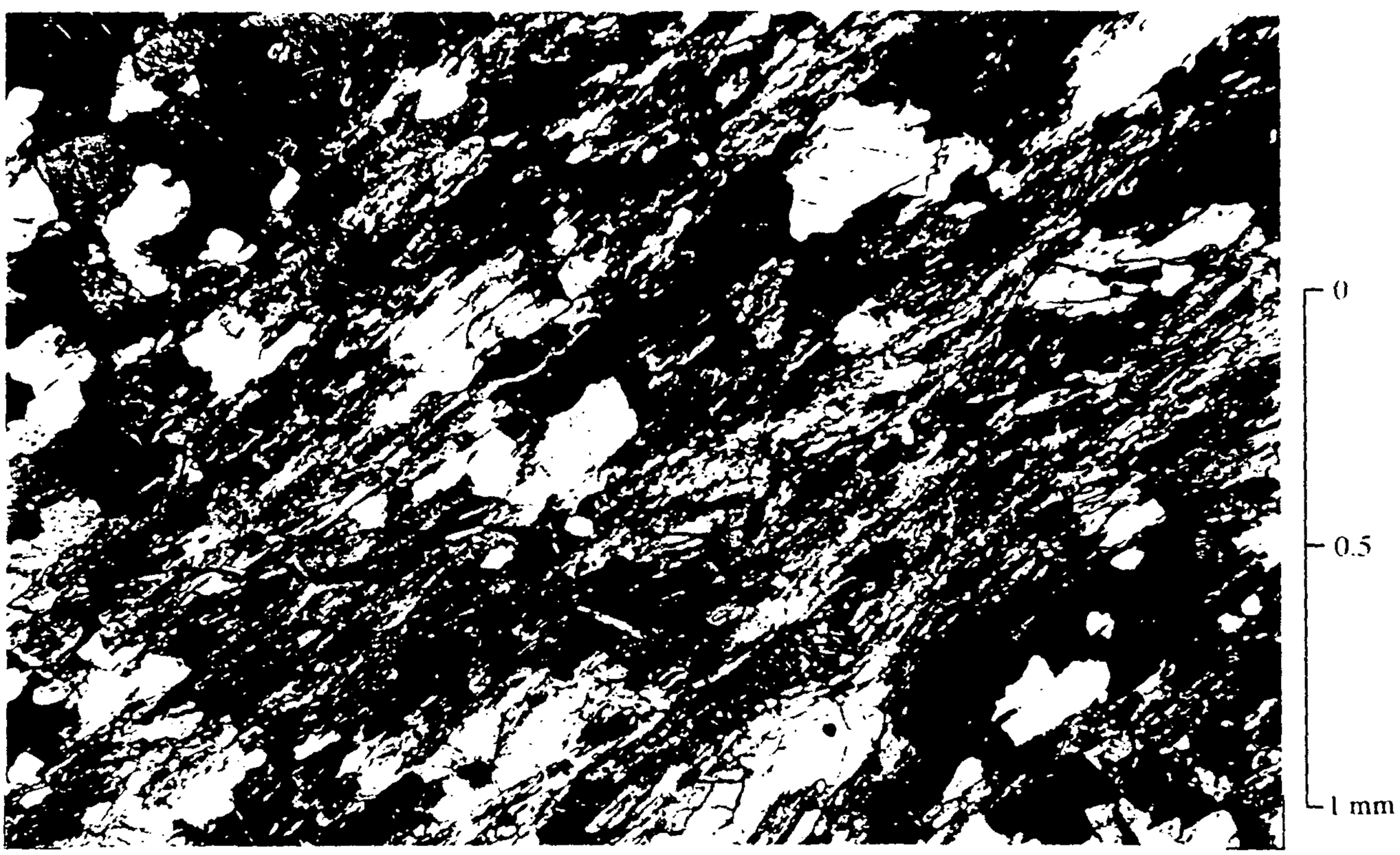


PLATE 25: SAMPLE SHRD 24, 188.8m (Photomicrograph, transmitted light, crossed polarisers, x5, Film 2 Frame 14). The rock is composed mainly of quartz (white to grey and black) and partly sericite-altered biotite (yellow, oriented NE-SW). A small amount of sillimanite occurs as small fibrolitic lenses, and as tiny acicular crystals aligned in the foliation.

SAMPLE : SHRD 24, 188.8m (Northern Territory)

SECTION NO. : SHRD 24, 188.8m (C71075)

HAND SPECIMEN : The drill core sample represents a fine-grained foliated rock with a dull brownish grey tinge and minor small darker green patches or foliae within the foliation.

ROCK NAME : **Sericite altered quartz-'biotite'-sillimanite gneiss**

PETROGRAPHY :

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

Mineral	Vol.%	Origin
Quartz	62	Metamorphic
Fibrolite (fine foliated sillimanite)	5	Metamorphic
Opaques (?graphite)	<1	Relict metamorphic
Sericite	25	Alteration (after biotite)
Sericite (incl. rutile)	5	Alteration
Chlorite	2	Alteration

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

Quartz is abundant, occurring as anhedral grains mostly ~0.2-0.4 mm in size. Many are elongated in the trace of the foliation but display little or no shadowy strain extinction. Thus, although they originally suffered strain, they have re-equilibrated.

Sillimanite occurs in minor amount in two forms:

i) Some occurs as finely felted mats located in biotite-rich laminae or layers. This fibrolitic sillimanite is locally difficult to distinguish from sericite.

ii) Some sillimanite occurs as tiny acicular crystals sparsely sprinkled through quartz grains. The sillimanite crystals are aligned in the trace of the foliation.

Sericite is moderately abundant, and occurs in two sites:

i) Much occurs as optically continuous replacements of biotite flakes that range widely in size, ~0.2-1.5 mm long. The strong preferred orientation of the biotite flakes contribute to the structure through the rock. The sericite is sprinkled with minute turbid Ti-phase granules (rutile).

ii) Some sericite occurs as very fine-grained massive replacement patches, and thin fillings along discontinuous fractures.

Chlorite occurs in minor amount as fine-grained dense dull green replacements, limited to a single lenticular patch aligned in the trace of the foliation. No precursor phase has been preserved to aid identification, and no definitive primary grain shapes are preserved, but it may have been garnet.

Opaques occur as tiny flakes concentrated in small lenticles ~0.2-0.4 mm long, aligned in the trace of the foliation. It may be graphite, but no reflected light observations are available for confirmation.

INTERPRETATION:

This sample represents a pelitic sedimentary rock that has suffered complete recrystallisation in response to a regional metamorphic event in the amphibolite facies. This generated a strongly foliated granoblastic assemblage of quartz + biotite + minor sillimanite + others (?garnet, ?graphite).

At a later time, the rock was invaded by hydrothermal fluids which caused weak selective alteration, generating sericite + chlorite.

