MINERALOGICAL REPORT No. 7722
by Ian R. Pontifex MSc. and Alan C. Purvis, PhD

November 20th, 1998

TO :	Mr Andrew Mackie Cameco Australia Pty Ltd PO Box 35921 WINNELLIE NT 0821
YOUR REFERENCE :	Order No. 00776
MATERIAL :	27 Samples, Sandstone and Mafic rocks samples, Arnhem Land
IDENTIFICATION :	DA98C10600 to DA96, C2 0695 DA98B10707 to DA98B10735
WORK REQUESTED :	Thin section preparation, description and report with comments and interpretations as specified.
SAMPLES & SECTIONS :	Returned to you with this report.
DIGITAL COPY :	Summary comments Emailed to you 2/12/98 Entire copy (except photos) in digital form with hard copy**.**

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INTRODUCTION

This report describes twenty-seven samples from Arnhem Land in the Northern Territory from normal thin sections, with two offcuts of opaque ferruginised rock, polished to investigate textures and possible relict minerals. The lithologies identified in these sections are summarised in Table 1, together with comments. Selected photomicrographs are included in the individual descriptions, mainly to illustrate aspects of texture and alteration.

One aim of this investigation (Andrew Mackie letter 30/9/98) was to document the nature of the approximately eight mafic samples in the suite, reported to be from the Kombolgie Sandstone. Another was to establish any characteristics of the sandstone samples which may indicate representation of Kombolgie Sandstone, as distinct from McKay Sandstone (which overlies the Kombolgie). With respect to the latter, additional information regarding Cameco's field interpretation of the stratigraphic position of the sandstone samples was received from Garth Drever, mid November 1998 and accordingly incorporated into these summary comments including Table 1, and the individual descriptions in this report.

Evidence was also requested for any hydrothermal alteration (particularly DA98B10729). These issues are variously addressed in the individual descriptions (and photos) and in the summary Table 1, followed by comments below.

Table 1: Sample list and petrographic I.D. (with comments)

Sample No. (all prefix DA98)	Cameco Reported stratigraphy and rock type		Petrographic ID and Notes
C10600	K	Gilruth Volcanic? Limonite rock with bright green clays.	Dolerite, intensely lateritised, accessory relict magnetite, coarse kaolinite, finer green clays.
C10601	K	Tuff? Volcanic rock fragment	Basalt, intensely weathered to limonitic clay-sericite-leucoxene with fairly distinctive relict textures, possibly weakly sheared.
C10605	K	Fe-jasper breccia Gilruth Volcanic?	Dolerite. Lateritised altered, clay-rich. Low temperature hydrothermal quartz veinlets.
C20605	K	Fe-jasper breccia Gilruth Volcanic	Breccia, largely replaced by low temperature hydrothermal quartz, limonitic matrix.
C10606	K	Volcanic? Gilruth Volcanic	Intensely lateritised dolerite (or basalt?).
C20607	K	Tuffaceous shale	Olivine-basalt, extensively weathered with clay veins.
C10609	K	Purple Tuff	Oxidised altered basalt, of C20607 and C10601.
C10610		Dolerite/basalt	Microdolerite or basalt, “hydrothermally” altered, with albite, quartz etc.
C10611	Mc	Fine felspar sandstone	Medium sandstone, abundant k-spar, authigenic quartz cf. B10733
C10612		Oenfelli Dolerite	Distinctly ophitic dolerite, altered, with some k-spar (in pegmatoidal areas).
C10672	Mc	Breccia felspathic sandstone	Heterogeneous, medium grained sandstone (breccia) with extensive matrix of fine, hydrothermal silicification, including quartz veins. No felspar.
C10673	Mc	Arkosic sandstone	Medium sandstone, clay limonite patches. Quartz veins
C10674	Within K	Pinkish-red altered dolerite	Reddened quartz microsyenite. Minor quartz veinlets.

K = Kombolgie Sandstone Formation
Mc = McKay Sandstone Formation

Sample No. (all prefix DA98)	Cameco Reported stratigraphy and rock type		Petrographic ID and Notes
B10707	Mc	Ferruginised fine sandstone	Extensive intergranular siliceous overgrowths/cement, but hand specimen is somewhat friable ("incipient ortho-quartzite").
B10708	Mc	Quartzite	Coarse (lithic) sandstone, silicified; (orthoquartzite).
B10709	Mc	Ferruginised quartz sandstone	Irregularly interbedded coarse fine sandstone, slumping and disruption, with possible intraformational lithic clasts. Silicification of coarse beds.
B10710	Mc	White quartz sandstone	Coarse quartz sandstone, weakly quartzitic.
B10727	Mc	White clay-rich felspar sandstone	Coarse/very coarse sandstone, minor clays and fine micas intergranular, no quartz overgrowths.
B10728	Mc	Poorly sorted impure sandstone	Coarse/very coarse gritty sandstone, fairly extensive intergranular limonite (?possibly oxidised clays), local (minor) quartz overgrowths.
B10729	K	Chloritic sandstone	Med/coarse sandstone. Interstitial clays and micas. No apparent hydrothermal alteration.
B10730	Mc	Quartzite	Bimodal sandstone, medium coarse, silicified to ortho-quartzite. Incorporates irregular clay-lenses.
B10731	Mc	Fine/medium quartz sandstone	Mostly fine/medium sandstone, silicified but overgrowths poorly defined. Intercalated coarse sand shows very clearly defined overgrowths/silicification.
B10732	Mc	Felspathic impure sandstone	Coarse poorly sorted quartz sandstone, extensive intergranular barite cement
B10733	Mc	Fine felspathic sandstone	Medium grained felspathic (lithic) quartz sandstone cf. C10611.
B10734	Mc	Medium siliceous quartz sandstone	Coarse sandstone. Lithic grains extensively silicified
B10735	Mc	Pink impure carbonate	Micaceous siltstone, carbonate flooding
B20735	Mc	Pink impure carbonate	(Silty) micritic limestone, weakly bedded

COMMENTS : Sandstone Samples

The petrography indicates that most sandstone samples described in this report are dominated by original subrounded to rounded quartz grains, mostly medium to very coarse size, locally bedded and in some cases, incorporating layers of finer grained sandstone, partly as discrete layers, and partly as infiltrations between coarser grains.

"Impurities" within these sandstones are generally only minor, (with less felspar than is suggested in the field notes), and as indicated in Table 1, these mostly occur in :

C10611	Abundant (15-20%) k-spar (microcline and orthoclase), cf. B10733
C10673	Altered lithic grains now seen as patches of clay-limonite incorporating fine quartz (silt) scattered to form about 30%. (this rock is not arkosic however). Zircon grains locally (anomalously) accompany these patches.
B10732	Is distinctive in having an extensive intergranular cement of barite, forming up to 20% of the rock.
B10733	Compares with C10611, with abundant (20-25%) grains of microcline and orthoclase.
B10734	Minor (7-10%) rounded lithic grains, variously rich in cryptocrystalline quartz, clay, limonite.

Accessory (heavy) minerals are nil or negligible, except as noted above, with a curiously anomalous abundance of fine zircon grains accompanying clay-limonite patches in C10673.

Minor amounts of clouded indefinite very fine clays ± sericite are intergranular in several samples, most notably in B10729, which your field note indicates as a "chloritic-sandstone", and is the only sample designated by the Cameco covering letter as Kombolgie Sandstone. However, samples B10727 and B10728 also have minor intergranular clays (which are selectively ferruginised in B10728). The presence of these intergranular clays appears to be distinctive, since they are basically absent from all other sandstones in the suite (which have extensive quartz overgrowths/intergranular silicic cement), and may provide a basis for distinguishing stratigraphic representation as discussed below.

As indicated, the greater majority of sandstones in this suite are cemented by extensive, optically continuous intergranular silicification manifest as optically continous merging quartz overgrowths on individual single crystal detrital quartz grains, although cores and overgrowths are more clearly distinguished in some samples than in others. These

overgrowths are interpreted to occupy former intergranular porosity (although they may replace a former matrix). The resultant silicification as seen in the thin sections may be broadly considered as “authigenic”, and generally regarded as having developed during diagenesis. Such silicification however may occur by somewhat variable processes, at various intensities, and at different time periods, conceivably by reaction between inherent constituents of the sediment (detrital and chemical) and meteoric ground fluids, or indeed it may involve introduction of new components, including possible (low temperature) hydrothermal or metasomatic related genesis. The resultant silicified sandstone may be classified as a ‘sedimentary quartzite”, or orthoquartzite. Sandstone sample B10732 is distinctive in having a ubiquitous intergranular cement of barite rather than of silica.

This report does not discuss these different silicification processes, except to mention that silicification in several of the sandstones, notably C10672, C10673 and the silicified breccia C20605 do seem to have a hydrothermal component, particularly where siliceous overgrowths pass into veins (which may be poorly to well defined) of granular to prismatic quartz, of probable low-temperature hydrothermal origin. [Quartz veins also occur in C10674 which is a quartz microsyenite, and the field notes indicate to be within Kombolgie Sandstone.]

[There is no particular evidence of hydrothermal activity within B10729 (as questioned in your field notes), which is a sample indicated by Cameco to represent Kombolgie, see below.

In the event of any detailed assessment which may be required on the genesis of quartz overgrowths within these or any other sandstones, particularly to establish signatures of hydrothermal association as suggested for at least 3 samples, then cathodoluminescence microscopy should be considered. [The National Centre of Petroleum Geology within University of Adelaide has this facility, which is used by sedimentary petrologists to investigate genesis/diagenesis of oil-bearing sandstone aquifers, and Pontifex has occasionally integrated results from this analytical technique into aspects of petrological investigations.]

COMMENTS : Mafic Samples

The petrography confirms that most of the non-sandstone samples, which the Cameco field notes indicate to be within Kombolgie Sandstone, are “mafic rocks” however intense supergene alteration (oxidation) of these samples and/or hydrothermal alteration prevents positive or specific classification (as basalt versus dolerite for example) in several cases. Sample C10674 is a microsyenite however.

Indeed, of these samples, only C10610, and the Oenpelli Dolerite C10612, which is typically quite coarse, ophitic and with pegmatoidal domains including k-spar, are fresh enough to show primary minerals, and/or hydrothermal alteration involving albite, chlorite, adularia, sericite, carbonate, clays and rare prehnite. This mineral assemblage suggests alteration at 200-300°C, at low pressures.

The other (altered) mafics are very extensively weathered/lateritised and composed essentially of various proportions of limonite ± clays ± leucoxene ± hematite. Commonly however, these have the rather diagnostic signature of scattered ex-titaniferous magnetite crystals pseudomorphically altered to leucoxene-limonite. Their genesis is therefore interpreted by consideration of relict textures preserved by these secondary minerals. Samples C10601, C20607 and C10609 are interpreted to be (similar) original (flow-textured?) basalts, with probable ex-olivine inferred in C20607 and C10609, and anomalously abundant plagioclase in C10601. The other mafics seem most likely to be original dolerites.

COMMENTS : Other Samples

Samples C10735 and C20735 have a field identification of “pink impure carbonate”. Petrographically, C10735 is identified as a (micaceous) siltstone, with a patchy interstitial carbonate and clay matrix (?or cement), also with more or less conformable narrow calcite veins. The sample C20735 is dominated by compact massive albeit weakly layered, extremely fine and diffusely micritic limestone, incorporating minor (<5%) disseminated and some patchy quartz silt ± detrital sericite and is identified as a (sedimentary) weakly silty limestone. Carbonate matrix in C10735 may, like the veins in this sample, be introduced, but the sedimentary nature of carbonate in C20735, indicates the same inherent sedimentary genesis for both samples, with the veins in C10735 probably migratory/supergene.

COMMENTS : Stratigraphic Representation of the Sandstone Samples

As noted above, the Cameco field data received 16/11/98 reports sample DA98B10729 as the only representative of Kombolgie Sandstone. All other sandstones are indicated as probable McKay Sandstone.

Also as discussed above, and in the individual descriptions, the petrography indicates that DA98B10729 has minor (but potentially distinctive/diagnostic) intergranular clay ± sericite. [Previous examination of Kombolgie Sandstone samples by Pontifex and Associates also indicates (minor) intergranular clay-sericite, which indeed appears to be resistant to alteration, occurring even in sandstone in which all quartz has been replaced by chlorite.]

By comparison, most other sandstones in this suite (and nominated by Cameco as McKay Sandstone) typically have extensive optically continuous quartz overgrowths on original detrital quartz grains, filling (cementing) intergranular areas basically forming "ortho-quartzites". There is generally only minor lithic detritus, quartz-rich (and indeed some sericitic), in some of these silicified sandstone. "Significant" felspar occurs in two silicified, nominated McKay samples, C10611 and B10733, but these do not have intergranular clay-sericite.

The petrography therefore indicates a potential distinction between Kombolgie Sandstone and McKay Sandstone on the basis of the presence or absence of intergranular clays (in Kombolgie) and of advanced to complete "authigenic" silicification (in McKay). These characteristics are probably more-or-less, but perhaps not completely, mutually exclusive. [The (limited) evidence suggests that the presence or absence of lithics and/or of felspar seems not be to diagnostic.]

In this context, samples B10727 with minor intergranular clays, and B10728 with intergranular limonitised clays, may therefore also be Kombolgie, (rather than the Cameco designated McKay), like B10729.

INDIVIDUAL DESCRIPTIONS

DA98C10600

DA98C10600 **Massive to weakly layered limonite to goethite, with relict textures interpreted to be after pyroxene and plagioclase, and together with accessory disseminated hematite ± leucoxene after (titano)magnetite, indicates a lateritised dolerite. Minor interstitial, decussate green clays of uncertain specific composition; coarser colourless microspherulitic clay probably kaolinite.**

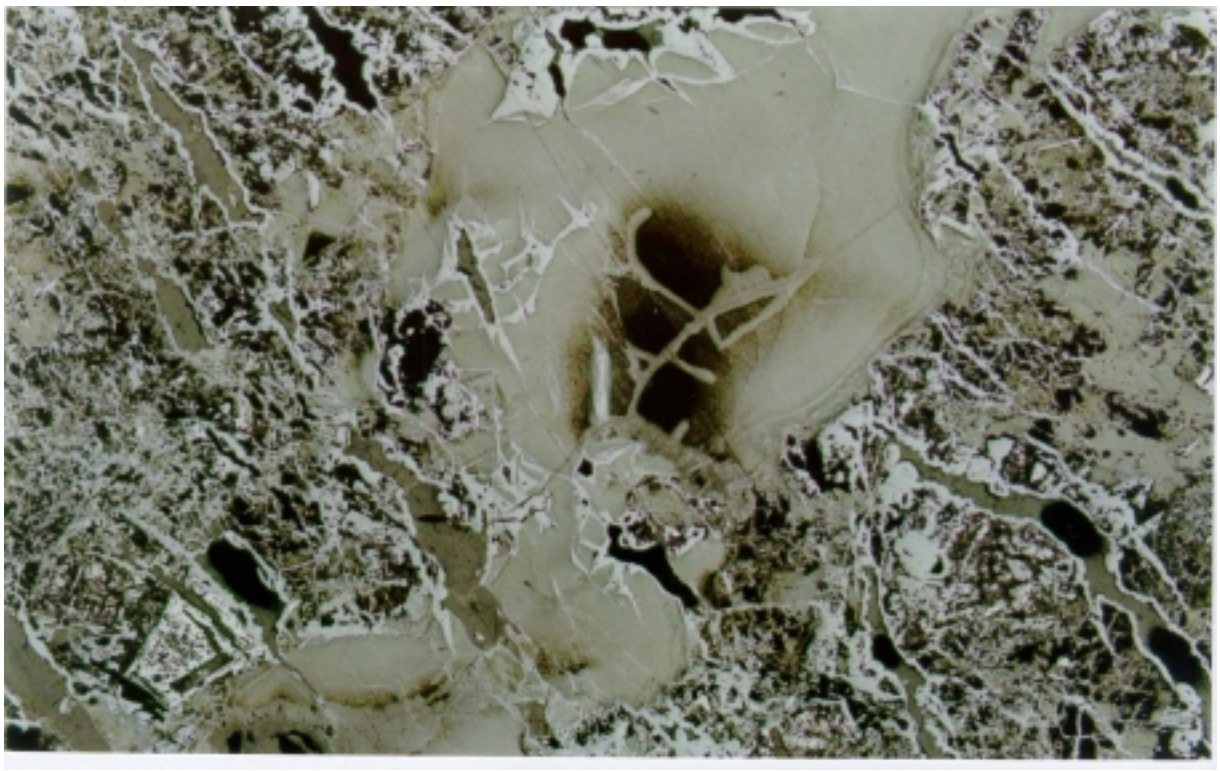
Field Note : *Gilruth Volcanic?*

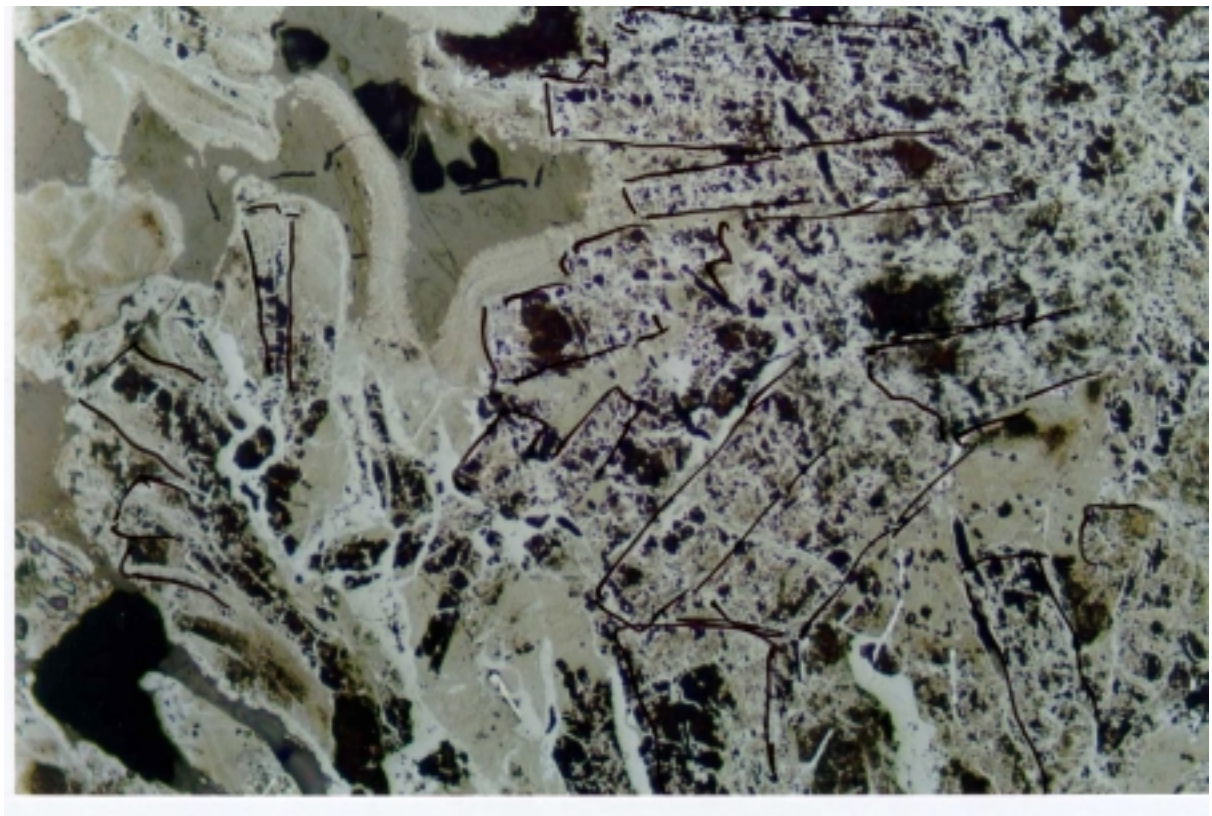
This sample is deep red-brown in colour due to extensive apparently lateritic limonite. Apart from subparallel veins with voids rimmed by colloform goethite, minor scattered patches of clouded leucoxene and minor voids filled by extremely fine decussate green phyllosilicate, and slightly more abundant coarser colourless ?kaolinite. The sample is essentially opaque in thin section and the offcut was therefore polished for better investigation of the possible origin of the rock.

The polished section revealed disseminated oxidised magnetite crystals to 0.5 mm in size, now largely hematite (martite) ± leucoxene. There are also large irregular “smooth” areas with internal microscopic network fabric (reflecting former “cleavages”) which suggest replicas after former ophitic pyroxene, as well as some poorly preserved prismatic or tabular crystal shapes that may represent former plagioclase (less probably pyroxene or amphibole).

The above characteristics, particularly in the absence of quartz, indicate that this sample is almost certainly an original dolerite, extensively lateritised. The vague macrolayering, lined by colloform limonite, appear to be part of the supergene regolith development, and not indigenous, since the ex-doleritic aggregate is apparently massive, undeformed.

The composition or genesis of the minor (5-7%) small interstitial patches of very fine decussate green and distinctly pleochroic clays (or mica) cannot be determined by optical microscopy, but they seem mostly likely to be “smectite” such as celadonite or nontronite.





Figs 1, 2 **DA98C10600** **0.09 mm**

Reflected light. These photos show limonite, goethite and hematite in a totally oxidised rock, with relict textures indicative of probable ex-pyroxene, also plagioclase (especially in Fig. 2). Interpreted as lateritised dolerite.

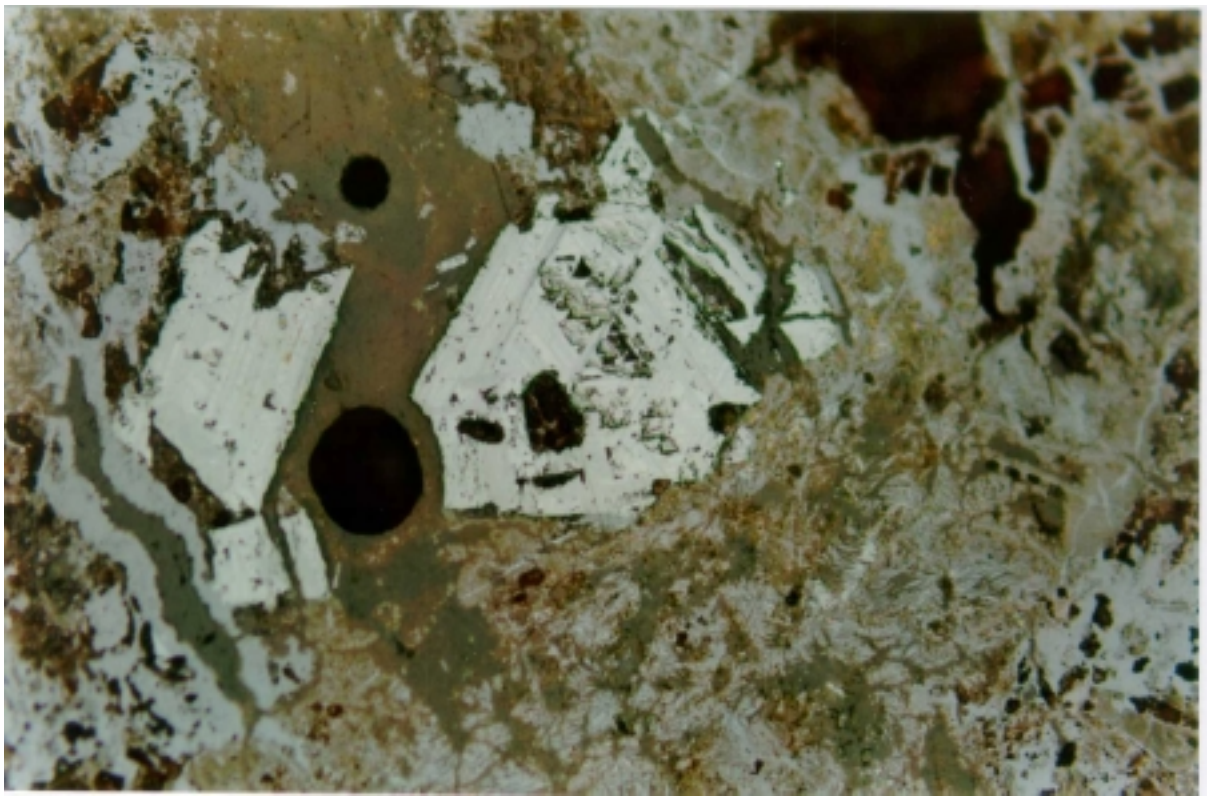


Fig 3 **DA98C10600** **0.04 mm**

Reflected light. Several crystals of limonite/leucoxene-oxidised, disseminated magnetite crystals, as residuals within an original extensively oxidised doleritic host rock.

DA98C10601

DA98C10601 **Fine "weakly-schistose-layered" aggregate of oriented clay-sericite interpreted as sheared-altered pyroxene, (finer than ex-plagioclase), lenses and replicas interpreted to be after plagioclase, within limonite, with minor scattered leucoxene-limonite replicas after magnetite. Interpreted as original basalt, similar to DA98C10609 and 20607, but seems to be abnormally plagioclase-rich.**

Field Note : *Tuff? Volcanic Rock Fragment*

Petrographically, this sample consists predominantly of abundant (50%) closely spaced, shredded lenses of limonite, also random limonite replicas, incorporating abundant (50%) clay-sericite and similarly oriented pseudomorphs of elongate grains/crystals. The most abundant pseudomorphs have the form of elongate prisms or laths which seem to be best interpreted to be ex-plagioclase, about 0.5 mm in length and these also tend to occur in lenses which may be partly tectonic.

Replicas of leucoxene and limonite have replaced 5% original, scattered opaque oxide to 0.4 mm in size, which may be considered typical of a former mafic igneous rock such as a basalt, but due to intense limonite flooding, this evidence is less distinctive than in other weathered basalts in this batch. For example it differs from sample DA98C20607 in having had possibly 65% plagioclase, and differs from DA98C10609 in having more abundant sericite-clay veins and patches.

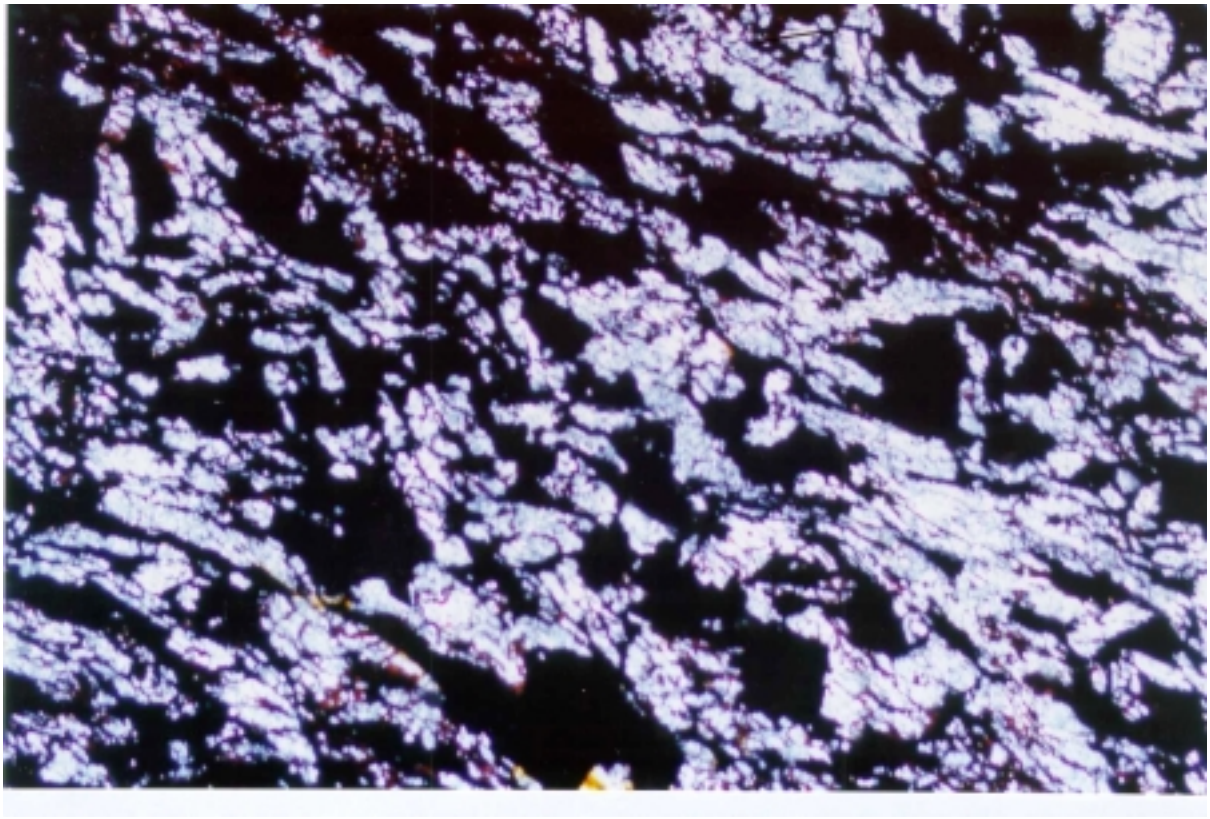


Fig 4 **DA98C10601** **0.18 mm**

TS. Xnic. 'Loose' aggregates of similarly aligned clay-sericite replicas probably after original plagioclase, within limonite, which is interpreted as largely replicas after pyroxene. Some leucoxene is visible in the limonite in low-angle incident light, and together with accessory apparent leucoxene-limonite replicas after magnetite, indicates a probable ex-basalt, but anomalously plagioclase-rich..

DA98C10605

DA98C10605 **Lateritised probable altered dolerite. Incorporates a zone of closely spaced quartz veinlets of low temperature (?supergene) origin.**

Field Note : *Fe-jasper breccia. Gilruth Volcanic?*

This limonite-rich rock has a zone some 5-6 mm wide in which limonite is interlaminated with narrow veins and stringers of cherty to microsparry quartz ± chalcedony. The textural preservation in the host rock is poor adjacent to these veins but further away these are better preserved, manifest as:

- Disseminated leucoxene pseudomorphs of compact to skeletal opaque oxides about 0.5 mm in grainsize, typical of accessory scattered titaniferous-magnetite as seen in dolerites.
- Patches of clays after apparently random poikilitic or ophitic mafic silicates to 2 mm in length as seen in reflected light in C10600.
- Clays after accessory unidentified small prisms to 0.2 mm long, possibly ex-apatite.

This evidence indicates a weathered altered dolerite, with low-temperature hydrothermal or supergene veining by quartz, as well as pervasive (lateritic) clay-limonite alteration.

DA98C20605

DA98C20605 **Chaotic (silicified) breccia with fragments of low temperature hydrothermal quartz, and a matrix of limonitic-clays + colloform possible halloysite incorporating finer siliceous fragments, which may include extensively altered ex-basalt.**

Field Note : *Fe-jasper breccia. Gilruth Volcanic.*

Macroscopically, and in thin section, this rock is seen to have a heterogeneous breccia texture on a scale of 2 to 15mm. The fragments consist of apparent low temperature hydrothermal quartz, manifest as various combinations of cryptocrystalline/microcrystalline quartz commonly incorporating 'cores' of small patches and veins of microsparry quartz apparently occupying voids within the finer (and probably slightly earlier) massive silicification. Diffuse limonite staining and minor small discrete limonite replicas occur within this quartz, including possible leucoxene-limonite replicas after magnetite.

A highly irregular network of relatively concentrated limonite occurs as a matrix between these chaotic, various sized siliceous/silicified and kaolinised fragments, incorporating even finer (?some comminuted) siliceous material, some of which may be extensively oxidised basalt as seen in some samples above, also locally colloform brown clays (?halloysite).

It is not certain if this 'breccia' is relict primary (as may form within a volcanic for example) or whether it may be relatively superficial and part of regolith development.

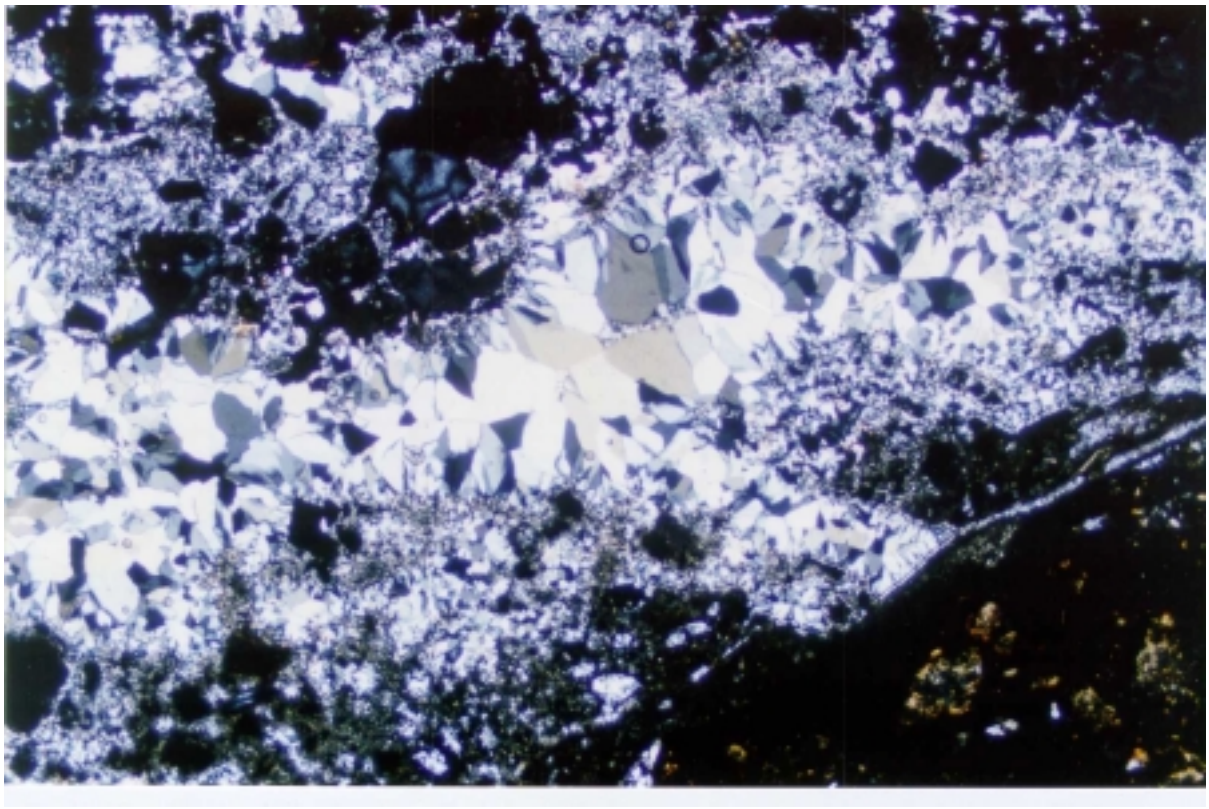


Fig 5 **DA98C20605** **0.45 mm**

Areas of cherty to sparry (‘dogtooth’) low temperature, hydrothermal quartz, apparently as (?silicified) breccia fragments, with a “matrix” of supergene limonite/limonitic-clays.

DA98C10606 **Massive "earthy" and basically nondescript (?lateritic) limonite and hematite > clays and silica. Accessory scattered leucoxene replicas after opaque oxide, which by comparison with other (slightly better preserved) weathered rocks in this suite suggest a probable intensely oxidised dolerite (or basalt).**

Field Note : *Gilruth Volcanic?*

Like DA98C10600, this sample is largely opaque in thin section. The polished section revealed little in the way of primary textures however, (less than in C1 0600), except for minor, scattered, small leucoxene-limonite replicas after original opaque-oxide crystals to 0.4mm, which also occur in C1 0600 and indicate a probable original mafic igneous rock.

These replicas occur within a heterogeneous matrix of "earthy" microporous limonite and hematite mixed with minor patchy (?kaolinitic) clays ± minor supergene silica, with an overall fairly non-descript supergene/regolithic fabric. Certainly, there is no clear boxwork or replica textures as seen in some extensively oxidised mafic rocks in this suite (including C1 0600).

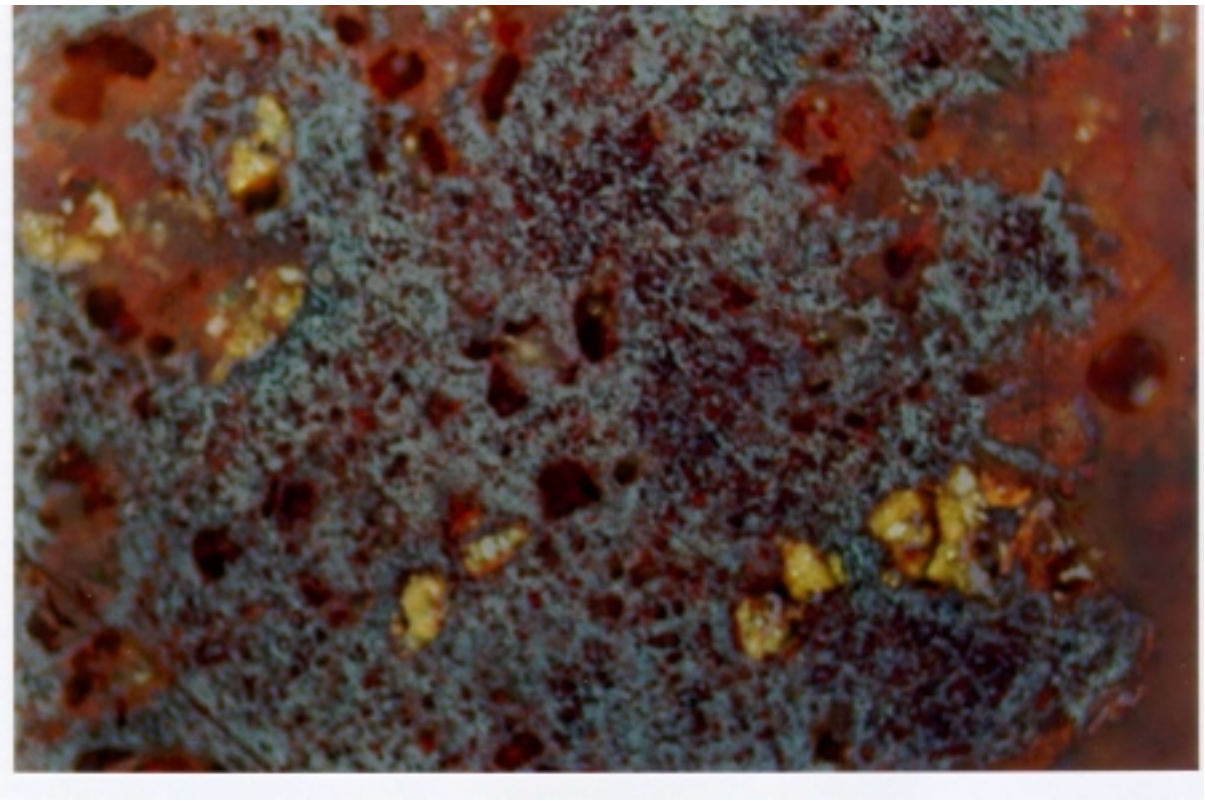


Fig 6 **DA98C10606** 0.04 mm

Reflected light, nicols partly crossed; bright patches of leucoxene, within massive microporous and earthy hematite + limonite, as probable pseudomorphs after small primary opaque oxide, suggesting an original mafic host rock.