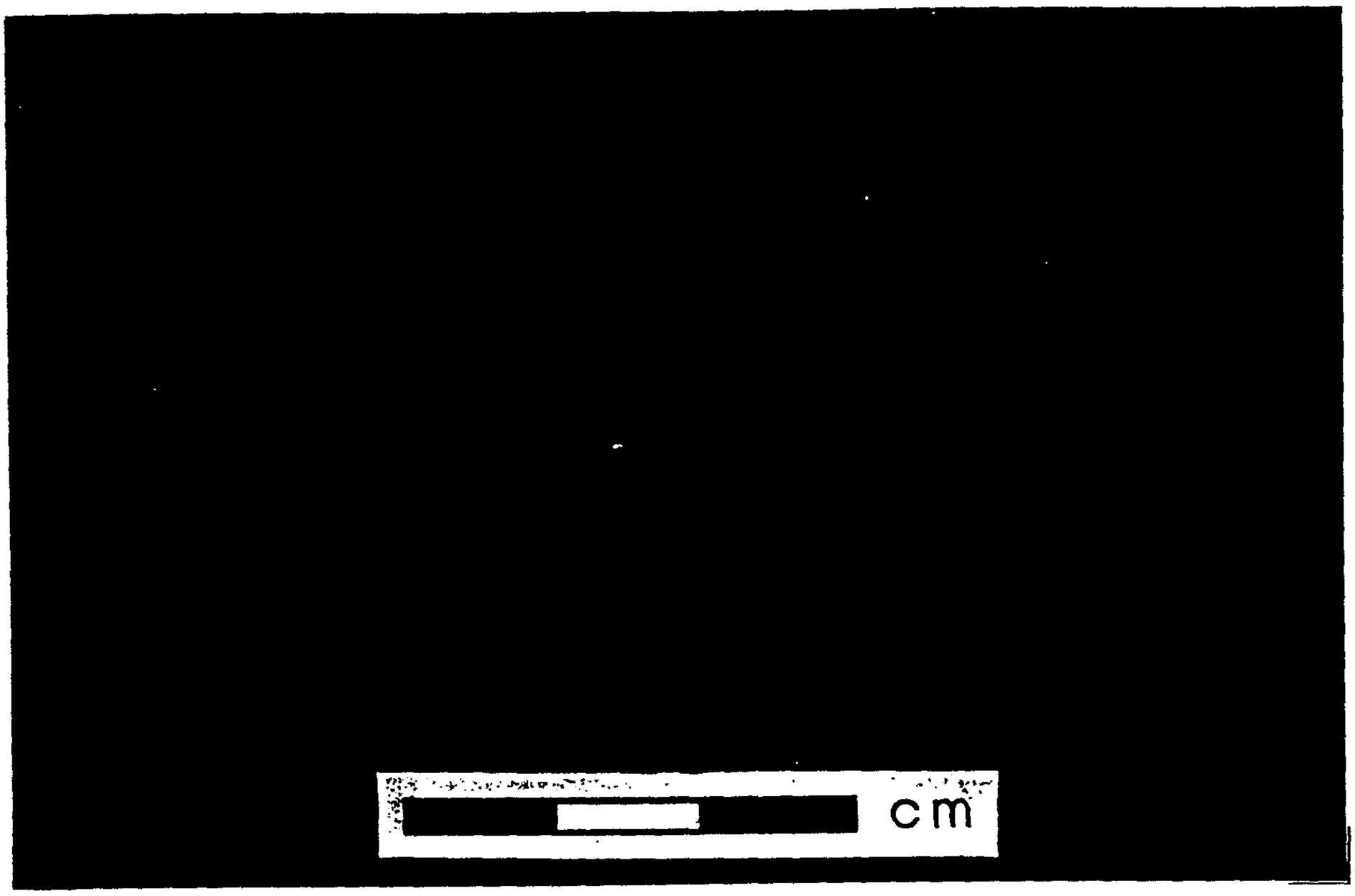


PLATE 26: SAMPLE SHRD 25, 151.5m (Macrophotograph, sawn drill core, wet, Film 1 Frame 20) Compositional layering in this gneissic metamorphic rock is defined by a darker, finer-grained biotite-richer layer (right) and a paler (biotite-poorer), coarser grained layer (left).

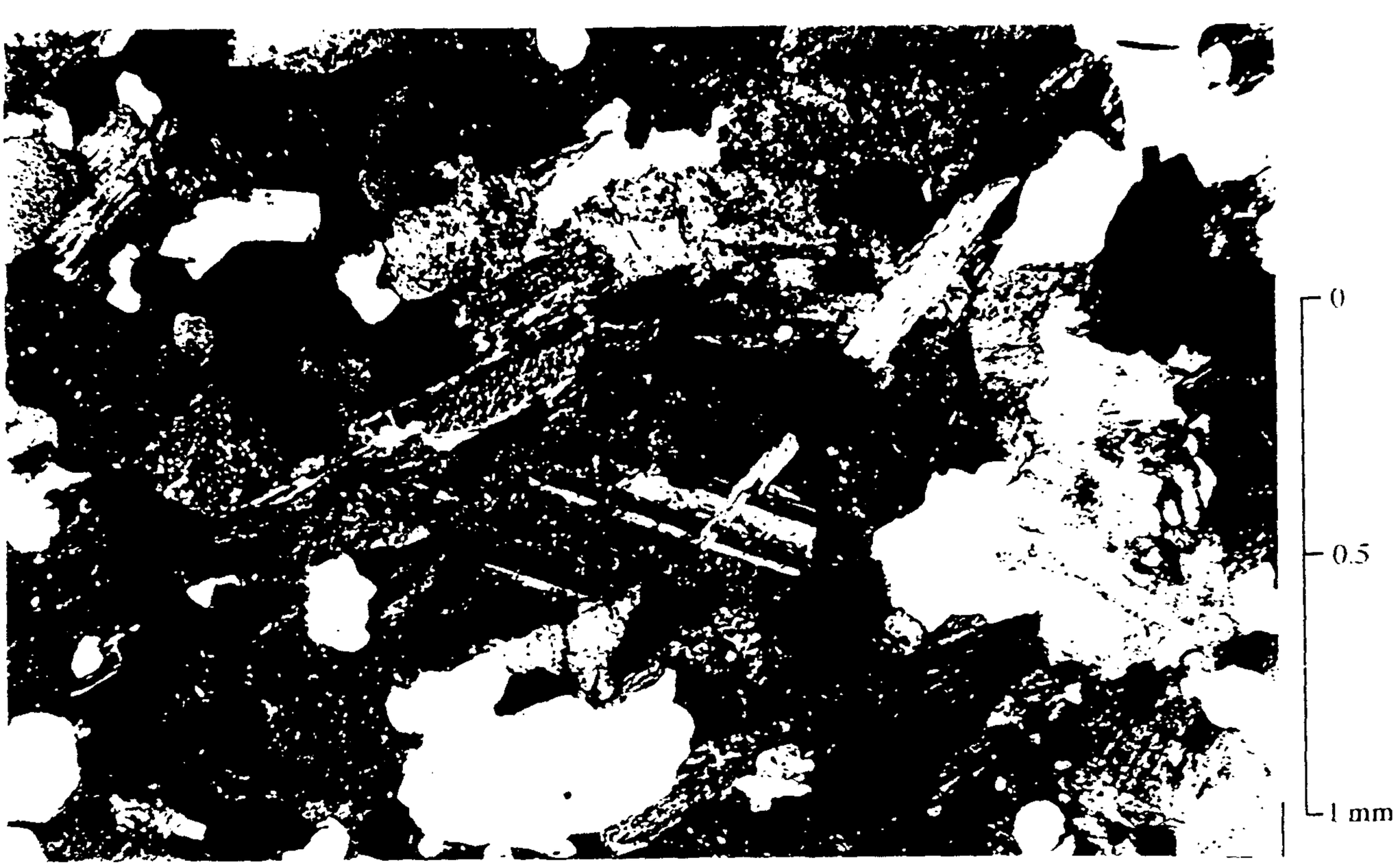


PLATE 27: SAMPLE SHRD 25, 151.5m (Photomicrograph, transmitted light, crossed polarisers, x5, Film 2 Frame 15). This view was taken from the darker, finer-grained layer. It is composed of plagioclase (grey, twinned), quartz (white to grey, clear), minor muscovite flakes (red to yellow), and biotite (drab brown flakes, bottom, top left).

SAMPLE : SHRD 25, 151.5m (Northern Territory)

SECTION NO. : SHRD 25, 151.5m (C71073)

HAND SPECIMEN : The drill core sample represents a medium-grained crystalline rock with moderate foliation. Two bands (layers) are evident: one is medium grey with a mauvish (biotitic) tinge, and the other is pale yellowish cream with scattered tiny dark mica flecks.

ROCK NAME : **Layered biotite quartzo-feldspathic gneiss**

PETROGRAPHY :

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

Mineral	Vol.%	Origin
Plagioclase (incl. trace sericite)	51	Metamorphic (incl. trace alteration)
Quartz	40	Metamorphic
K-feldspar (microcline)	3	Metamorphic
Biotite	5	Metamorphic
Muscovite	1	Metamorphic

In thin section, this sample displays a medium- to coarse-grained granoblastic metamorphic texture. The section has captured the contact between the paler and darker bands: the darker band is finer-grained and contains more biotite, while the felsic band is coarser grained and contains less biotite.