DA98C20607

DA98C20607 **Probable original, olivine-bearing basalt, interpreted from quite well preserved supergene, limonite and clay-sericite replicas after pyroxene, plagioclase and olivine; also including veins and patches of clays. [Similar to DA98C10601 and 10609.]**

Field Note : *Tuffaceous shale?*

Approximately 50% of this sample consists of similarly aligned and fairly evenly disposed limonite lath-form replicas and vague limonitic “foliae”. These are intergrown with abundant clay-sericite pseudomorphs of two types of mineral. The most abundant of these has the form of elongate prisms or laths of probable ex-plagioclase, to 0.5 mm in size. The other, which is much less abundant, has a more prismatic to pyramidal form and has rare small opaque oxide inclusions, and is interpreted as former olivine, to 1 mm in size. There are also lamellae, veins and irregular masses of clays, largely sericitic, that seem to postdate the original rock.

In the context of this suite, these supergene alteration textures are interpreted to represent a weathered and altered basalt, similar to DA98C10601 and C1 0609 but apparently poorer in plagioclase than DA98C10609, and has more probability of having contained olivine.

DA98C10609

DA98C10609 **Probable original basalt, completely supergene altered to clay-sericite, limonite and leucoxene, with fairly diagnostic preserved relict textures. [Similar to DA98C10601 and C2 0607.]**

Field Note : *Purple Tuff*

The supergene/weathering mineralogy and preserved textures in this sample are essentially the same as in C20607; manifest as limonite, intergrown with a subequal abundant of clay-sericite pseudomorphs of elongate grains. The most abundant pseudomorphs have the form of elongate prisms or laths almost certainly representing ex-plagioclase, from 0.5 to 2 mm in size. Other, rarer grains/crystals have a more prismatic to pyramidal form with small opaque oxide inclusions. These may have been olivine, to 0.5 mm in size, but the evidence for this interpretation is largely camouflaged by the extensive weathering and therefore inconclusive. Disseminated leucoxene has replaced 5% opaque oxide to 0.4 mm in grainsize.

This rock is interpreted as a weathered and altered basalt, similar to C1 0601 and C2 0607.

DA98C10610

DA98C10610 **(Quartz)-micro-dolerite or basalt, with "primary-hydrothermal" albite-clay-chlorite-quartz-adularia-anatase-alteration. Local clay-carbonate veins containing sparse quartz.**

Field Note : *Dolerite/basalt*

In hand-specimen, this is a relatively fresh grey-green massive rock. In thin section, it is identified as a microdolerite or basalt, dominated by clay to albite-altered plagioclase laths to 0.5 mm long. There is also abundant interstitial material, variously composed of chlorite, smectites, quartz and adularia, including some euhedral adularia crystals to 0.5 mm long and minor biotite.

Accessory disseminated opaque oxide grains, apparently primary titanomagnetite and ilmenite, have been altered to probable anatase ± leucoxene. Rare fresh opaque oxide remains but it is not clear whether this is of primary or metamorphic origin. Trace apatite needles are (typically) present.

Along one side of the thin section there is a vein of chlorite ± smectite, possibly partly corrensite, with carbonate and very minor quartz.

Clearly, this is a fine crystalline mafic igneous rock, but objectively in this one thin section, distinction cannot be made between microcrystalline quartz dolerite (?chilled margin) or a (silicified) basalt.

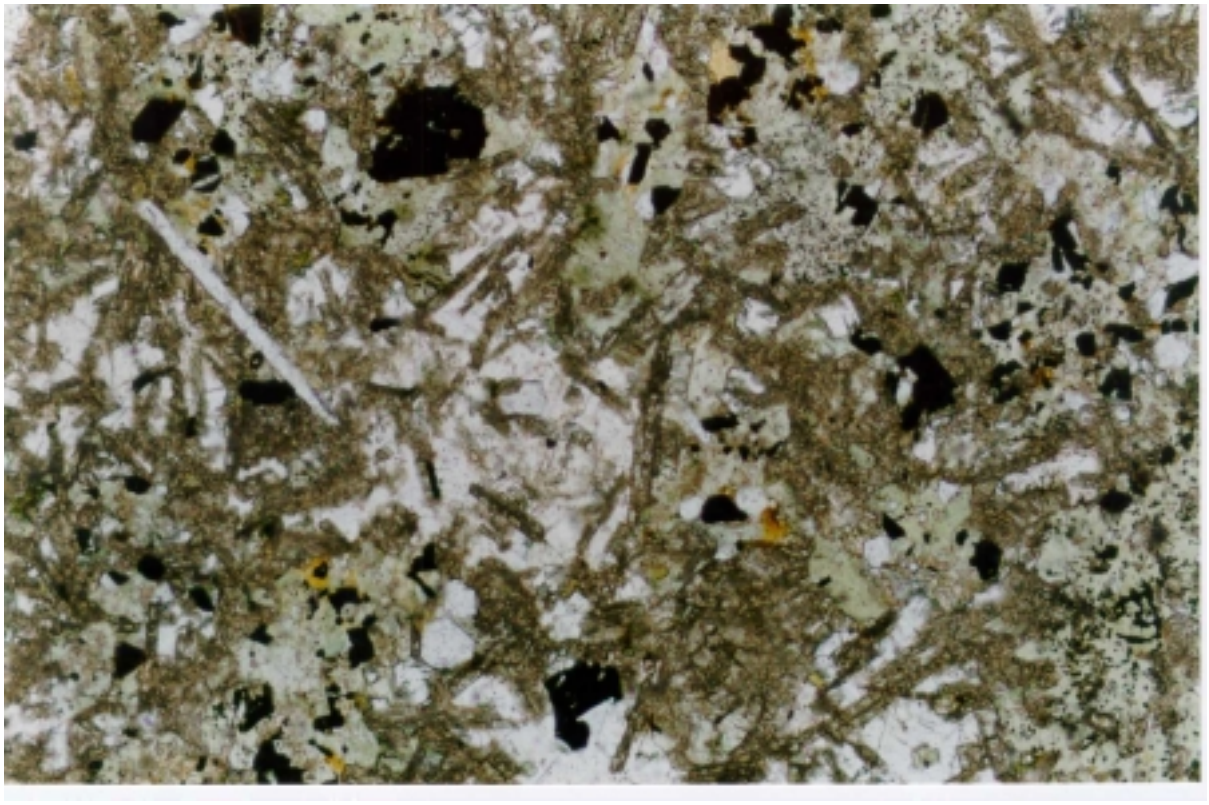


Fig 7 **DA98C10610** **0.18 mm**

Altered quartz micro-dolerite of possible basalt with clearly defined random ex-plagioclase laths, altered to extremely fine albite, clay-sericite, disseminated opaque oxides and abundant clays. A large needle of apatite is seen on the left hand side.

DA98C10611

DA98C10611 **Massive to weakly bedded, medium grained, felspathic quartz sandstone, with orthoclase, microcline, quartz-rich to sericite-rich lithic grains. Extensive quartz overgrowths occupying intergranular ex-porosity. Also limonite-clay spots, some of which may be after carbonate, also intergranular films of limonite. Compares with DA98B10733.**

Field Note : *Fine felspar sandstone. McKay Sandstone?*

Macroscopically, there seems to be a weak layering in this sandstone, with layers variably rich and poor in spots of limonite. In thin section, it is dominated by grains about 0.4 mm in diameter, including.

- Single crystal detrital quartz grains, mostly smaller than 0.5 mm, seen as well-defined detrital cores with optically continuous overgrowths which merge to effectively fill pre-existing intergranular porosity. 70%
- Clear to clouded grains of alkali feldspar, varying from orthoclase to microcline. 15-20%
- Polycrystalline grains, usually of quartz, with clays and/or limonite. 7-8%
- Detrital micas and sericite-rich lithic grains. <1%
- Interstitial limonite-clay aggregates, including patches of limonite to 2 mm in diameter, enclosing the detrital cores of quartz grains and possibly after carbonate. 5%

This sample is very similar to sample DA98B10733.

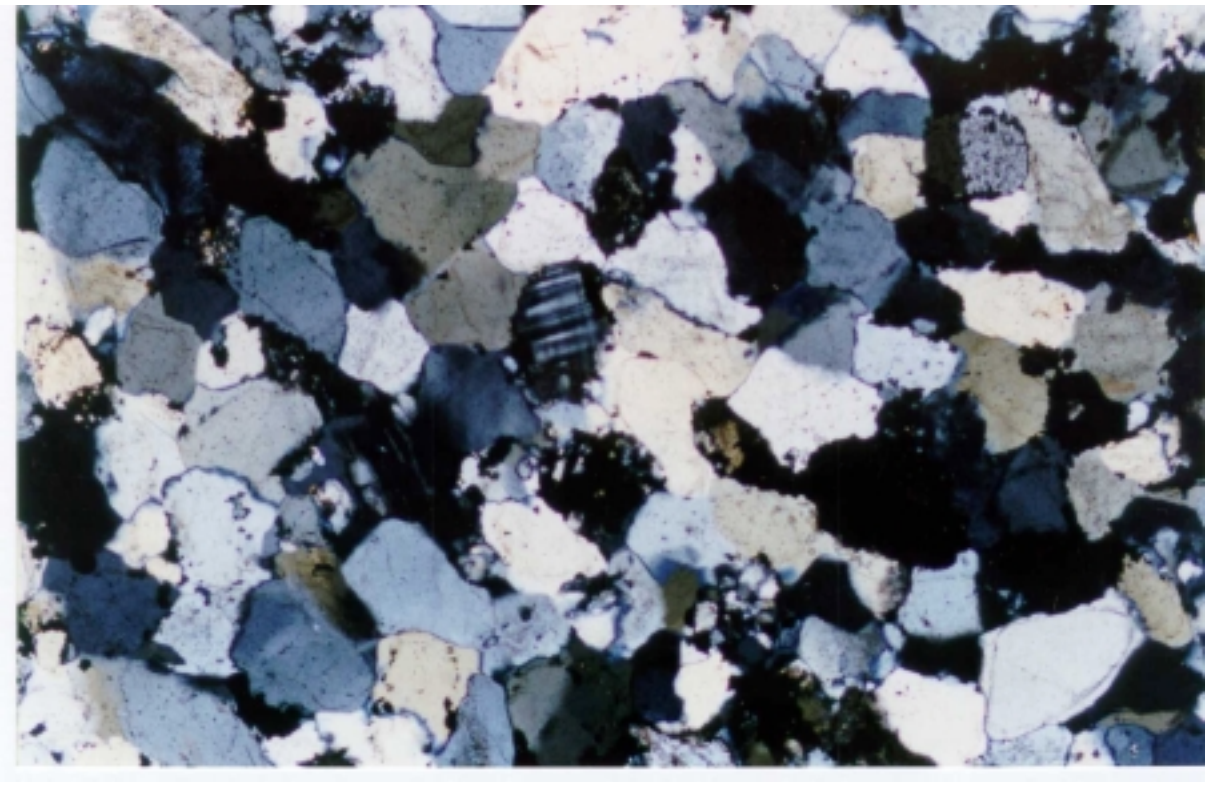


Fig 8 **DA98C10611** 0.18 mm

TS. Xnic. Well-sorted quartz sandstone with a felspathic component represented by a grain of microcline (centre), also rare lithic grains. Most quartz grains with authigenic quartz overgrowths, occupying former intergranular porosity and the original subrounded quartz grain surface preserved by a dust rim (SE corner).

DA98C10612

DA98C10612 **Massive, undeformed, ophitic dolerite, with albite-sericite-adularia-clay-chlorite-(prehnite) alteration and typical scattered skeletal opaque-oxide crystals.**

Field Note : *Oenpelli Dolerite*

This massive crystalline grey-green rock is seen macroscopically to be of mafic igneous affinity. Petrographically, it is seen to consist of :

- Albite to sericite-altered plagioclase phenocrysts to 6 mm long. 5%
- Albite to sericite to adularia-altered plagioclase laths 0.4 to 1.5 mm long, randomly interlocking and forming apparently pegmatoidal areas rich in secondary alkali (potassium) feldspar as laths to 3 mm long. 40-45%
- Fresh clinopyroxene from 3 to 6 mm in diameter typically ophitic by enclosing abundant altered plagioclase. 35%
- In the pegmatoidal areas opaque oxide-decorated clay-altered prisms, presumably of pyroxene occur, as well as widespread patches of chloritic clays ± smectite. Rare patches of prehnite substitute for chlorite-smectite aggregates. 12-13%
- Rare rounded patches of chlorite ± smectite occur to 3 mm in diameter, possibly after olivine. <1%
- Granular to weakly skeletal opaque oxide is also disseminated. 5%

This sample is identified as a distinctly ophitic dolerite, with albite-sericite-clay-chlorite-alkali feldspar-(prehnite) alteration.

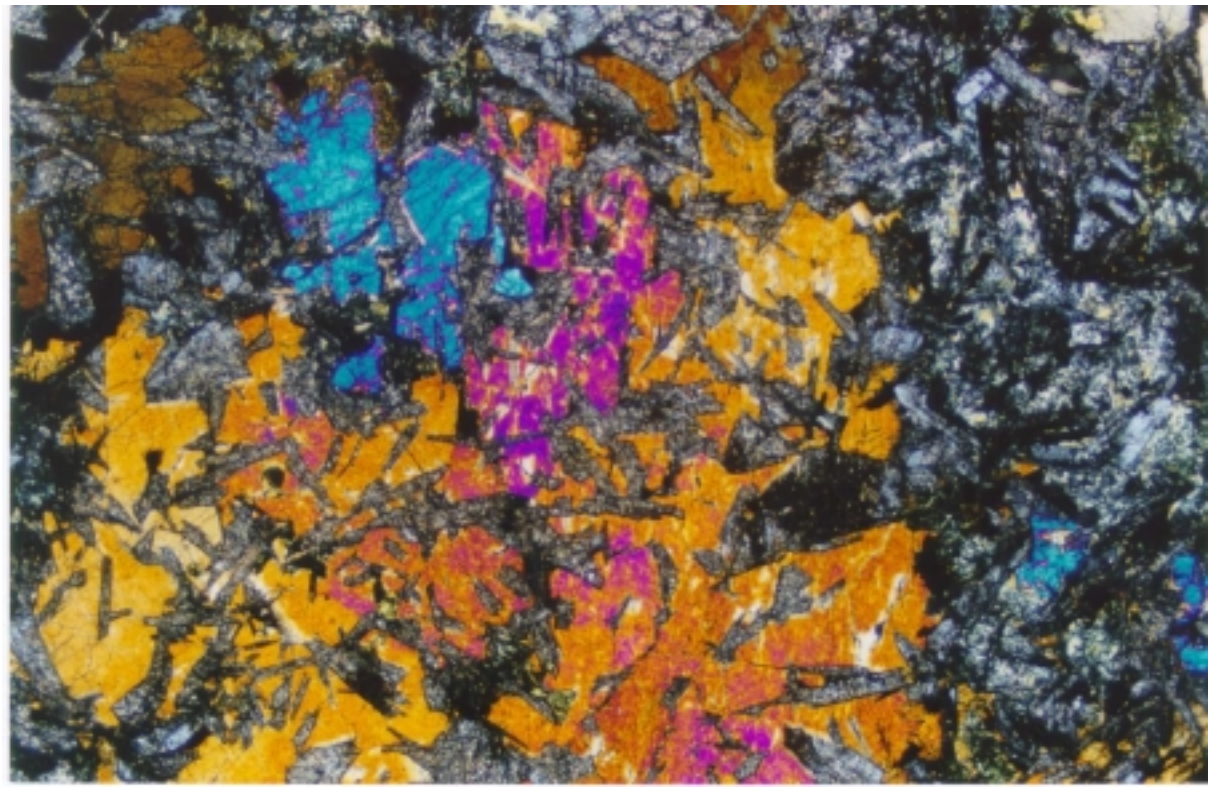


Fig 9 **DA98C1, 0612** 0.45 mm

TS. Xnic. A large fresh ophitic grain of clinopyroxene is seen in this photo, typically enclosing random clearly defined altered plagioclase laths.

Fig 10 **DA98C1, 0612** 0.45 mm

TS. Xnic. A pegmatoidal area as described, rich in secondary alkali feldspar, also with minor sericite and randomly interlocking albitised plagioclase laths.

DA98C10672

DA98C10672 **Hydrothermally silicified fine quartz sandstone. Lenses of medium grained sandstone as apparent relict clasts or breccia fragments, merging into low-temperature hydrothermal quartz with variable micro-textures mixed with clays and limonite especially in the finer-grained areas. Local relatively discrete hydrothermal quartz veins.**

Field Note : *Breccia, felspathic sandstone. McKay Sandstone.*

This handspecimen indicates a massive heterogeneous sandstone with numerous irregular lensoidal to wispy vein-like masses of cream silica, which could be regarded as breccia fragments.

Petrologically, some of these are seen as veins, to 4 mm wide, with granular to prismatic quartz to 2 mm in grainsize. However, other pale lenses seem to be residual areas of sandstone (breccia fragments) with rounded grains to 0.4 mm in size, including <5% clay-limonite clouded lithic grains, with the quartz grains locally with narrow optically continuous quartz overgrowths. Some of these areas of apparent relict sandstone clasts or fragments pass into patches of massive felted-prismatic quartz to 0.7 mm in size, and these seem to represent low-temperature hydrothermal silicic alteration of the sandstone.

The bulk of the rock basically as a matrix to the above components, is a mixture of inequigranular quartz and clays. The quartz includes cherty, microsparry, felted-prismatic and locally, some granular to prismatic quartz in vein-like lenses. The clays, which are usually limonite-stained, are most abundant in the areas of finer-grained quartz. These domains also appear to have hydrothermal affinities.

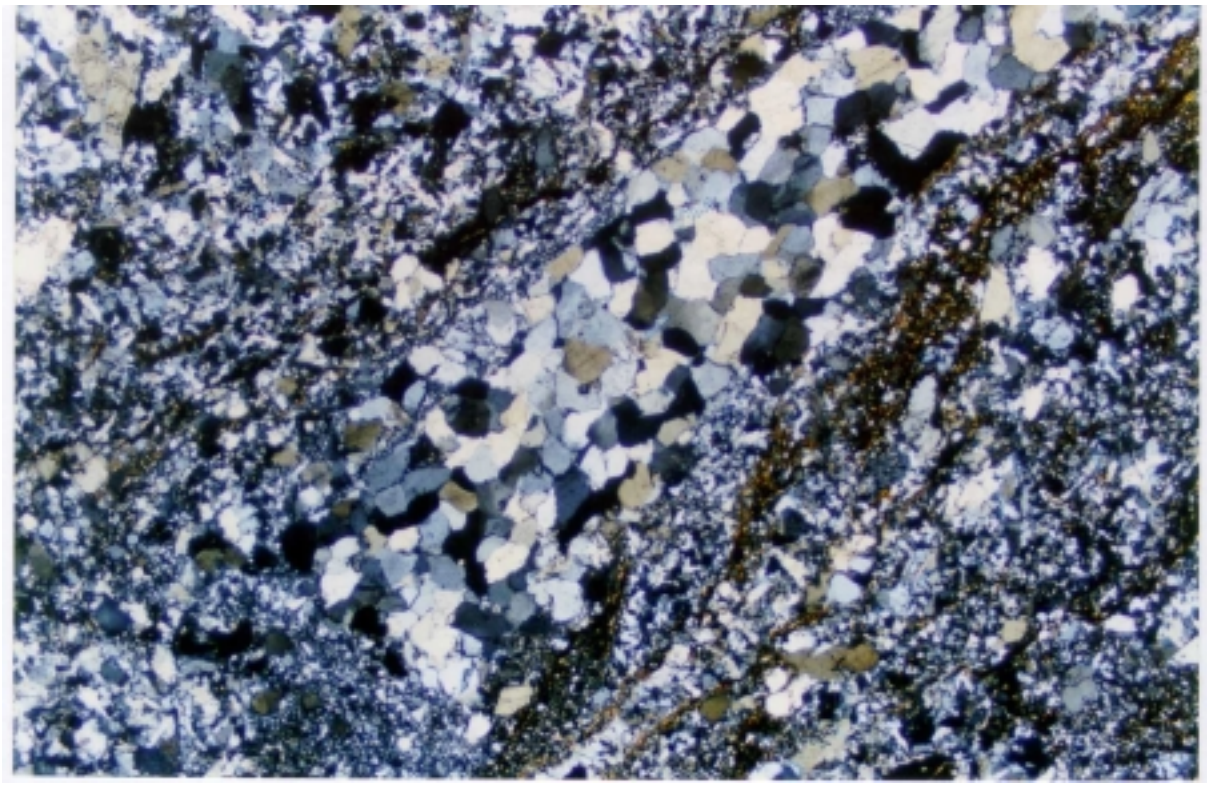


Fig 11 **DA98C10672** 0.45 mm

TS. Xnicols (Xnic). The area of coarser quartz in this photo seems to be a lens or fragment of sandstone, enclosed in cherty to microsparry hydrothermal quartz.

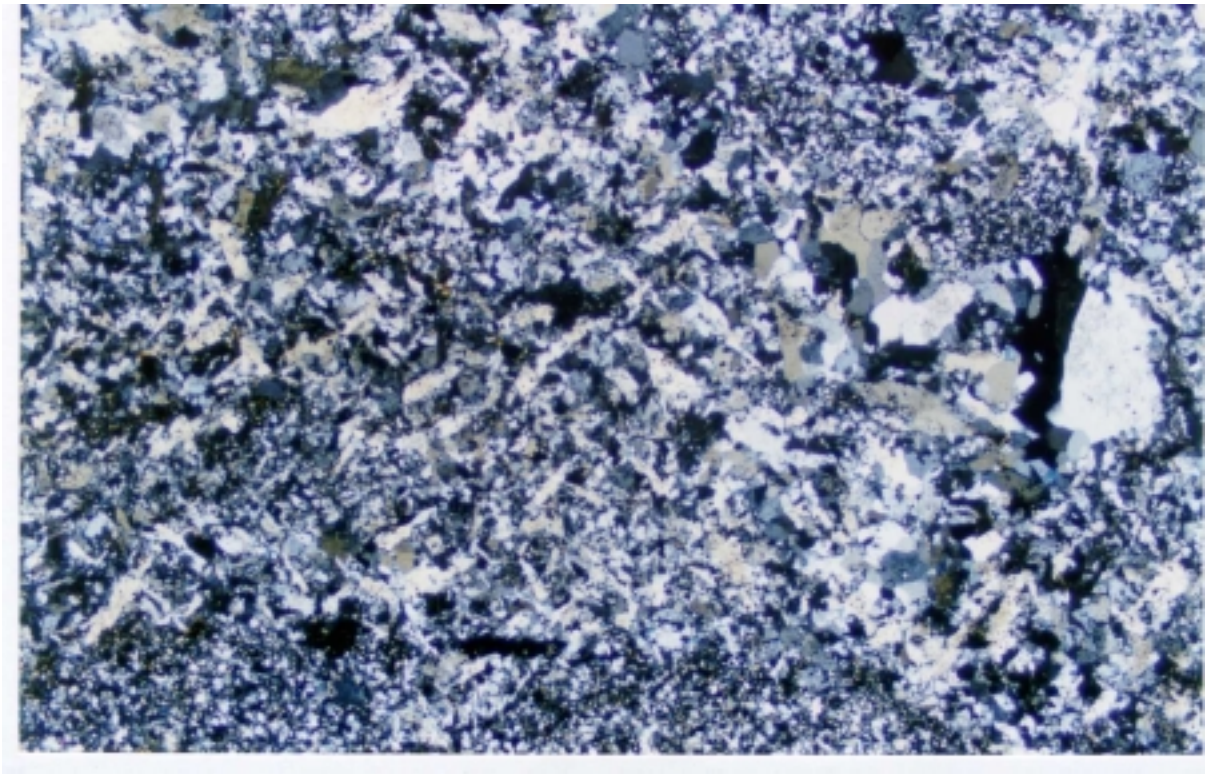


Fig 12 **DA98C10672** 0.45 mm

TS. Xnic. This photomicrograph shows largely felted-prismatic quartz of low temperature hydrothermal origin, passing into sparry vein quartz, also hydrothermal.

DA98C10673

DA98C10673 **Medium grained sandstone with extensive optically continuous overgrowths, passing into quartz veins with small crystal-lined cavities and of apparently low temperature hydrothermal. Abundant clay to limonite rich patches with fine-grained quartz, accessory plagioclase and apparently low temperature hydrothermal and lithic grains and anomalous clusters of fine zircon to 0.15 mm in grainsize.**

In hand-specimen, this looks like a porous weathered quartz-rich sandstone with a bedding foliation. In thin section there are irregular millimetre to centimetre scale domains of sandstone, composed of grains with rounded detrital cores to 0.4 mm in grainsize (medium grained sandstone), mostly with extensive optically continuous overgrowths. The overgrowth quartz commonly passes into areas of granular to prismatic quartz to 1 mm or more in grainsize, with some crystal-lined cavities to suggest a low temperature hydrothermal origin of these overgrowths.

There are also abundant (35%) patches of clays and/or limonite, incorporating very fine (silt size) quartz, and these patches range in size from 0.03 to 0.1 mm in grainsize. Curiously, there are locally abundant zircon grains to 0.15 mm in length in and adjacent to these patches. Small lithic grains and rare albite also occur in and adjacent to these areas. Some of these patches also contain a minor porosity and may have been formed or modified by low-temperature hydrothermal activity.

It appears that these patches may be responsible for the field suggestion that this rock is arkosic, but only accessory felspar is seen in the thin section.

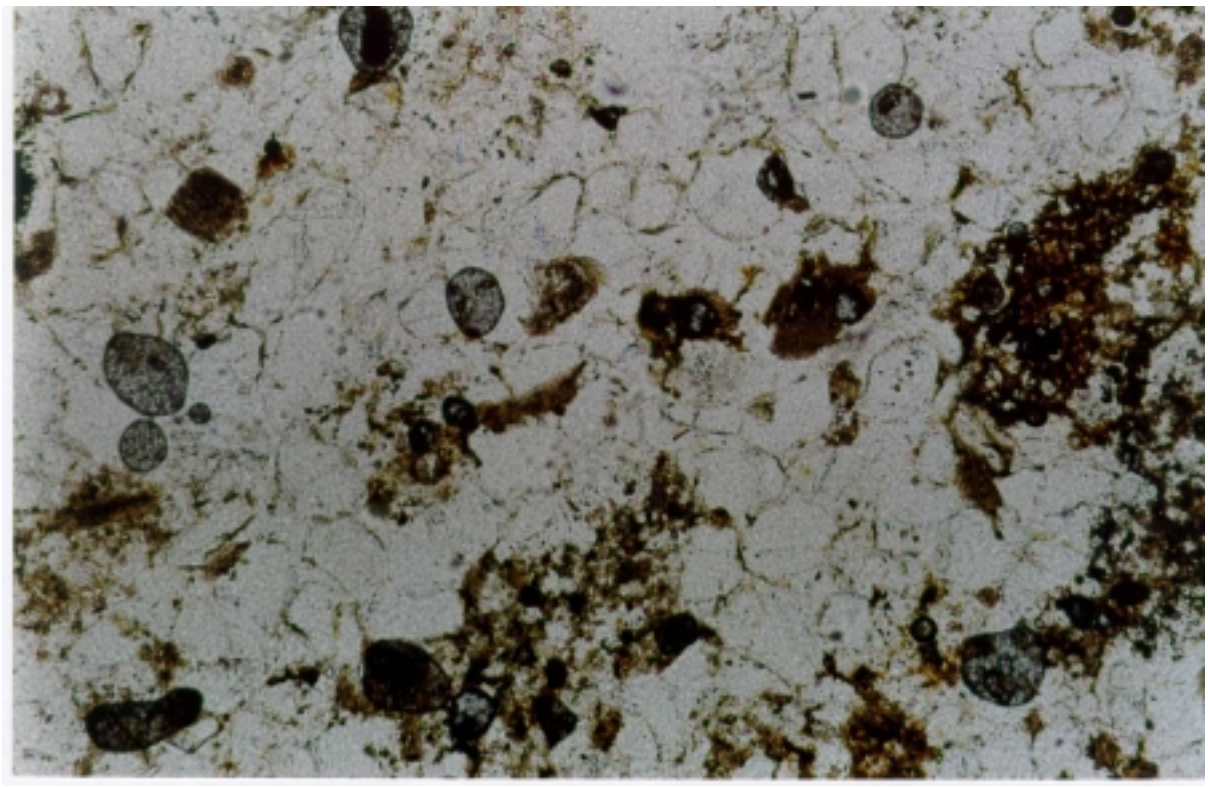


Fig 13 **DA98C10673** 0.18 mm

TS. Plane polarised light (PPL) Mostly medium sandstone showing rounded detrital quartz cores, outlined by limonitic dust rims enveloped by quartz overgrowths, also irregular patches of limonitic clays.

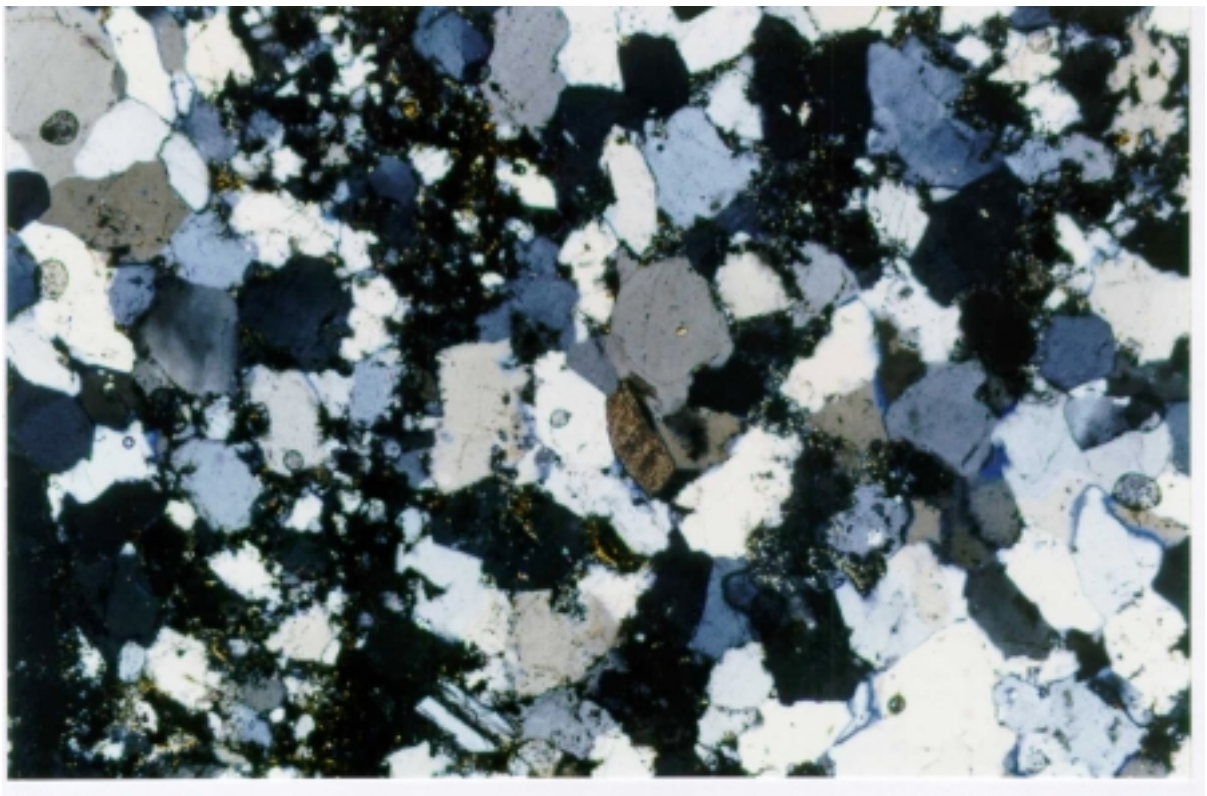


Fig 14 **DA98C10673** 0.18 mm

TS. Xnic. This photo shows some optically continuous overgrowths on the quartz. The clay-limonite-fine quartz areas are also visible. A small lithic grain (brown) is seen in the centre of the photo.

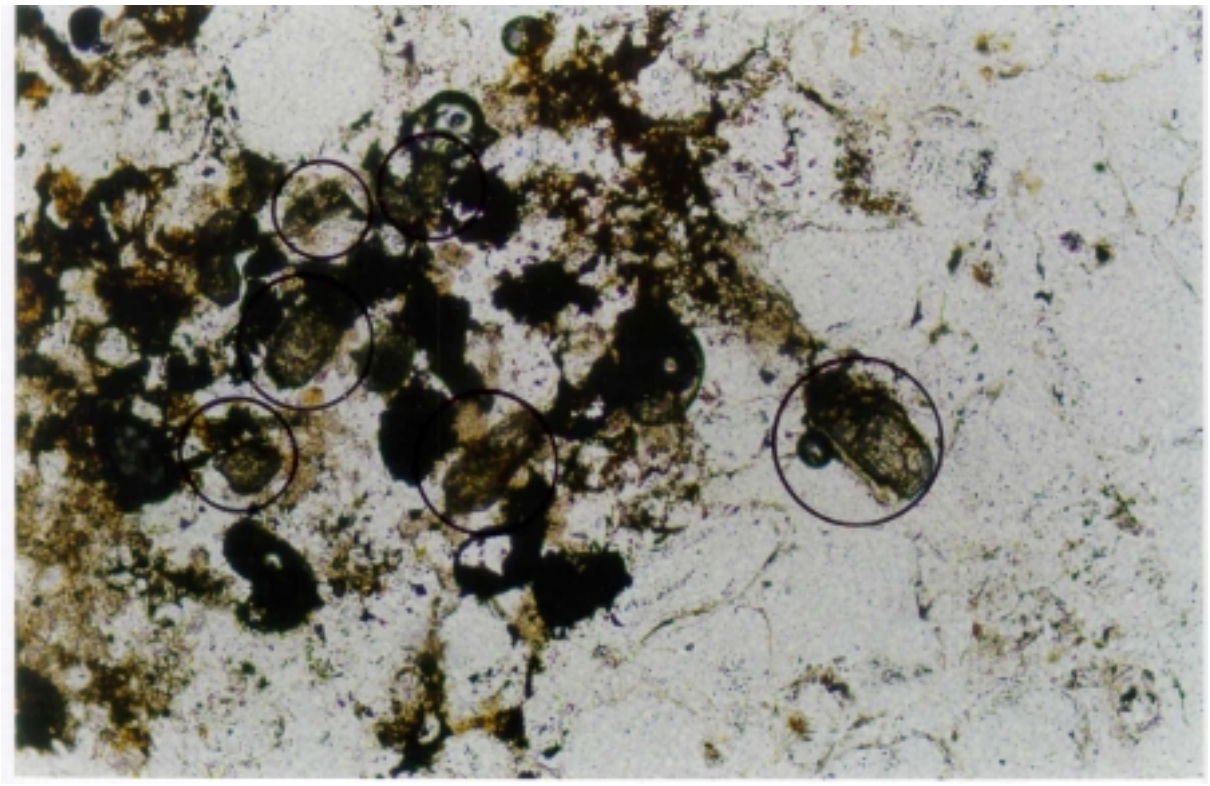


Fig 15 **DA98C10673** **0.09 mm**

TS. PPL. An area of fine quartz and limonitic clays, with abundant zircon grains (high relief circled).