Plagioclase is abundant, occurring as equant anhedral grains ~0.5-0.8 mm in size in the slightly finer-grained darker band, and ~1-2 mm in size in the coarser paler band. All grains display combined simple and multiple twinning, and all display a trace of sericite alteration which has formed as tiny replacement flecks along cleavage traces and in ragged patches and clouds through the grains.

Quartz is moderately abundant, forming equant anhedral grains ~0.2-0.4 mm in size in the finer-grained darker band, and ~2-4 mm in size in the coarser felsic band. Most of the quartz grains display weak shadowy strain extinction.

K-feldspar occurs in minor amount as anhedral equant grains in granoblastic relationship with plagioclase and quartz. The presence of 'tartan' twinning (combined carlsbad and albite twinning) confirms identification as microcline.

Biotite forms small flakes ~0.2-0.4 mm long in the darker band, where their preferred orientation defines a foliation that is subparallel to the mineralogical and grain size layering. Although pleochroic in reddish browns, the biotite flakes display incipient alteration in the form of bleaching and replacement along cleavage traces by sericite. The uncommon biotite flakes in the felsic band are somewhat larger, up to ~0.6 mm long.

Muscovite is uncommon, forming clear well-crystallised flakes up to ~0.5 mm long. They are very sparsely scattered through the rock.

INTERPRETATION:

This sample represents a quartzo-feldspathic rock, possibly of clastic sedimentary origin. It has suffered complete recrystallisation in response to regional metamorphism in the amphibolite facies, generating the new granoblastic assemblage of plagioclase + quartz + biotite + minor muscovite. The mineralogical and grain size layering is considered to reflect primary layering in the sediment, i.e. a finer-grained more pelitic layer (darker) and a coarser-grained felsic layer.

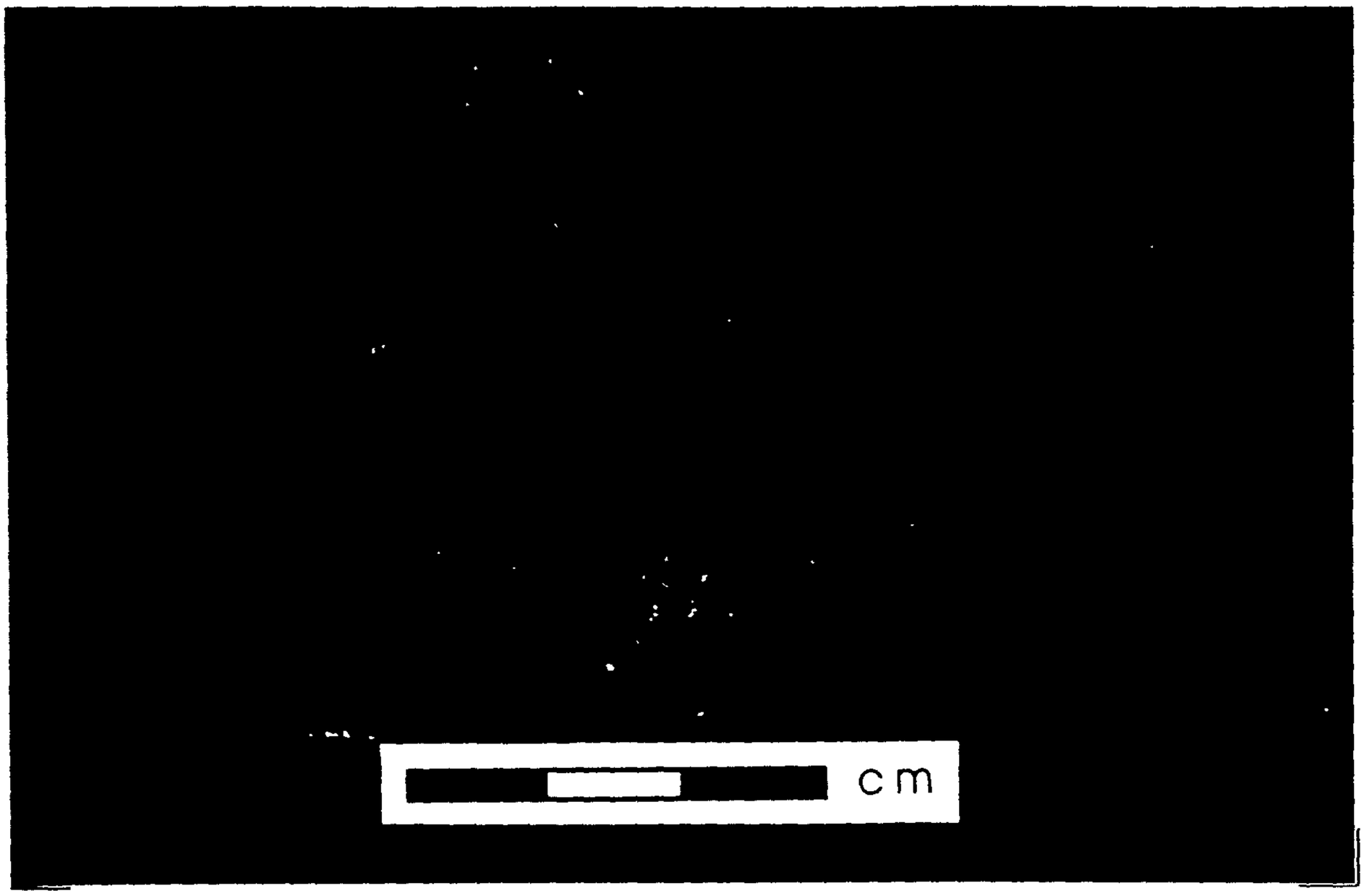


PLATE 28: SAMPLE SHRD 25, 1910m (Macrophotograph, sawn drill core, wet; Film 1 Frame 21) In this gneissic rock, large pods or layers of quartz-rich felsic crystalline material lie in a finer grained matrix of strongly foliated biotite and minor sillimanite