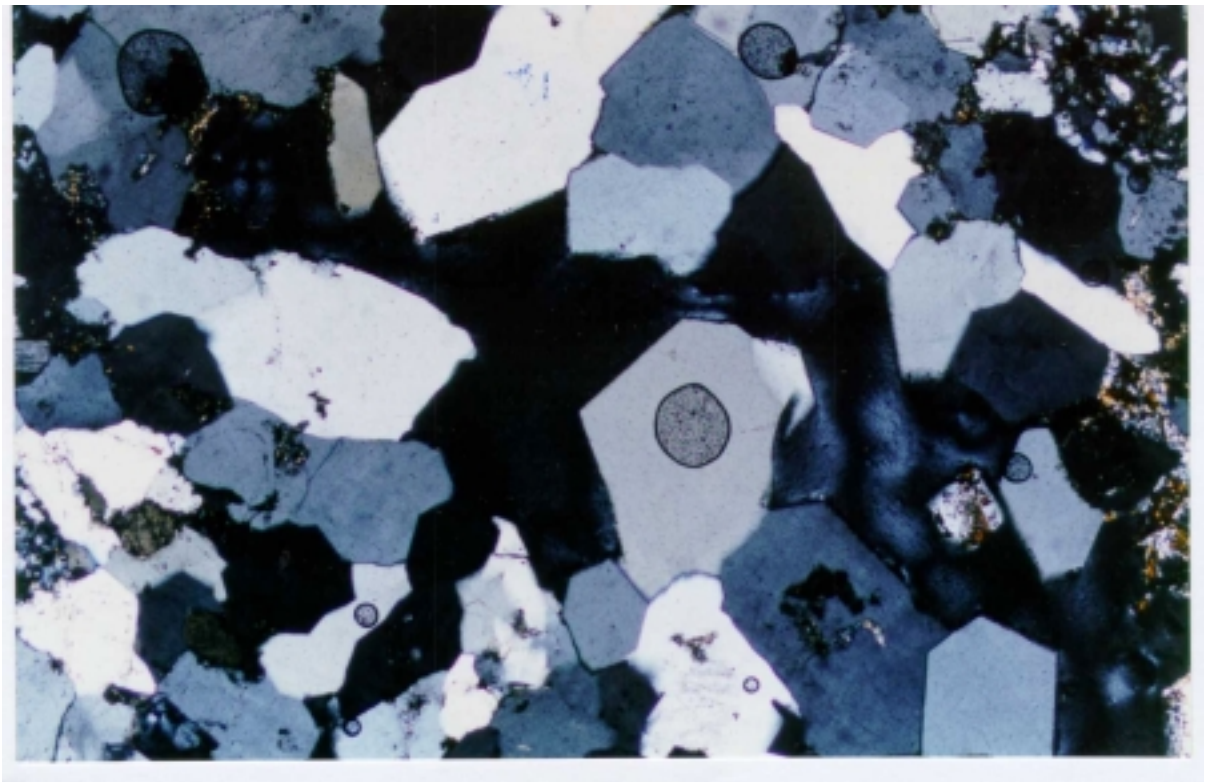


Fig 16 **DA98C10673** **0.18 mm**

TS. Xnic. Example of a patch of probable low temperature hydrothermal quartz, with some quartz crystals euhedral against a small cavity black central part of photo.

DA98C10674

DA98C10674 **Massive, reddened quartz microsyenite, with minor parallel quartz veins.**

Field Note : *Pinkish-red-altered dolerite.*

Mineral	Vol %
Orthoclase	80%
Quartz	15%
Clays	5%
Leucoxene	tr

Hematite or limonite staining produces a distinctive red colour to this massive fine crystalline handspecimen, also with several narrow planar quartz veins.

In thin section, the rock is seen (according to the mineralogy listed in the adjacent table) to be a microsyenite to microgranite, with reddened alkali feldspar more abundant than granular late magmatic quartz and granophyre. The alkali feldspar seems to be orthoclase and occurs as laths to 0.8 mm long, with quartz and granophyre to 0.5 mm in grainsize. There are minor patches of smectites ± leucoxene that may have replaced ferromagnesian grains. Some of the quartz has inclusions of apatite.

The veins, which are less than 0.5 mm wide, are composed of granular quartz.

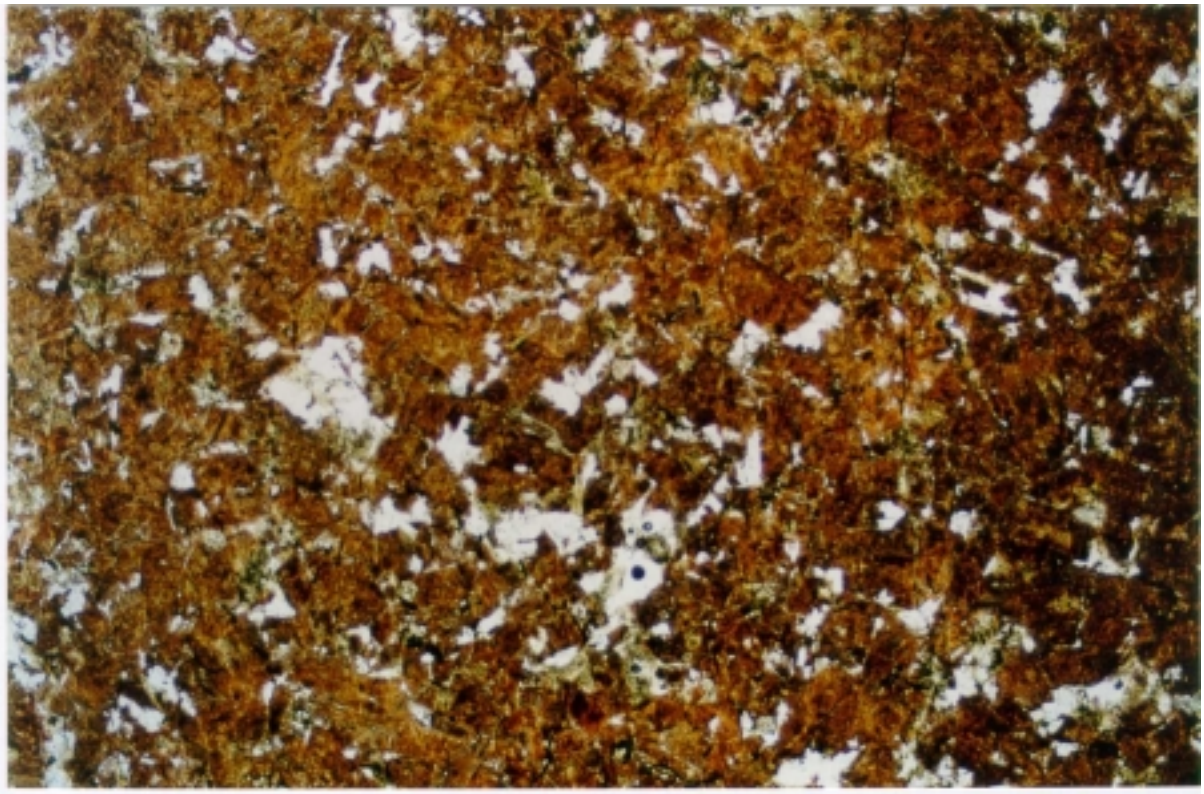


Fig 17 **DA98C10674** 0.18 mm

TS. PPL. This photo is essentially a microcrystalline mass of iron-stained orthoclase and minor quartz, comprising this quartz microsyenite.

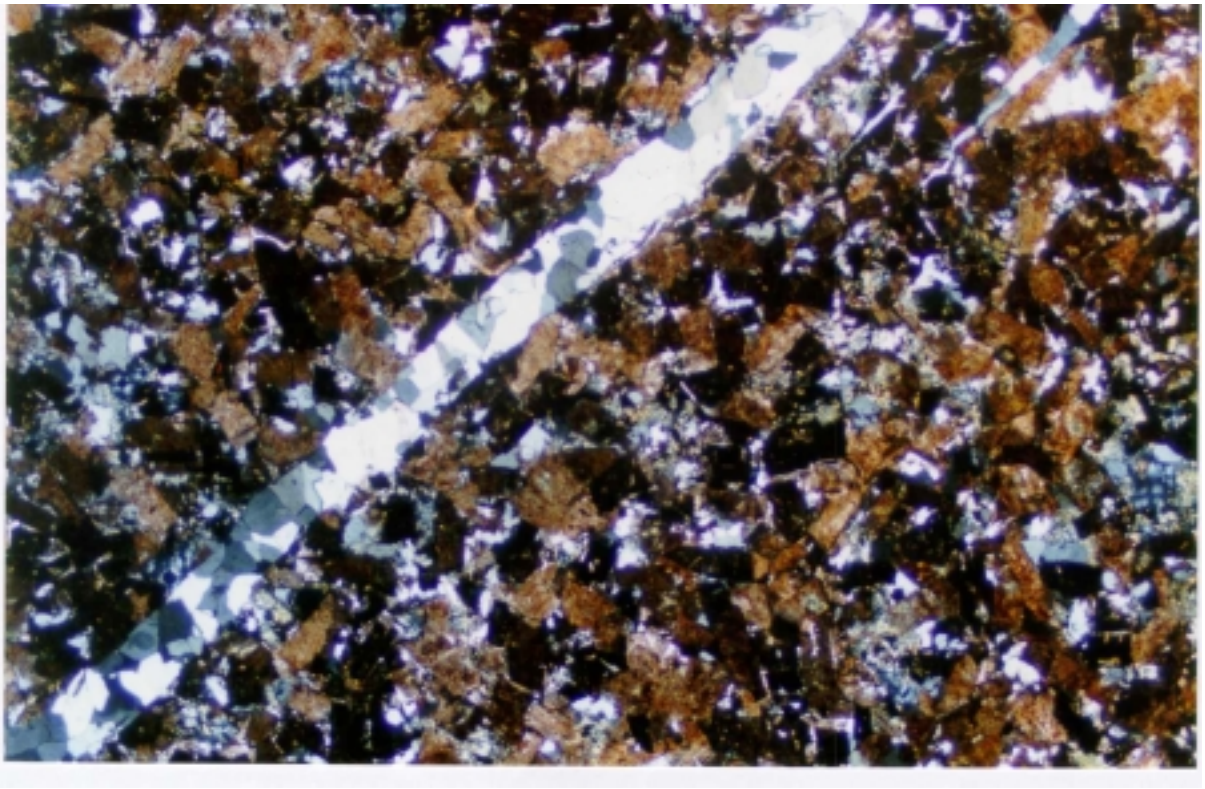


Fig 18 **DA98C10674** 0.18 mm

TS. Xnic. Another area of quartz microsyenite, with a planar vein of granular quartz.

DA98B10707

DA98B10707 **Quartz-rich medium to coarse grained sandstone with minor scattered quartz grit. Diffuse limonite staining and quartz overgrowths occupying previous intergranular porosity, effectively silicifying the sandstone (to incipient orthoquartzite) but in handspecimen, remaining somewhat friable, particularly in relation to B10708.**

Field Note : *Ferruginous fine sandstone, possibly McKay Sandstone.*

Pale limonite to hematite staining is diffuse and occurs irregularly though this rock, which as seen in hand-specimen, seems to be a sandstone. The thin section is dominated by originally rounded to sub-rounded quartz grains from 0.3 to 0.6 mm in diameter (medium to coarse grained sandstone) with rare larger grains (to 2.5 mm in diameter) derived from vein quartz.

These original grains are outlined by partial to complete rims of limonitic dust, with outer optically continuous quartz overgrowths, occupying pre-existing intergranular porosity, merging into adjacent overgrowths, effectively silicifying the rock to produce an ortho-quartzite, with the (new grain) contacts having a subhedral/subpolygonal mosaic texture. This handspecimen however remains somewhat friable and so in spite of the petrography, the development of “ortho-quartzite” should be regarded as “incipient”.

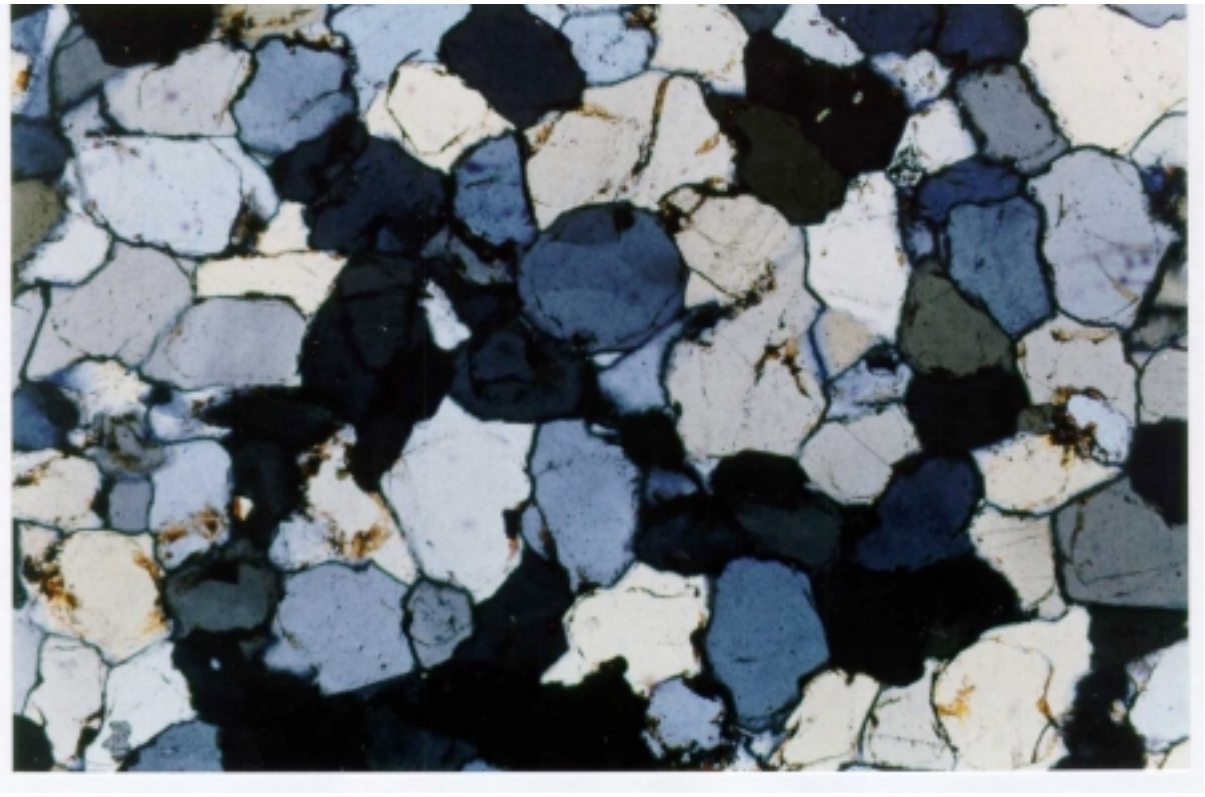


Fig 19 **DA98B10707** 0.18 mm

TS. Xnic. Sandstone, well sorted, well-defined optically continuous overgrowths on rounded cores outlined by films of limonite and effectively cementing/silicifying the sandstone to form an incipient orthoquartzite..

DA98B10708

DA98B10708 **Basically orthoquartzite i.e. coarse grained sandstone with dominant quartz grains accessory lithic grains, rare tourmaline and extensive siliceous quartz overgrowths as intergranular cement ± limonite, to produce (ortho)quartzite.**

Field Note : *Quartzite. McKay Sandstone.*

This is a typical quartz-rich sandstone dominated by an original rather loose packed aggregate of rounded to subrounded quartz grains. These grains all have optically continuous quartz overgrowths, merging and therefore occupying original intergranular areas, forming (ortho)quartzite.

- Original rounded clear single crystal detrital quartz grains to 1 mm in diameter. 95-97%
- Polycrystalline lithic grains composed of granular quartz, usually weakly or strongly clouded by limonite or clays, and possibly representing silicified acid volcanics. 2-3%
- Rare limonitised opaque oxide grains and rare tourmaline <1%
- Limonite commonly outlines the original rounded quartz grains and some present-day grain boundaries, as well as forming localised stylolite-like veins. <1%

One of the quartz grains has a small inclusion of biotite. There is nil or negligible intergranular clay-sericite (as seen in some samples of Kombolgie Sandstone).

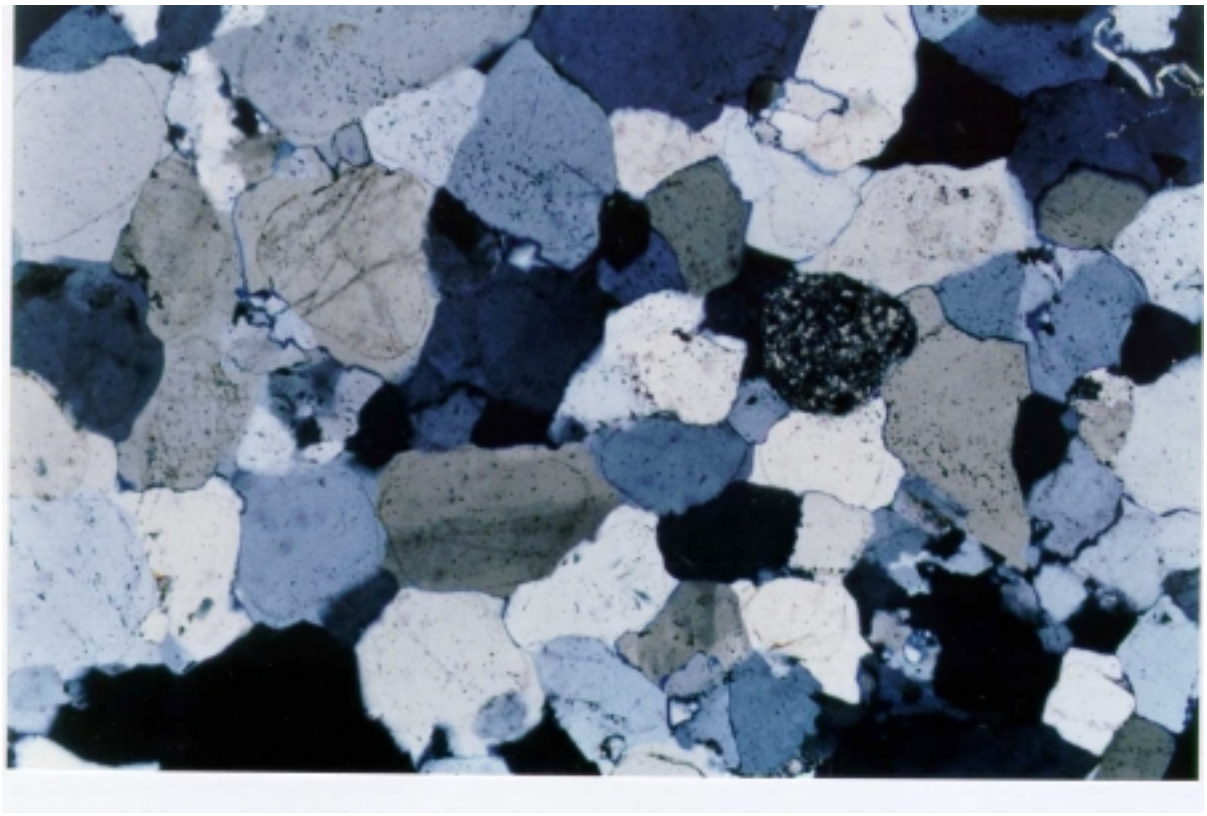


Fig 20 **DA98B10708** 0.18 mm

TS. Xnic. Well-sorted sandstone, dominated by loosepacked aggregate of originally rounded single crystal quartz grains, but with extensive optically continuous quartz overgrowths filling intergranular spaces and causing gross silicification and formation of orthoquartzite. A small lithic grain is seen to the right of centre.

DA98B10709

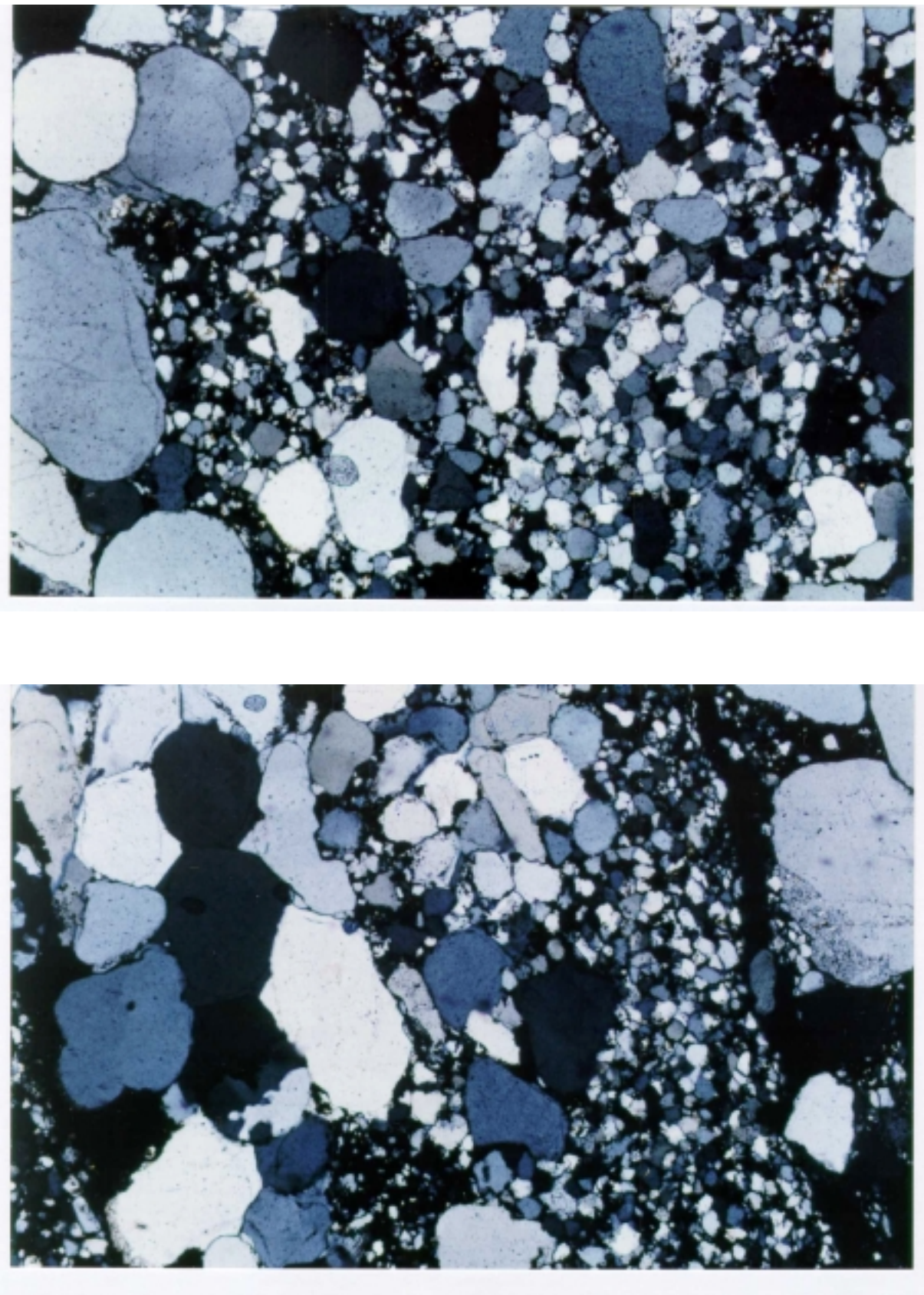
DA98B10709 **Irregularly interbedded coarse grained and fine grained quartz sandstone, with fine sandstone also infiltrated into the coarse sandstone, partly as slumped masses, partly as minor possible disrupted sedimentary dykes (or intraformational clasts). Extensive silicification, particularly in the coarser (and originally more porous) sand.**

Field Note : *Ferruginised quartz sandstone. McKay Sandstone.*

There are visible millimetre to centimetre scale bedding laminations in this sample as well as possible intraclasts or small sedimentary dykes, indicative of syn sedimentary disruption and basically a relatively high energy depositional environment.

The thin section shows layers composed partly or entirely of original rounded single crystal quartz grains to 1 mm in diameter, with extensive optically continuous quartz overgrowths. These are classified as coarse grained sandstones. There are also layers that contain or consist of quartz grains from 0.5 to 0.2 mm in grainsize and classified as very fine to fine grained sandstones.

Some areas of coarse grained sandstone have been infiltrated by fine grained sandstone so that the larger quartz grains have interstitial areas that, as well as (or instead of) optically continuous overgrowths, have smaller, fine-sand sized quartz grains as lenses and disrupted lamellae. A local accumulation of fine sand about 3mm x 5mm is elongate at a high angle to the bedding and possibly comprising a lensoidal sedimentary dyke or a disrupted intraformational fine sandstone clast. Other, more equant small rounded patches of fine sand may also be intraclasts, but could also represent slumped material.



Figs 21, 22 **DA98B10709** 0.18 mm

TS. Xnic. Bimodal sandstone, with optically continuous overgrowths on some coarse grains. This silicification is extensive within the coarse layers. Photos also show infiltration of finer sand between the coarser layers, and limonitic.

DA98B10710

DA98B10710 **Massive (quartzitic), quartz sandstone with incipient stylolitic (?incipient para-quartzitic) grain boundaries some with films of limonite. Rare polycrystalline quartz grains and grains of leucoxene after opaque oxide.**

Field Note : *White quartz sandstone. McKay Sandstone.*

In hand-specimen, this seems to represent a weakly layered pale pinkish sandstone. In thin section, it is a relatively massive sandstone with most of the rock composed of an original quite compact aggregate of quartz grains from 0.2 to 1 mm in size. The maximum grainsize in any area varies from 0.6 to 1 mm, and there are commonly some quartz grains to 1.5 mm in diameter.

Interestingly, the original grains are not as clearly identifiable as in other samples of sandstone in this batch, where they are seen as cores with limonitic dust rims, then optically continuous quartz overgrowths. The grain boundaries also tend to be slightly more intricately interlocking, suggesting incipient stylolitic grain boundaries. Films of limonite do occur however along some grain boundaries to locally produce a pale reddish to pinkish hue.

Minor polycrystalline quartz grains and rare leucoxene-altered opaque oxide grains are scattered.

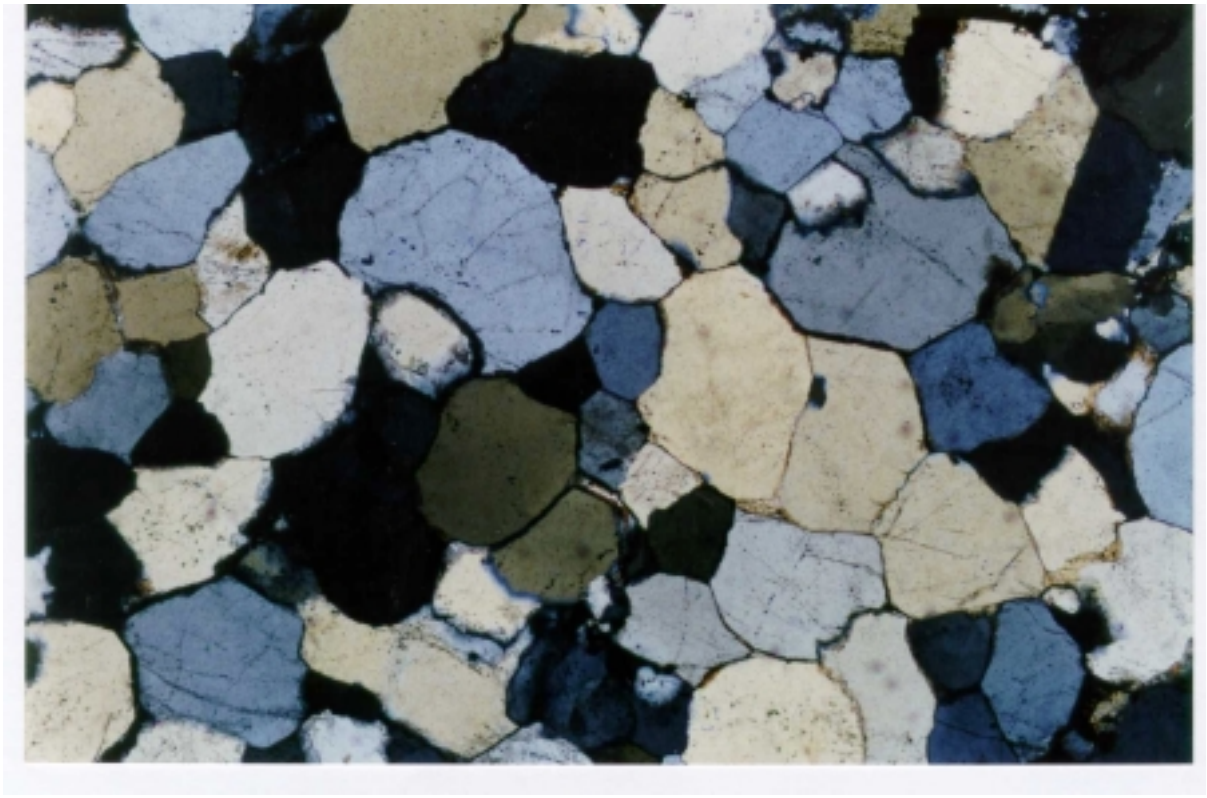


Fig 23 **DA98B10710** 0.18m

TS. Xnic. Reasonably well-sorted coarse quartz sandstone, with irregularly polygonal intergranular contacts but original detrital grains (as cores to siliceous overgrowth/cement) not as clearly defined as in most other sandstones in this suite.

DA98B10727

DA98B10727 **Coarse to very coarse gritty quartz-rich sandstone, with some bimodal layers containing accessory zircon. Also, minor sporadic intergranular extremely fine clays and micas, and no quartz overgrowths (therefore different from B10707 to 710. Rare quartz with inclusions of possible monazite.**

Field Note : *White clay-rich felspar sandstone. McKay Sandstone.*

In hand-specimen this seems to be a relatively friable, partly cross-bedded medium to coarse grained sandstone with weak, largely diffuse limonite staining. In thin section there are some layers with single crystal quartz grains less than 1 mm in diameter, but much of the rock has quartz grains from 1 to 2 mm in diameter.

There is no clear evidence of cross-bedding in thin section, and some of the layers that contain very coarse, sand-sized quartz grains are bimodal, with smaller quartz grains between the larger grains. One of the quartz grains is unusual in having several inclusions of possible monazite to 0.25 mm in diameter. There is locally accessory small zircon grains between the quartz grains, mostly where there are smaller quartz grains also been deposited between the larger grains (in the bimodal layers).

Minor interstitial extremely fine clays occur locally, overall forming 7% to possibly 10% of the whole rock with or without limonite. Minor clay-altered apparent detrital mica is also scattered sporadically interstitially. These characteristics and the apparent lack of optically continuous quartz overgrowths on original quartz grains distinguishes this sandstone from the four sandstones B10707 to 710 described above.

Sporadic intergranular clays suggests possible Kombolgie Sandstone (rather than McKay) see summary comments.

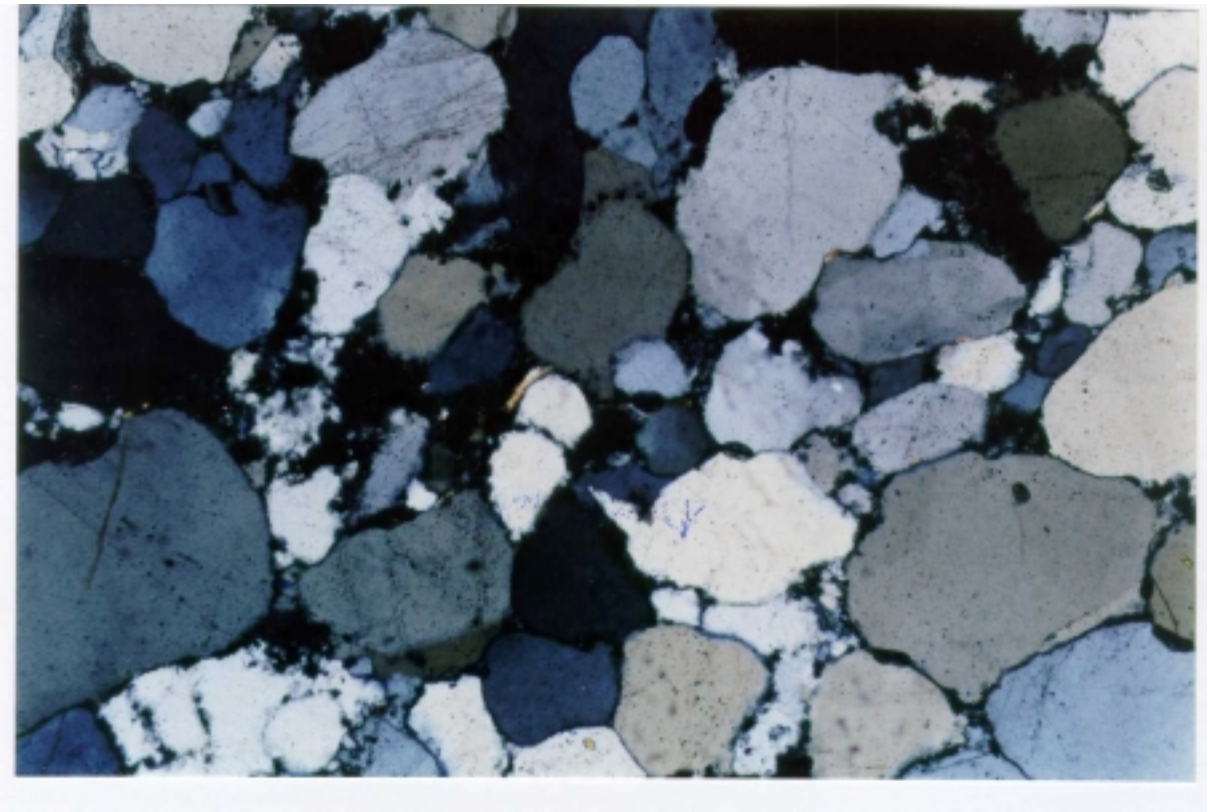


Fig 24 **DA98B10727** 0.18m

TS. Xnic. Poorly sorted sandstone, some stylolitic grain boundaries without apparent quartz overgrowths, but with minor intergranular clays (dark), also sparse fine micas partly oxidised (coloured).

DA98B10728

DA98B10728 **Quartz-rich coarse to very coarse grained sandstone and grit with bedding laminations. Characterised by fairly extensive intergranular limonite outlining well-rounded detrital grains and rare zircon. Relatively minor quartz overgrowths.**

Field Note : *Poorly sorted impure sandstone, McKay Sandstone.*

In hand-specimen, this is a reddish-limonitised coarse-grained and gritty bedded sandstone. In thin section, it is dominated by a fairly compact age of original rounded single crystal quartz grains, with fairly well defined beds on a millimetre to centimetre scale. There are mostly two types of sandstone:

(1) coarse-grained, with grains to 0.8 mm in size and

(2) very coarse grained sandstone-to-grit, with grains from 1 to 2.5 mm in size.

Some of the larger quartz grains are polycrystalline rather than single crystal, and these are less rounded than the single crystal grains. The outline of the original rounded detrital grains are commonly defined by rims of limonite, which is fairly extensive/intergranular, and possibly representing selectively oxidised ex-intergranular clay? or fine chlorite (as seen for example in B10727 and 729), which is sufficiently abundant to give a red colouration to the rock as seen in hand-specimen. There are also scattered patches of interstitial limonite.

A single grain of zircon was seen, 0.1 mm long, as the only detrital heavy mineral seen in this section. One of the quartz grains has a small inclusion of biotite.

[Possibly Kombolgie rather than McKay.]

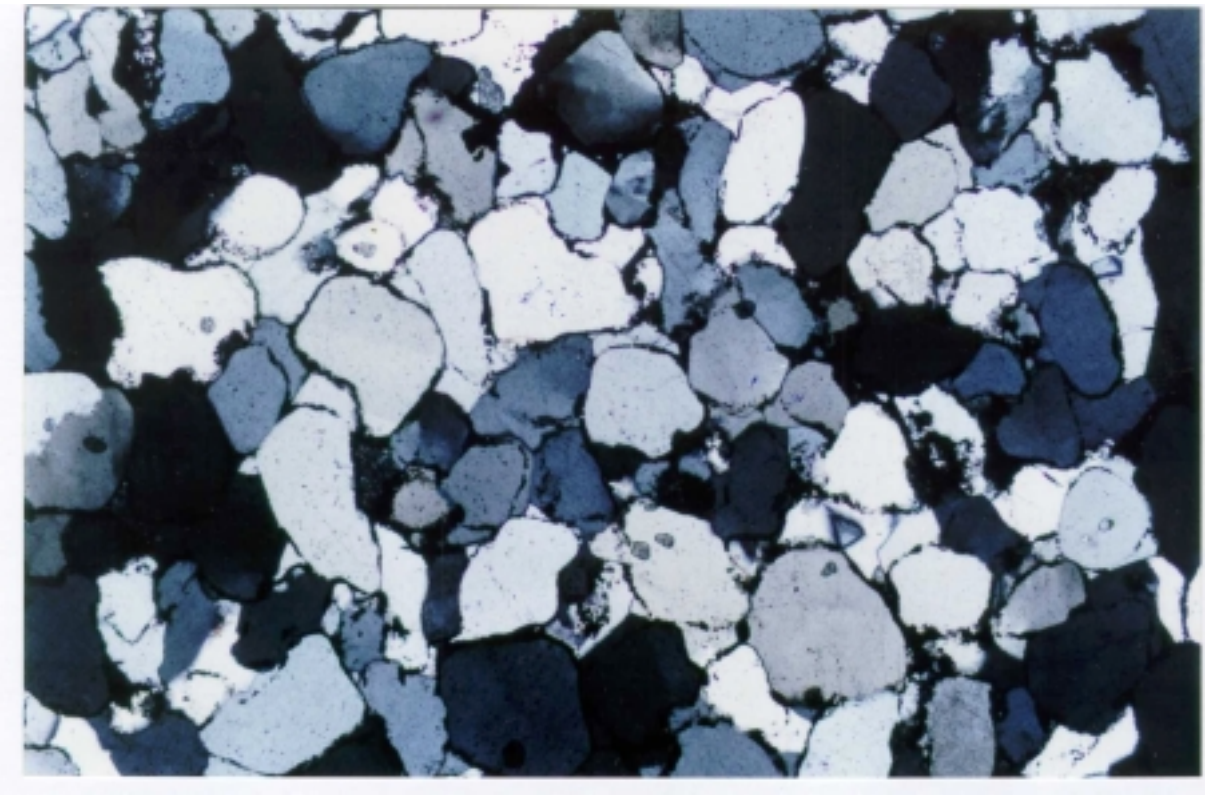


Fig 25 **DA98B10728** **0.18 mm**

TS. Xnic. Original rounded detrital quartz grains well-defined by dark rims of (intergranular) limonite and optically continuous overgrowths of quartz. The limonite may (partly) represent oxidised intergranular clays or fine chlorite.