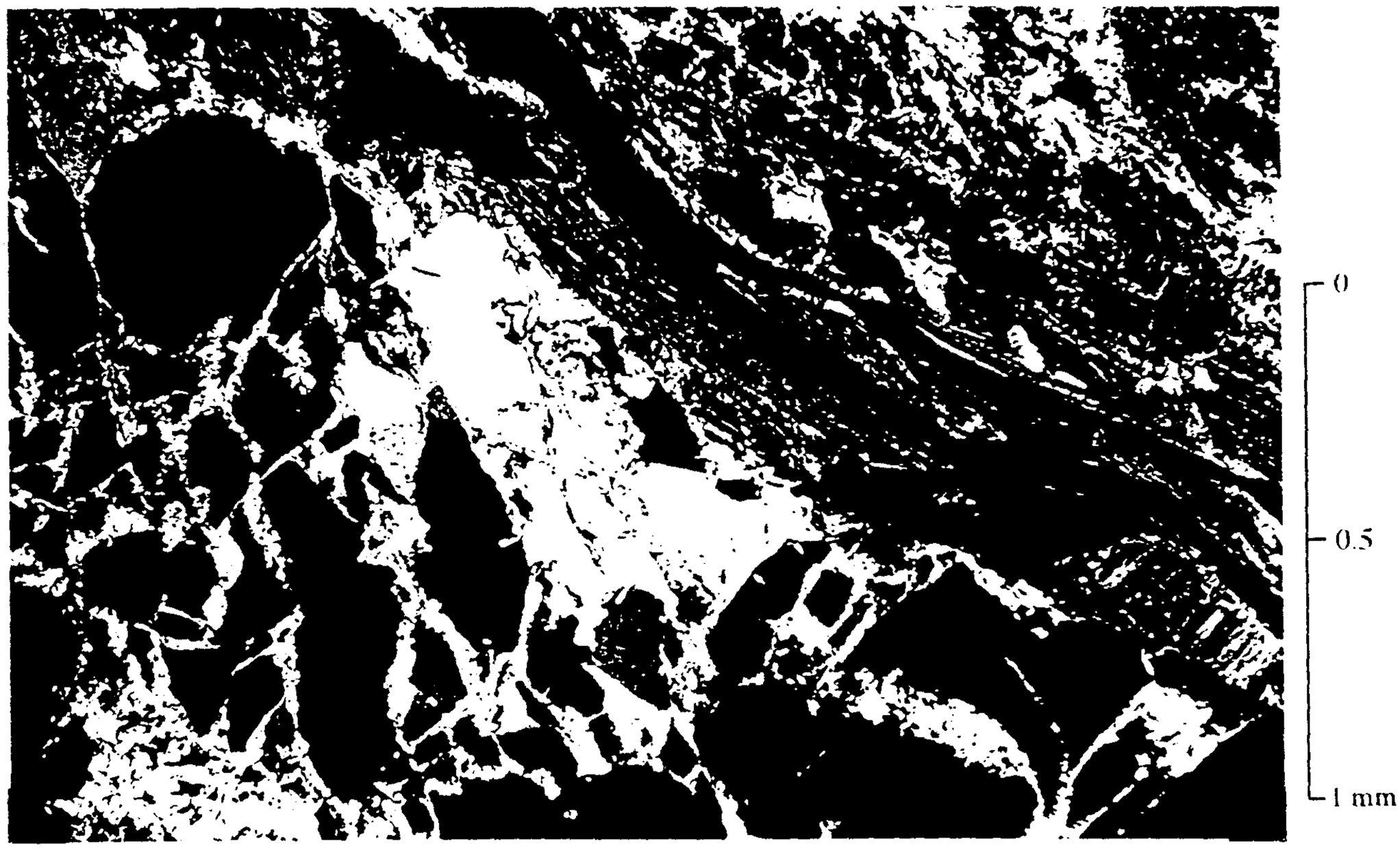


PLATE 29: SAMPLE SHRD 25, 1910m (Photomicrograph, transmitted light, crossed polarisers, x5, Film 2 Frame 17). This view captures the contact between a quartz-rich pod (left) and biotite-rich foliated matrix (right). Note the moderately abundant alteration sericite (tiny pale yellowish flecks) that fill a fine fracture network in quartz, and also has partly replaced biotite

SAMPLE : SHRD 25, 191.0m (Northern Territory)

SECTION NO. : SHRD 25, 191.0m (C71074)

HAND SPECIMEN : The drill core sample represents a strongly foliated dark grey rock with small equant dark green altered crystals (probably garnet). Within the foliation lie thick lenses or pods of felsic composition mostly translucent grey but with ragged yellowish pale green alteration patches.

ROCK NAME : **Low-intensity sericite-chlorite altered podiform banded biotite-sillimanite gneiss**

PETROGRAPHY :

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

Mineral	Vol.%	Origin
Biotite-sillimanite gneiss		
Biotite	83	Metamorphic
Sillimanite (fibrolite)	2	Metamorphic
Chlorite	5	Alteration (after ?garnet)
Sericite	10	Alteration
Felsic pods		
Quartz	94	Metamorphic
Biotite	2	Metamorphic
Sericite	3	Alteration
Chlorite	1	Alteration

In thin section, this sample displays a strongly foliated lepidoblastic metamorphic texture in the darker portion of the rock, and a coarsely granoblastic metamorphic texture in the felsic portion.

Biotite-sillimanite gneiss displays a strongly foliated lepidoblastic metamorphic texture. Large biotite flakes ~1-2 mm long form a strongly foliated mat. Most flakes display incipient replacement by sericite along cleavage traces, but most retain their brownish pleochroism.

Sillimanite occurs in minor amount as fibrolitic patches scattered through the biotitic mat.

Chlorite occurs in minor amount as fine-grained pale green massive replacements of precursor equant anhedral grains ~1-2 mm in size that most probably were garnet (but none is preserved for confirmation). Locally, the chloritised garnet grains lie in close association with fibrolitic sillimanite.

Felsic pods are dominated by quartz, which forms large anhedral unstrained grains ~2-4 mm in size that build a coarse granoblastic mosaic. Biotite is uncommon, forming small flakes and aggregates of flakes which, in contrast to the biotite in the adjacent foliated part of the rock, are randomly oriented. They display the same incipient replacement by sericite as observed in the foliated portion of the rock.

Sericite occurs in minor amount as tiny randomly oriented flakes. Locally they are concentrated in ragged patches, possibly after precursor ?feldspar grains. Elsewhere, sericite is concentrated along thin discontinuous fractures.

Chlorite occurs in trace amount as fine-grained pale green replacement patches associated with sericite.

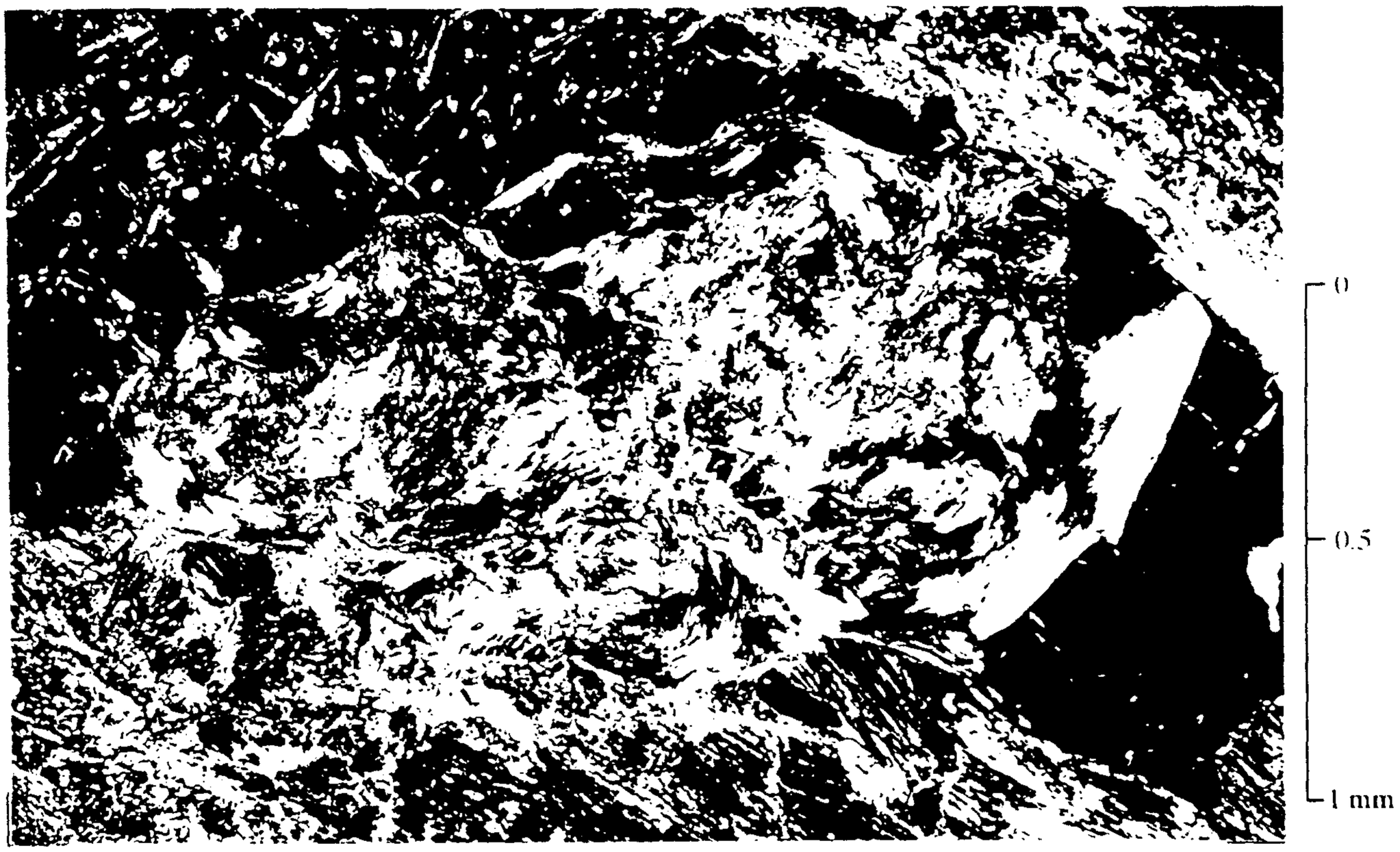


PLATE 30 SAMPLE SHRD 25, 191.0m (Transmitted light, crossed polarisers with condenser, x5, Film 2 Frame 18). This view shows part of the biotite rich matrix. An ovoid patch of fibrolitic sillimanite (centre, pale greyish white colours with fibrous texture) is accompanied by chlorite-altered garnet (very dark, top left, bottom right). Large biotite flakes (bottom) have been partly replaced by sericite

INTERPRETATION:

This sample is interpreted to represent a layered clastic sedimentary rock, originally composed of fine-grained pelitic materials with pods or discontinuous layers of felsic material. An alternative interpretation for the felsic 'pods' is that they represent strained large felsic fragments (e.g. granitoid), but this is rejected because of the very quartz-rich composition of the felsic pods.