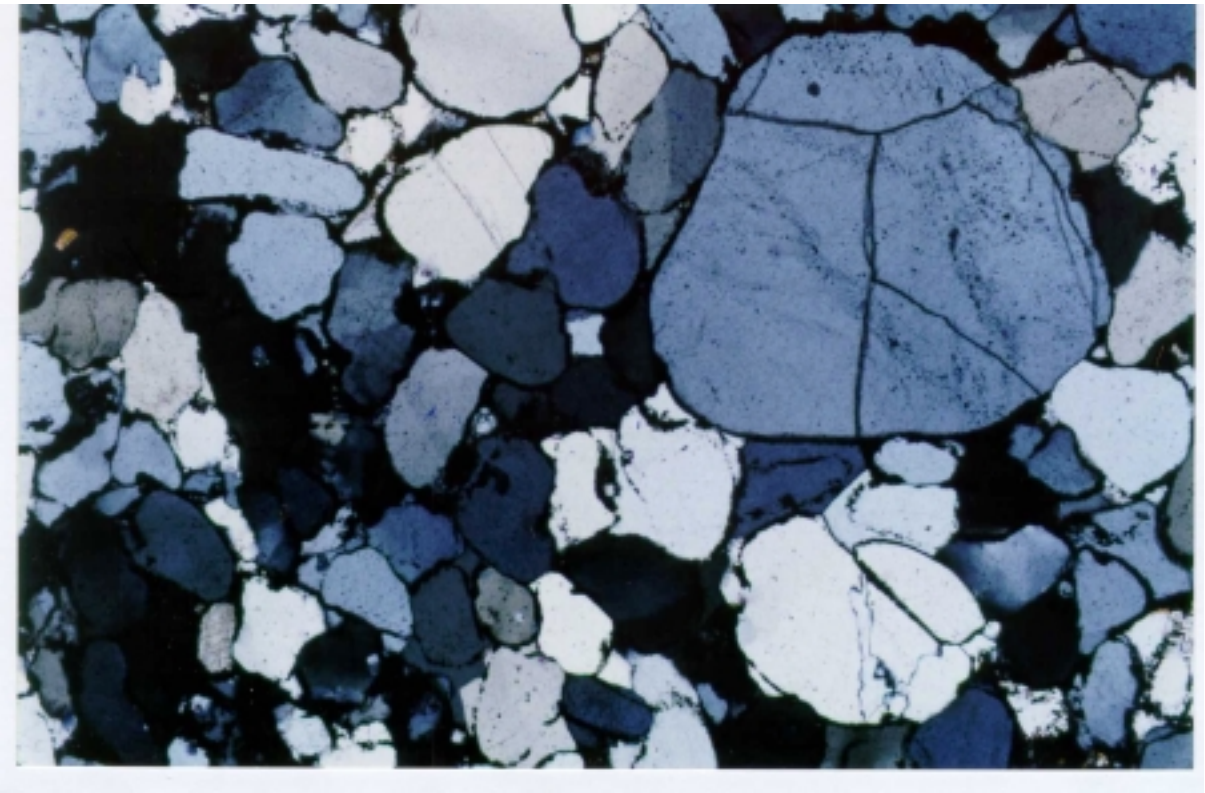


Fig 26 **DA98B10728** **0.18 mm**

TS. Xnic. A more poorly sorted domain than in Fig 25, but with equally well-defined original rounded detrital quartz grains, dark rims of limonite.

DA98B10729

DA98B10729 **Bedded quartz-rich sandstone with layers of medium grained sandstone and very coarse grained sandstone as well as poorly sorted sandstone with fine to very coarse sand-sized quartz grains. Interstitial clays, limonite and leucoxene, also detrital micas and rare zircon. [No particular evidence of hydrothermal alteration].**

Field Note : *Chloritic sandstone. Kombolgie Sandstone. Any evidence of hydrothermal alteration?*

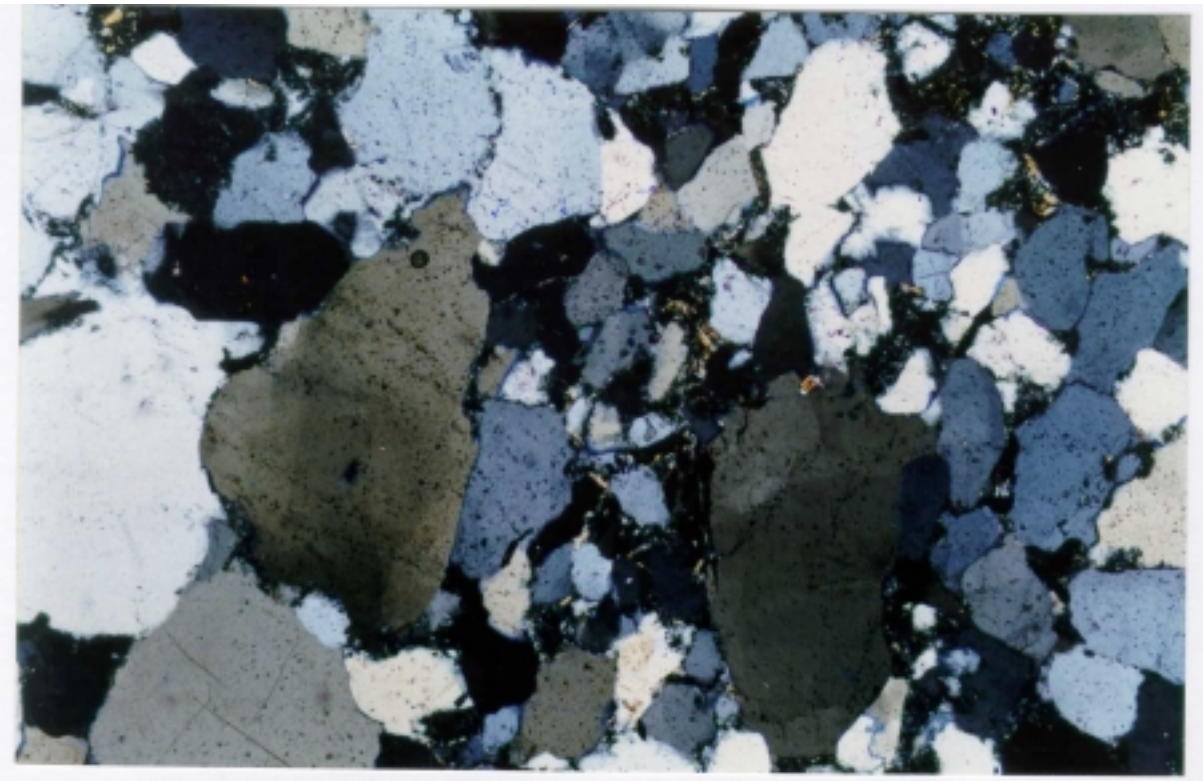
In hand-specimen, this seems to be a poorly sorted sandstone with poorly defined bedding laminations with possibly some sericite ± clay, as well as disseminated patches of limonite or hematite. In thin section, there are poorly defined millimetre to centimetre scale bedding laminations with:

- Some layers of quartz to 0.5 mm in grainsize (medium grained sandstone).
- Layers dominated by rounded single crystal quartz grains from 1 to 2 mm in diameter (very coarse grained sandstone).
- Common layers that are poorly sorted with single crystal quartz grains from 0.2 to 2 mm in diameter, covering the range from fine to very coarse sand.

Polycrystalline (vein) quartz grains are rare and there are locally small aggregates of zircon grains to 0.2 mm in diameter.

Minor intergranular “clay-sericite” is widespread and apparently diagnostic forming about 10% of the whole rock. These very fine clouded phyllosilicates include minor small patches of clays and/or sericite, also limonite and/or leucoxene, all most common in the finer-grained and more poorly sorted areas. There is some detrital muscovite as well as clays possibly after detrital biotite.

In spite of the intergranular clay-sericite, there is no conclusive petrographic evidence that this results from hydrothermal alteration, as questioned in the covering letter.



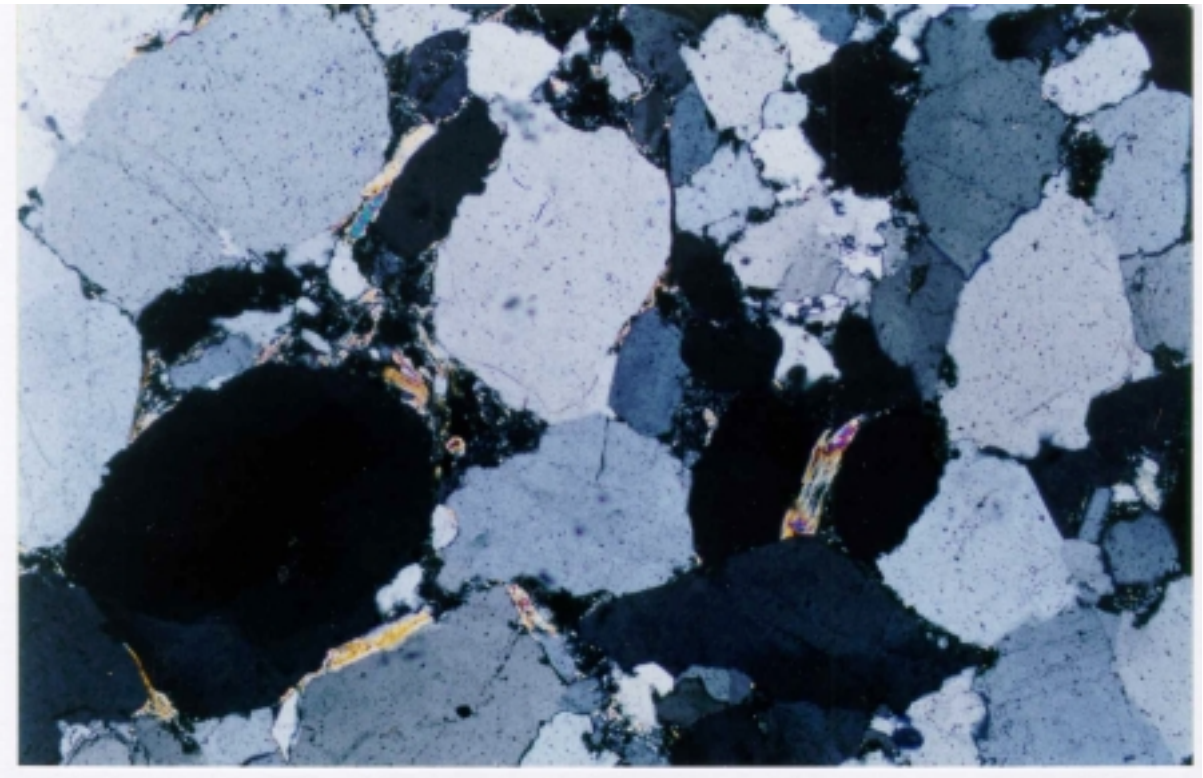


Fig 27, 28 **DA98B10729** 0.18 mm

TS. Xnic. Poorly sorted sandstone with relatively angular grains. Coloured micas more abundant in Fig. 28, minor detrital mica (coloured) also dark oxidised clays/chlorite intergranular. Some stylolitic grain boundaries.

DA98B10730

DA98B10730 **Bimodal quartz-rich medium to very coarse grained sandstone, extensively silicified to "ortho-quartzite". Local aggregates of clays ± limonite with quartz grains impressed into the clay during compaction and lithification.**

Field Note : *Quartzite. McKay Sandstone.*

This sandstone compares with the B10707-710 group, notably the nature of extensive quartz overgrowths, constituting extensive intergranular silicification. An exception is the incorporation of a patch of decussate 'clays'. In hand-specimen this is a pale quartz-rich sandstone, seen to enclose an irregular lens to 20 mm long that may be clay-rich. In thin section it is a bimodal quartz-rich sandstone with one grain size population 0.2 to 0.5mm and another 0.5 to 1.25 mm, representing fine to medium sand and coarse to very coarse sand, respectively. These grains are largely cemented by optically continuous overgrowths. Trace zircon about 0.1 mm in grainsize.

There are some clay to quartz-rich lithic grains among the finer-grained population. The large clay lenses referred to above are decussate to foliated clays, irregularly spotted and stained by limonite and these are moulded against the larger quartz grains, indicating plastic deformation during compaction and lithification of the sandstone.

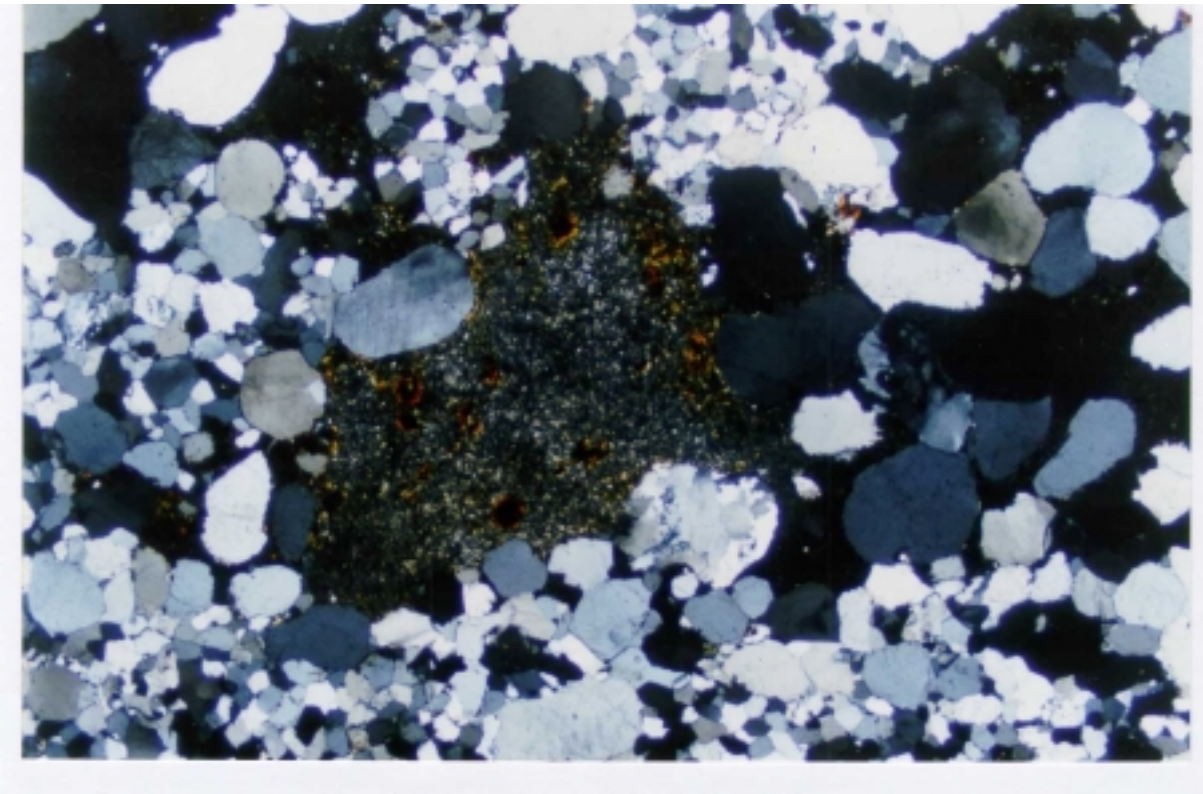


Fig 29 **DA98B10730** 0.45 mm

TS. Xnic. Bimodal sandstone incorporating a large patch of kaolin ± limonite centre of photo. The sand grains have been impressed into the clay during compaction.

DA98B10731

DA98B10731 **Original bedded quartz-rich sandstone, fine to medium grained, alternating with thinner beds of coarse grained sandstone. Minor lithics. Quartz overgrowths/ intergranular silicification fairly extensive but commonly poorly defined to form incipient orthoquartzite.**

Field Note : *Fine/medium quartz sandstone. McKay Sandstone.*

Macroscopically, beds in this sample are seen to be from 3 mm to over 40 mm thick, apparently of medium grained sandstone, with thinner beds of coarse grained sandstone.

In thin section the thicker beds are composed of loose packed original rounded detrital quartz grains with a maximum grainsize varying from 0.3 to 0.5 mm, between beds i.e. fine to medium grained, but locally larger quartz grains to 0.8 mm. Optically continuous quartz overgrowths in these layers, are mostly poorly defined.

The thinner beds are dominated by original rounded coarse single crystal quartz grains to 0.8 mm in diameter, (very coarse quartz sand), cemented by very well-defined optically continuous overgrowths, and intergranular silicification. In parts of these layers, smaller quartz grains have infiltrated between the larger grains. Small clay to quartz-rich lithic grains occur largely in the fine to medium grained sandstone, with rare leucoxene.

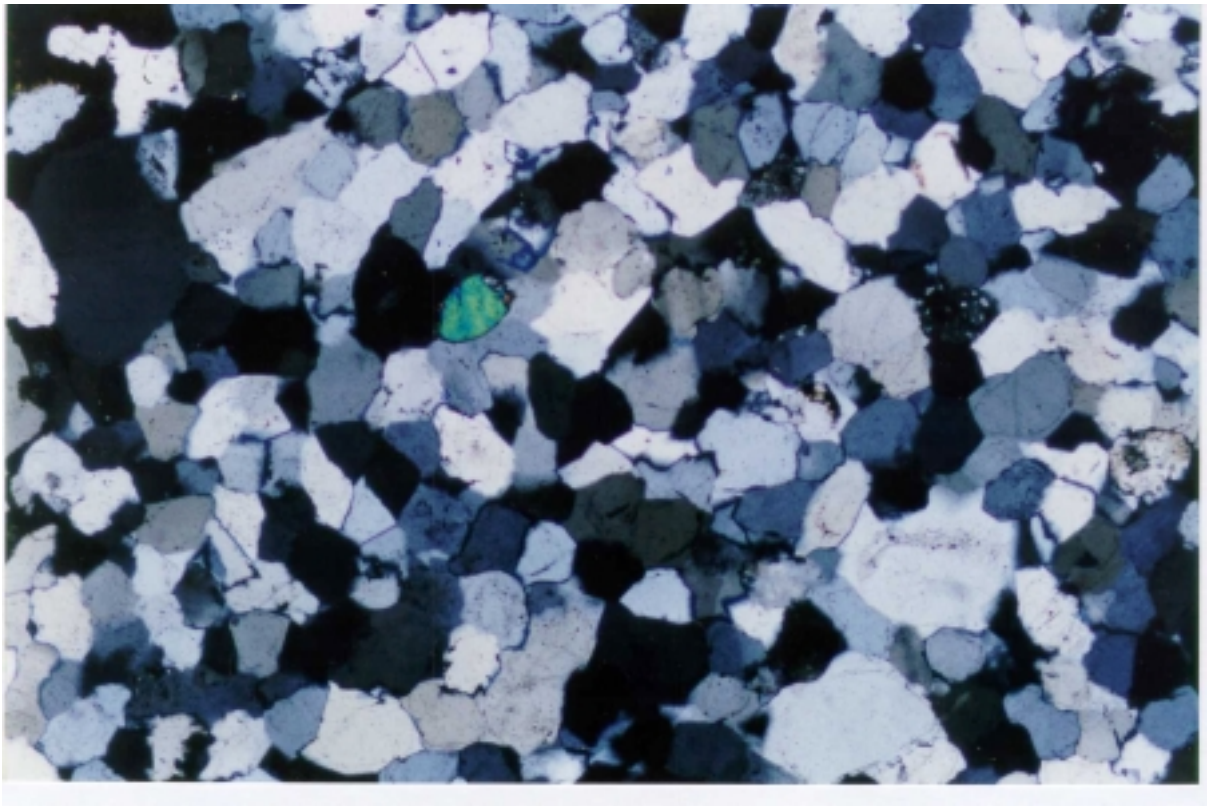


Fig 30 **DA98B10731** 0.18 mm

TS. Xnic. Sandstone, fine grained bed with original grains as relatively poorly defined cores to extensive siliceous overgrowths. A single grain of tourmaline is seen in this photo, with a green birefringence. [Quartz overgrowths are extremely well defined within intercalated, coarser grained sandstone].