The rock suffered regional metamorphism in the amphibolite facies. The aluminous pelitic sediment recrystallised to a strongly foliated mat of biotite + ?garnet + sillimanite. The siliceous pods or bands recrystallised to quartz + minor biotite + ?feldspar.

At a later time, the rock body suffered very mild alteration, generating minor sericite + chlorite. The sericite formed by incipient replacement of biotite and complete replacement of the minor ?feldspar, and chlorite formed by replacement of ?garnet.

Petrographic Descriptions for Drill Core Rock Samples from EL 2506 (Northern Territory, Australia)

SUMMARY

1. Rock Samples

- drill core rock samples from EL 2506 have been studied using petrographic and mineral staining methods.

2. Brief Results

- Rock names and mineralogy are summarised in TABLE 1.

- Primary rock types

  - Four of the samples may have formed as clastic sedimentary rocks of quartzo-feldspathic to pelitic composition. The primary rock types of these samples are difficult to infer owing to complete metamorphic recrystallisation and subsequent alteration (see below).

- Regional metamorphism

  - Four samples display medium- to coarse-grained foliated granoblastic metamorphic textures. The metamorphic assemblages of these rocks included quartz, plagioclase, K-feldspar, biotite, muscovite and accessory apatite.
    Mineralogical layering is evident in sample SHW02, 161.05m.
    The textures and assemblages are consistent with medium-grade (amphibolite facies) regional metamorphism of quartzo-feldspathic to pelitic sedimentary rocks.

- Low-grade alteration

  - The four gneissic metamorphic rocks display selective pervasive hydrothermal alteration to assemblages of sericite, chlorite, leucoxene/rutile, hematite, quartz and opaques.

TABLE 1: SUMMARY OF ROCK NAMES AND MINERALOGY

SAMPLE	ROCK NAME	MINERALOGY*		
		Primary**	Metamorphic alteration***	Veins
SHW02, 141.6m	Medium-intensity sericite-chlorite altered quartz-feldspar-biotite gneiss	-	Qtz, apa, bio; Ser, chl, rut, opq	
SHW02, 161.05m	Medium intensity sericite-chlorite altered layered quartz-feldspar-mica gneiss	-	Qtz, Kf, mus; Ser, chl, qtz, leu/rut, opq	

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

Mineral abbreviations:
Alb = albite; apa = apatite; bio = biotite; chl = chlorite; hem = hematite; Kf = K-feldspar; leu = leucoxene; mus = muscovite; opq = undifferentiated opaques; pla = plagioclase; qtz = quartz; rut = rutile; ser = sericite; serp = serpentine; sid = siderite; zir = zircon.

1. INTRODUCTION

A suite of drill core rock samples was received from Mr Peter Wollenbey (AFmeco Mining and EXploration Pty Ltd, Darwin, Northern Territory) on 21 October 1999.

It was indicated that the samples originate from EL 2506 Particular requests were:

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

ii) To provide photographs (macrophotograph + photomicrograph) of each sample.

iii) To stain the section offcuts for K-feldspar.

The SUMMARY and TABLE 1 of this report were provided to Mr Wollenbey by facsimile on 29 October 1999. This report contains the full results of this work.

2. METHODS

The drill core samples were examined in hand specimen and marked for thin section preparation. The 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 polarised light microscopy was used to prepare the routine petrographic descriptions.

Preliminary petrographic observations suggested that K-feldspar was present in one sample (SHW02, 161.05m). For confirmation, each section offcut was stained for K-feldspar using the conventional sodium cobaltinitrite method. Each offcut was etched in HF for ~10 seconds, rinsed in water, covered with freshly made saturated solution of sodium cobaltinitrite for ~30 seconds, and finally rinsed. This procedure generates a bright yellow stain where K-feldspar occurs in the rock. The results are provided in TABLE 2, and are also given under Hand Specimen description in the individual petrographic descriptions.

TABLE 2: RESULTS OF STAINING FOR K-FELDSPAR

SAMPLE	RESULT*	COMMENTS
SHW02, 141.6m	Negative	K-feldspar absent.
SHW02, 161.05m	Positive	K-feldspar is moderately abundant, occurring as ragged grains concentrated in indistinct bands up to ~1 cm wide.

*: Positive = Yellow stain for K-feldspar observed in section offcut under binocular microscope.
Negative = No yellow stain for K-feldspar observed in section offcut under binocular microscope.

3. PETROGRAPHIC DESCRIPTIONS

The petrographic descriptions are provided in the following pages. The descriptions are ordered alphanumerically by drill hole number and depth.

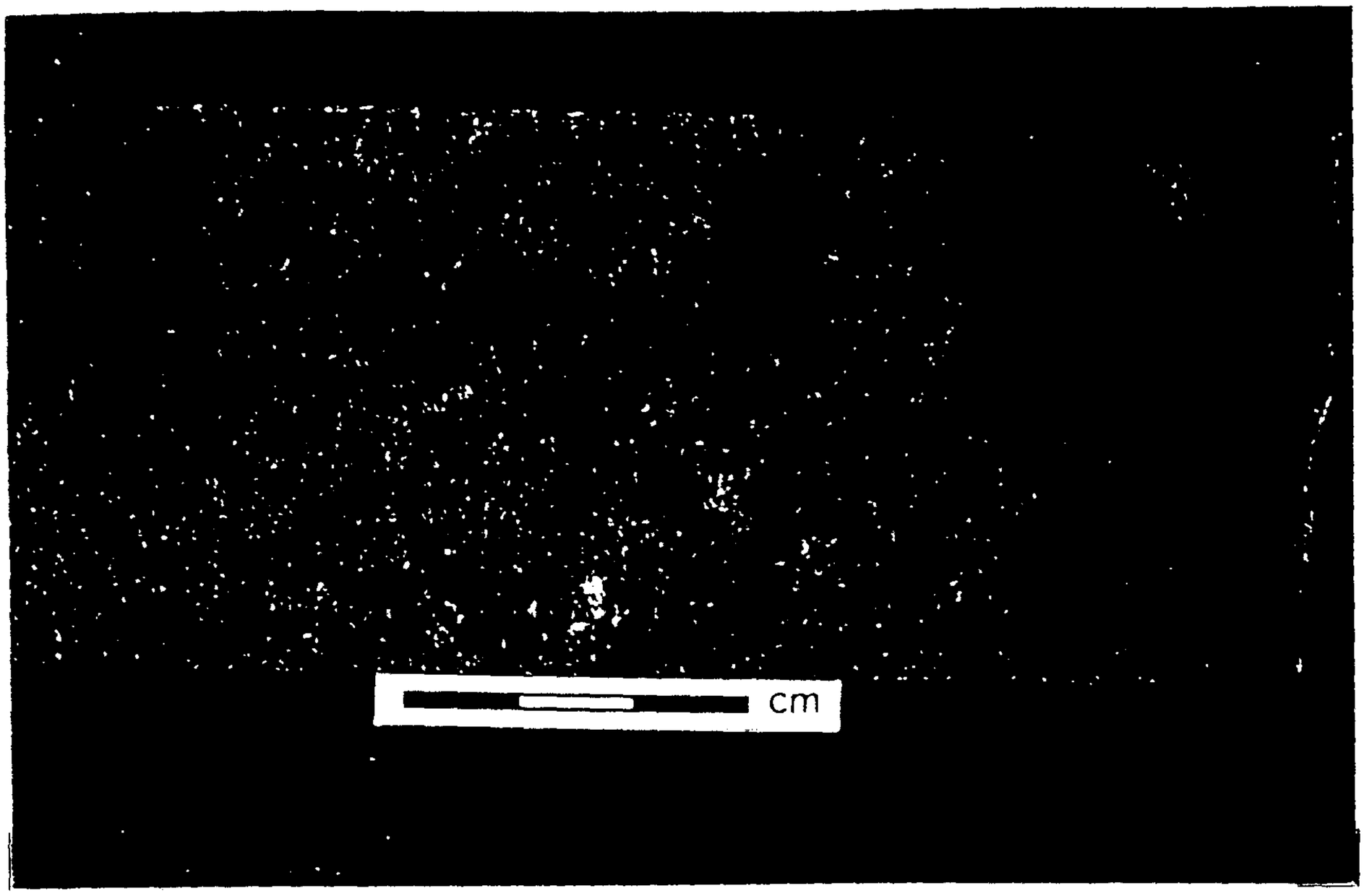


PLATE 3. SAMPLE SHW02, 141.6m (Macrophotograph, sawn drill core, wet, bar for scale. Film 1 Frame 1). This view shows the even-grained foliated crystalline texture of the gneissic rock. Selective pervasive sericitic alteration of ?plagioclase has generated the small yellow patches throughout the rock.

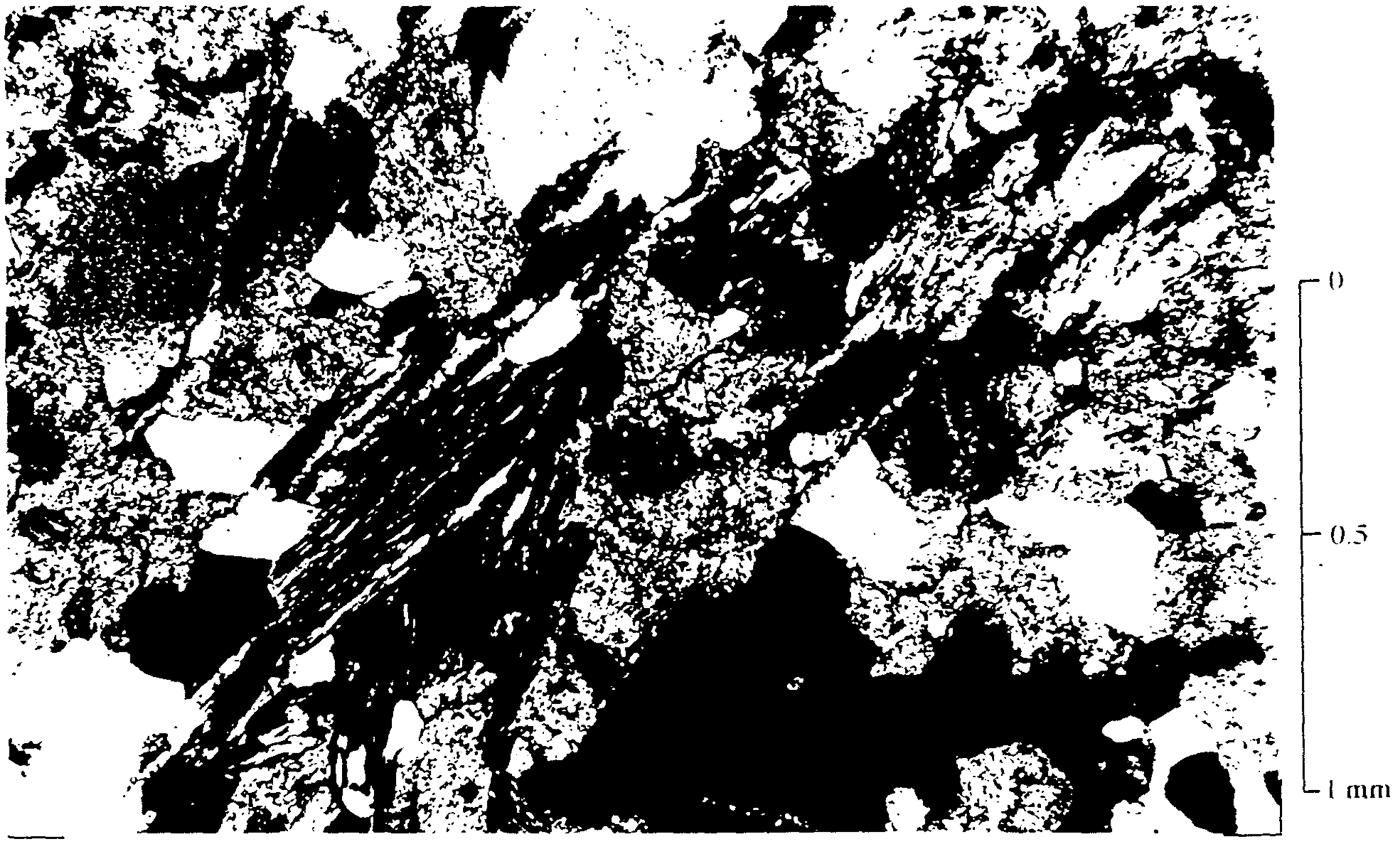


PLATE 4: SAMPLE SHW02, 141.6m (Photomicrograph, transmitted light, crossed polarisers with condenser, x5, Film 2 Frame 3) Metamorphic quartz grains (white, pale yellow, grey) remain clear and well preserved, but ragged grains of ?plagioclase have been completely replaced by sericite (very fine aggregates, yellowish), and biotite has been replaced by chlorite (dull dark green flakes, oriented in foliation NE-SW).

SAMPLE : SHW02, 141.6m (EL2506, Northern Territory)

SECTION NO. : SHW02, 141.6m

HAND SPECIMEN : The drill core sample represents a foliated crystalline rock composed of dull grey aligned mica flakes and abundant equant yellowish altered ?feldspar grains. It has the appearance of an altered gneissic rock.

The section offcut failed to accept the stain for K-feldspar, suggesting it is absent.

ROCK NAME : **Medium-intensity sericite-chlorite altered quartz-feldspar-biotite gneiss**

PETROGRAPHY :

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

Mineral	Vol.%	Origin
Quartz	30	Metamorphic
Apatite	Tr	Metamorphic
Biotite	Tr	Relict metamorphic
Sericite	57	Alteration (after ?plagioclase)
Chlorite (incl. rutile)	12	Alteration (after biotite)
Opaques	Tr	Alteration

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

Quartz is moderately abundant, forming equant anhedral grains mostly ~0.2-0.6 mm in size but some range up to ~1 mm in coarser-grained polycrystalline aggregates. The quartz is distributed more-or-less uniformly through the rock.

Sericite is abundant, occurring mostly as minute randomly oriented flecks which form dense replacement mats pseudomorphous after precursor equant anhedral grains ~0.4-1.0 mm in size. They most likely were mainly plagioclase, but none is preserved for confirmation. A small amount of sericite also occurs as fine-grained aggregates along cleavage traces of mainly chlorite-altered biotite flake sites.

Chlorite occurs in significant amount as optically continuous pleochroic dull pale green flakes that have completely replaced precursor well-shaped biotite flakes ~0.4-1.0 mm long. The preferred orientation of the biotite flakes defined the foliation in the gneissic rock. Tiny crystals of rutile pepper the chlorite-altered biotite flake sites. Very rare small pleochroic reddish brown biotite flakes are preserved where they are completely enclosed within single quartz grains (and therefore were shielded from the pervasive alteration fluids).

Apatite occurs in trace amount as small stumpy colourless prisms sparsely scattered through the rock.

Opaques are uncommon, occurring as small ragged grains in microgranular aggregates scattered very irregularly through the rock.

INTERPRETATION:

This sample represents a gneissic metamorphic rock, originally composed of the foliated medium-grained granoblastic assemblage of feldspar (?plagioclase) + quartz + biotite + trace apatite. Other phases may have been present but have been obscured by the alteration event.

The gneissic rock was invaded by hydrothermal fluids which caused selective pervasive alteration: ?plagioclase was completely replaced by fine-grained massive sericite, and biotite was completely replaced by chlorite + trace rutile. A small amount of unidentified opaques formed as sparsely disseminated small microgranular aggregates.

The nature of the primary rock has been completely obscured by the metamorphic and overprinting alteration events. However, the inferred metamorphic mineralogy (plagioclase > quartz > biotite) suggests it was a pelitic to quartzo-feldspathic rock of possible sedimentary origin.

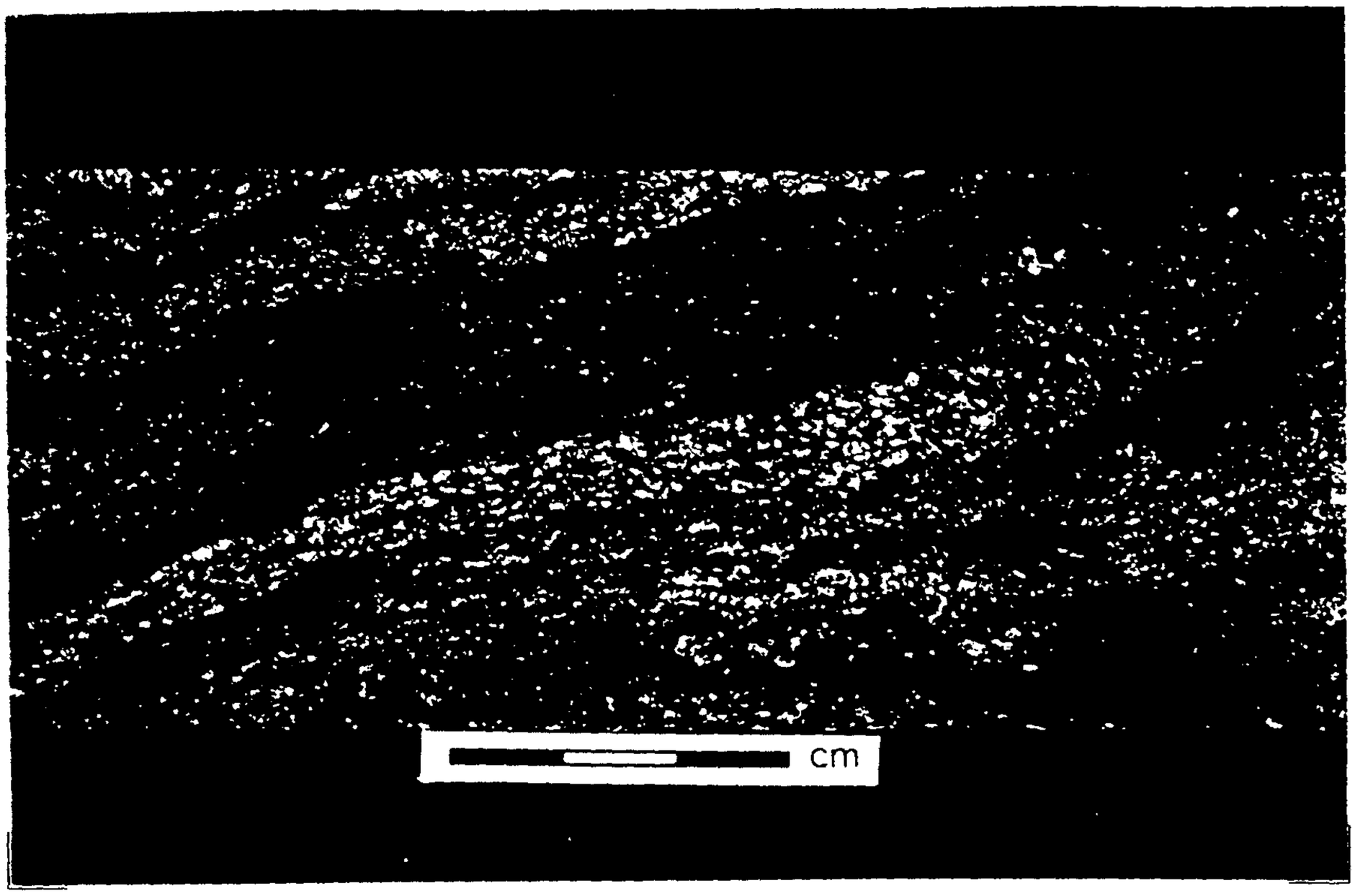


PLATE 5. SAMPLE SHW02, 161.05m (Macrophotograph, sawn drill core, wet, bar for scale; Film 1 Frame 2). Layering in this altered gneissic rock is defined by variable abundances of metamorphic K-feldspar (pale pink, central layer), sericite (waxy pale yellowish green, after ?plagioclase), and chlorite (darker green, after biotite).

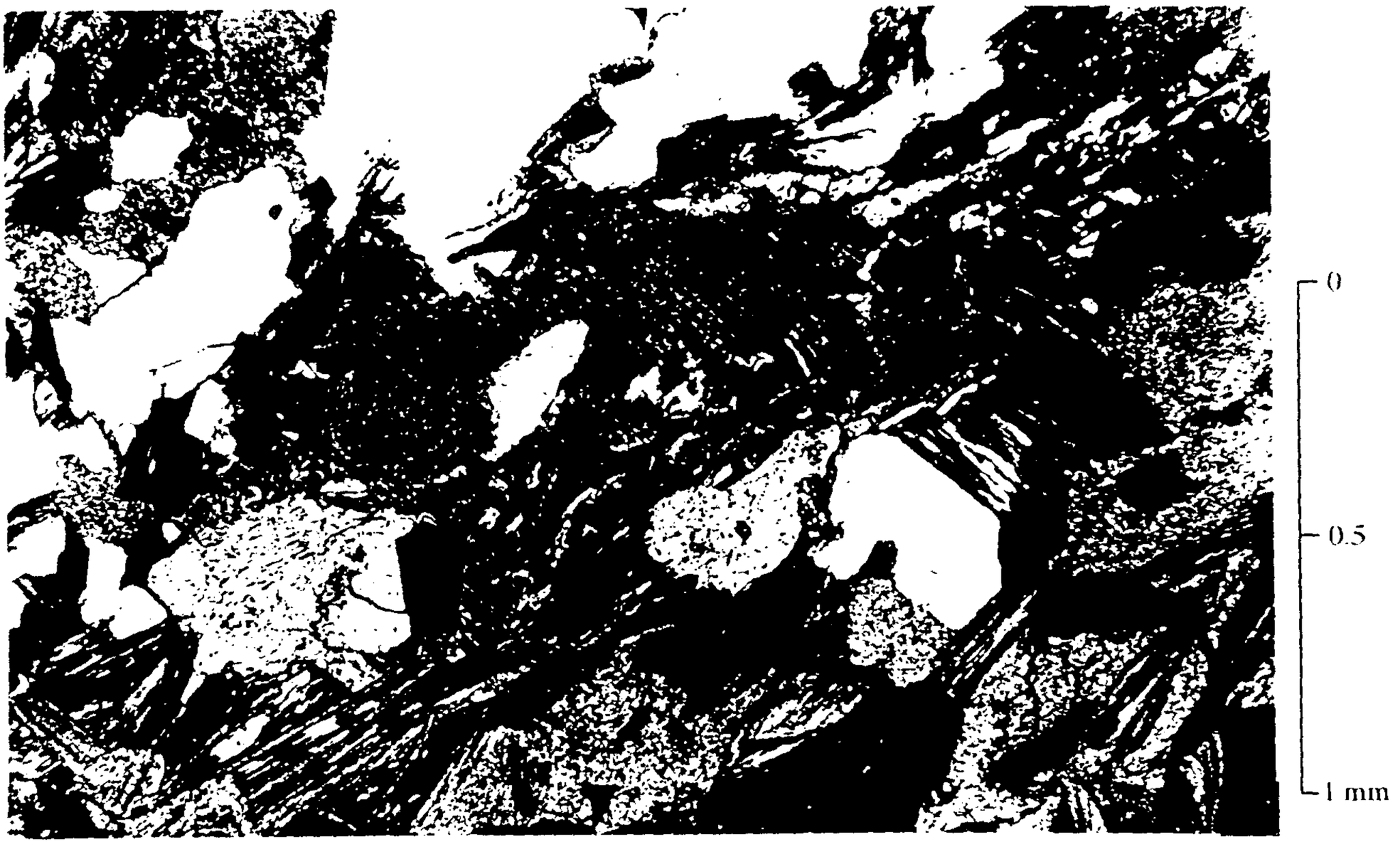


PLATE 6. SAMPLE SHW02, 161.05m (Photomicrograph, transmitted light, crossed polarisers, x5. Film 2 Frame 5) Fresh metamorphic muscovite (bright blue-green) and quartz (clear white, pale yellow, pale grey) are well preserved, but metamorphic plagioclase is replaced by fine-grained sericite in ragged aggregates, and biotite is replaced by chlorite (dark flakes with anomalous blue and green interference colours)

SAMPLE : SHW02, 161.05m (EL2506, Northern Territory)

SECTION NO. : SHW02, 161.05m

HAND SPECIMEN : The drill core sample represents a foliated medium-grained gneissic rock in which mineralogical layering is defined by variable abundances of cream to pale pink feldspar grains and waxy dull greenish grey altered mica flakes.

The section offcut accepted a positive yellow stain for K-feldspar, confirming it occurs in moderate amount as small ragged grains concentrated in indistinct layers up to ~1 cm thick.

ROCK NAME : **Medium intensity sericite-chlorite altered layered quartz-feldspar-mica gneiss**

PETROGRAPHY :

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

Mineral	Vol.%	Origin
Quartz	30	Metamorphic
K-feldspar	10	Relict metamorphic
Muscovite	3	Metamorphic
Sericite	35	Alteration (after ?plagioclase)
Chlorite (incl. leucoxene/rutile)	20	Alteration (after biotite)
Quartz	2	Alteration (after K-feldspar)
Opaques	Tr	Alteration

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

Quartz is moderately abundant, occurring as equant to elongate anhedral grains of wide size range (~0.2-2.0 mm). The quartz is distributed more-or-less uniformly through the rock, but is more abundant in indistinct layers. The more elongated grains are preferentially aligned in the trace of the foliation which is subparallel to layering.

K-feldspar occurs in significant amount as anhedral grains concentrated in indistinct layers with lesser other phases. All of the K-feldspar grains display partial alteration to turbid cryptocrystalline indeterminate brownish material (probably a cryptocrystalline clay phase), and some grains also are partly replaced by small ragged clear quartz grains.

Biotite formed relatively large flakes ~1-2 mm long. They were more abundant in some layers than in others, and their strong preferred orientation contributed to the foliation through the rock. All of the biotite flakes have suffered complete replacement by optically continuous pleochroic dull green chlorite through which are scattered tiny turbid Ti-rich granules (leucoxene or better-crystallised rutile). Rare small flakes of pleochroic reddish brown biotite are preserved where they are completely enclosed within larger quartz grains.

Muscovite occurs as large well-shaped plates up to ~2 mm in size, which locally are interleaved with (altered) biotite flakes. In places the muscovite forms more ragged poikiloblastic plates. It represents a metamorphic phase.

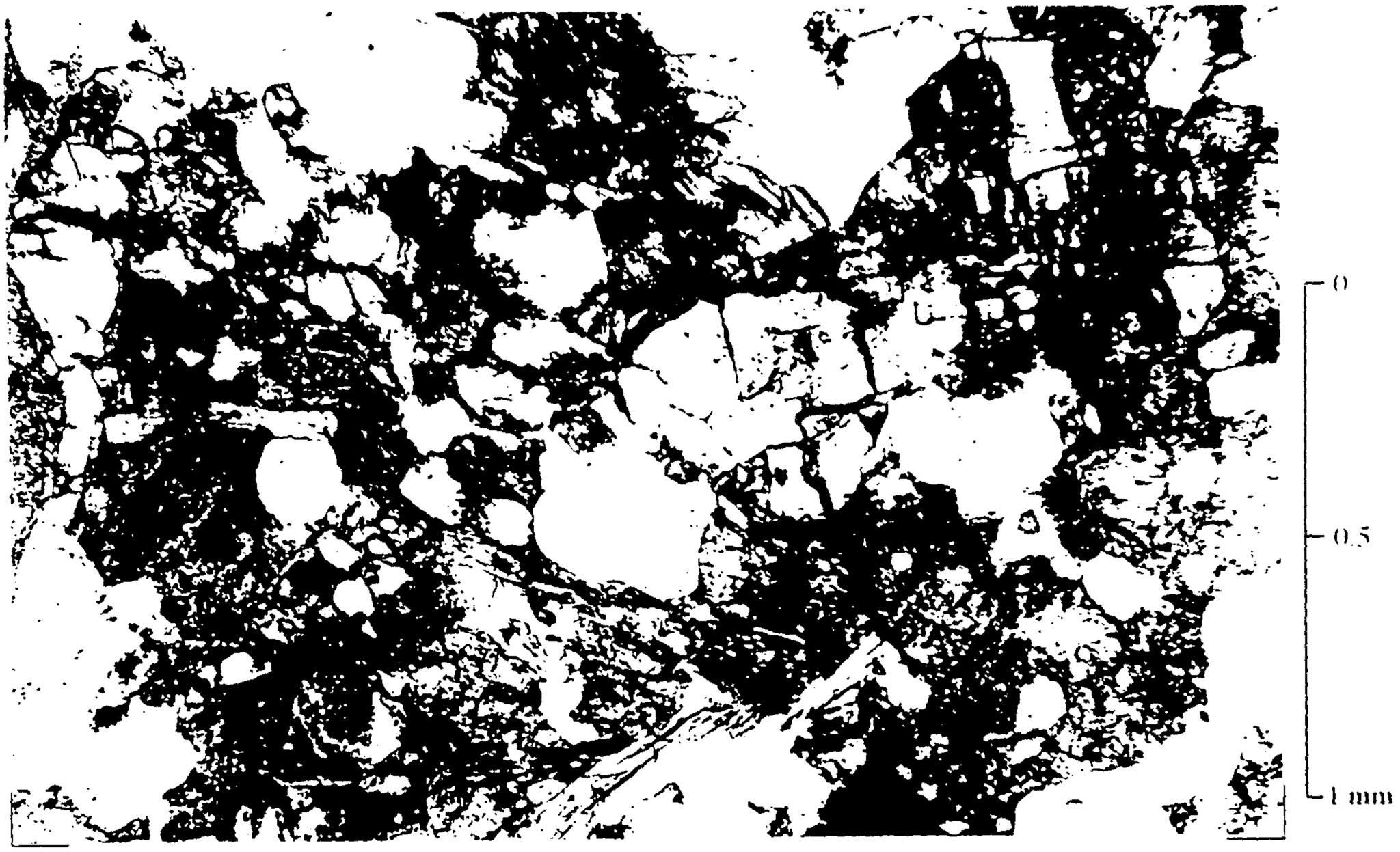


PLATE 7: SAMPLE SHW02, 161.05m (Photomicrograph, transmitted plane polarised light, x5; Film 2 Frame 6) This view was taken in a layer rich in K-feldspar. The K-feldspar has suffered partial alteration in the form of cryptocrystalline turbid dark brown clouding (top right, centre left) which locally mimics the cleavage of the K-feldspar (top right)

Sericite is moderately abundant. Most occurs as tiny randomly oriented flecks that form dense replacement mats pseudomorphous after equant anhedral grains (probably plagioclase but none is preserved for confirmation). A small amount of sericite occurs as similar fine-grained material that is concentrated along cleavage traces of otherwise chlorite-altered biotite flakes.

Opaques are uncommon, occurring as small ragged grains and loose aggregates very sparsely scattered through the rock.

INTERPRETATION:

This sample represents a layered foliated medium-grained gneissic rock, in which layers were composed of variable proportions of ?plagioclase, quartz, K-feldspar, biotite and muscovite. The rock was invaded by hydrothermal fluids which caused selective pervasive alteration to the new assemblage of sericite + chlorite + minor quartz + rutile.

The nature of the primary rock has been obscured by the metamorphic and later alteration events, but the metamorphic mineralogy suggests that the precursor was a quartzo-feldspathic or pelitic rock of probable sedimentary origin. The origin of the layering remains uncertain: it might reflect primary sedimentary layering of the primary rock, but there remains the possibility that it formed in response to deformation during the metamorphic event.