DA98B10732

DA98B10732 **Massive poorly sorted fine to coarse quartz sand, with well rounded grains within an extensive intergranular cement of barite. Minor limonite and fans of unidentified minerals, also rare lithic grains and tourmaline.**

Field Note : *Felspathic impure sandstone. McKay Sandstone.*

In hand specimen, this seems to be a sandstone, but has abundant pale spots with minor to abundant interstitial reddish limonite-rich material.

The thin section shows a very loose packed detrital aggregate of very poorly sorted well rounded single crystal quartz grains from 0.1 to 1 mm in diameter, and would in a gross sense be classified as a coarse grained sandstone. Instead of optically continuous siliceous overgrowths, these quartz grains are enclosed in poikilitic grains of barite, continuous and occupying adjacent intergranular areas, for distances from 1 to 4 mm. This barite occupies up to 15-20% of the thin section area.

In some areas there are limonite-rich patches and elsewhere there are pinkish radiating unidentified small crystals, possibly a zeolite, in fans to 0.5 mm long. In addition to quartz, there are some clay to quartz-rich lithic grains and there is rare accessory tourmaline.

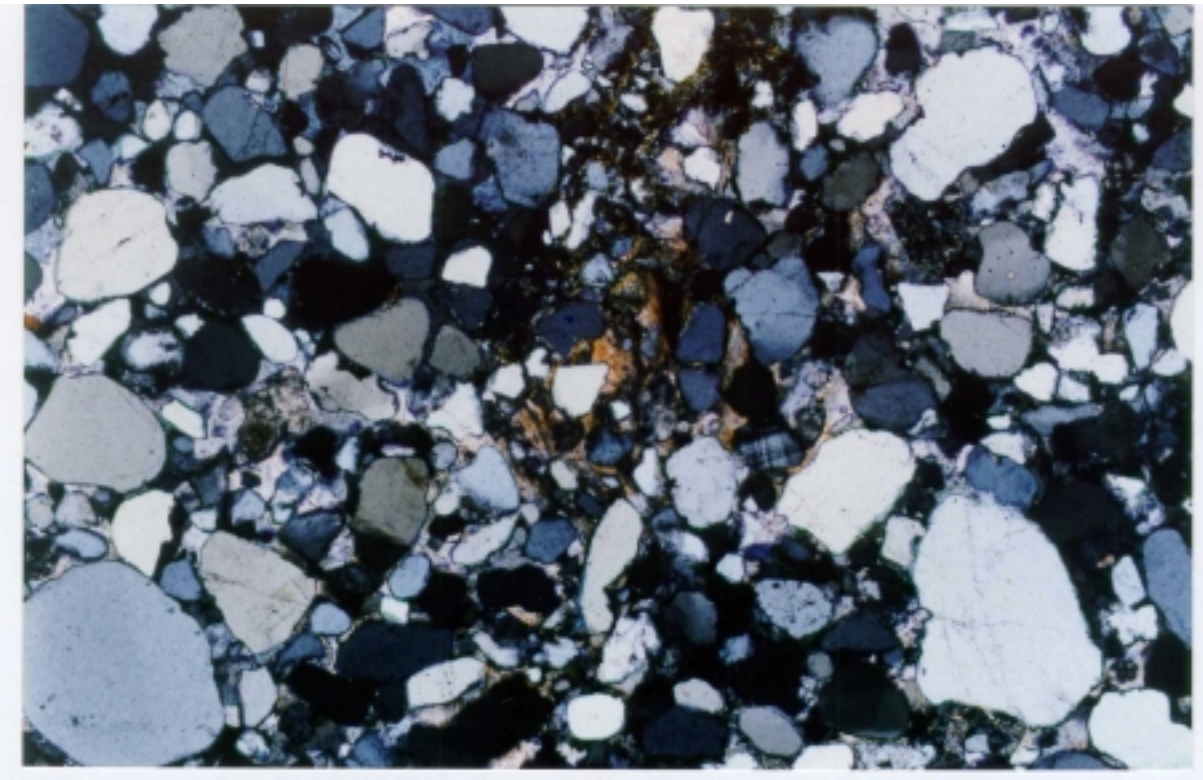


Fig 31 **DA98B10732** **0.18 mm**

TS. Xnic. Poorly sorted sandstone with a single grain of microcline, below and to the right of centre. The microcline and adjacent smaller quartz grains in the centre of the photo are enclosed in a brownish fibrous unidentified mineral. Barite occurs elsewhere (see Fig 32).

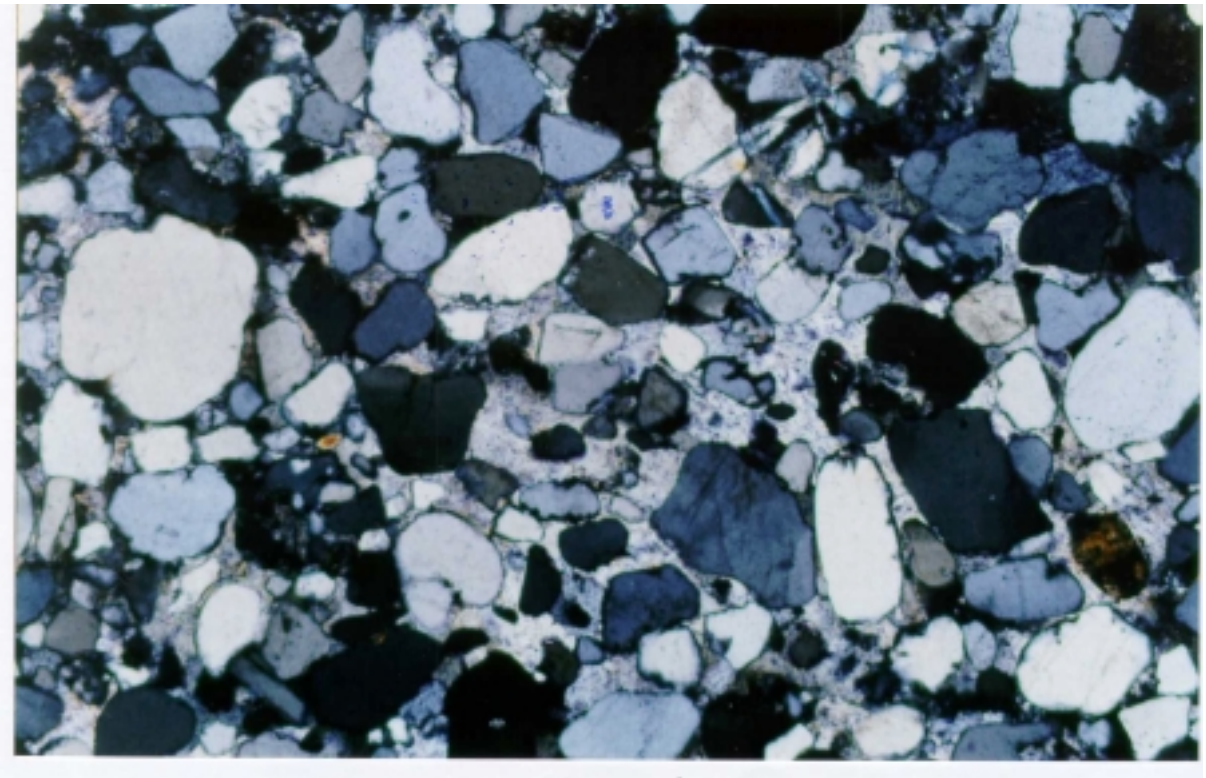


Fig 32 **DA98B10732** **0.18 mm**

TS. Xnic. Loose packed poorly sorted, rounded quartz grains within extensive intergranular cement of barite, (very pale whitish grey).

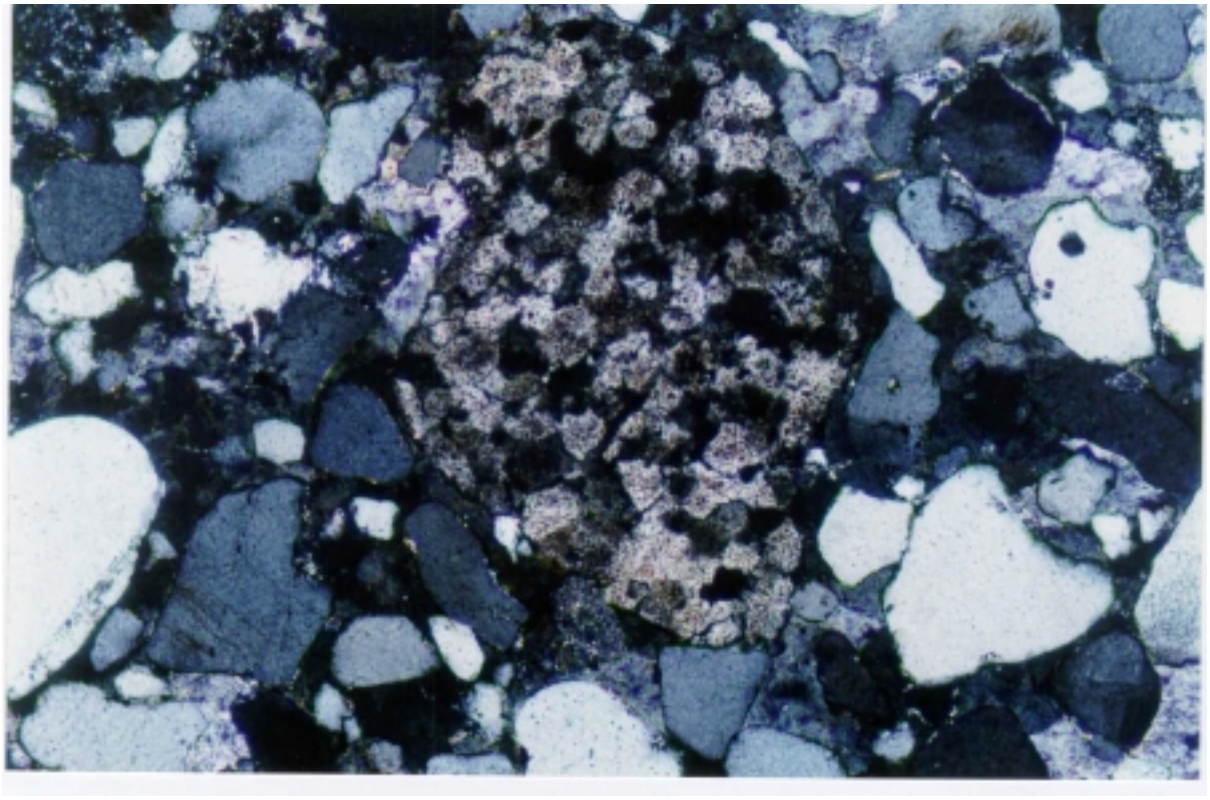


Fig 33 **DA98B10732** 0.09 mm

TS. Xnic. Polycrystalline lithic grain in the centre of this photo is similar in texture to some silicified acid volcanics. An area of barite cement can be seen in far SE corner.

DA98B10733

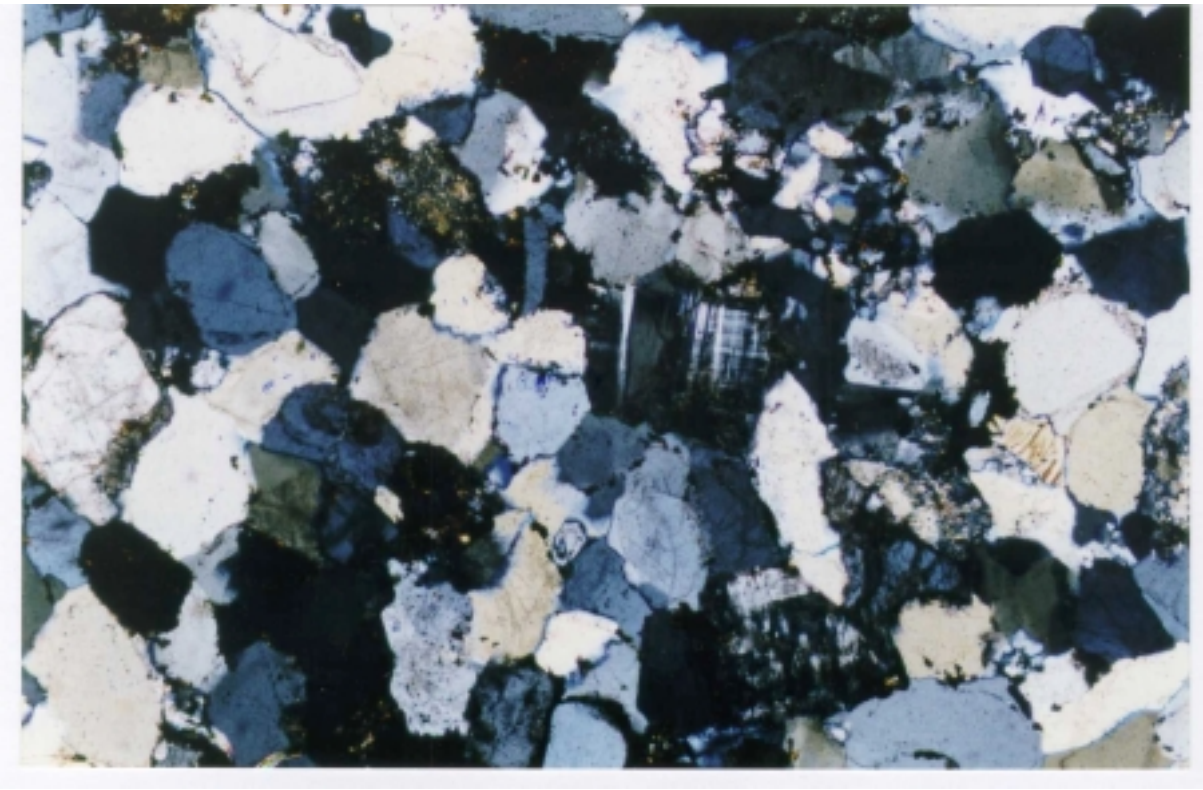
DA98B10733 **Mixed, quartzofeldspathic (and lithic) medium grained sandstone, with grains of orthoclase, microcline, rare granophyre and quartz-rich to sericite-rich lithic grains. Also limonite-clay spots and intergranular films of limonite. Most quartz grains have siliceous overgrowths.**

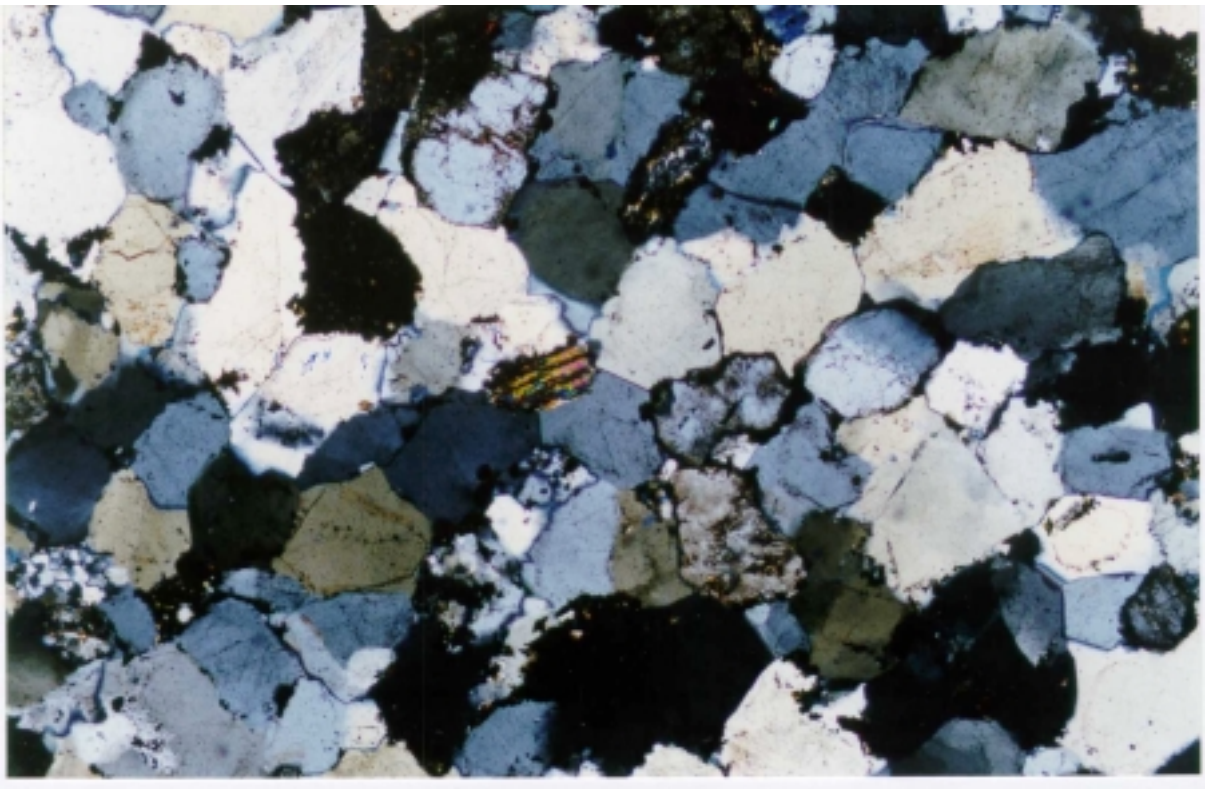
Field Note : *Fine felspathic sandstone. McKay Sandstone.*

In hand-specimen this is a massive pale pink sandstone with some limonite spotting. In thin section it is mostly a medium grained sandstone with:

- Quartz grains with well-defined original detrital grains as cores to optically continuous quartz overgrowths, mostly smaller than 0.5 mm. 60%
- Clear to clouded grains of alkali feldspar, varying from orthoclase to microcline, and rare composite grains with alkali feldspar and/or granophyre. 20-25%
- Polycrystalline grains, usually of quartz, with clays and/or limonite. 7-8%
- Detrital micas and sericite-rich lithic grains. <1%
- Interstitial limonite-clay aggregates. 5%

Intergranular films of limonite are common, resulting in a pervasive pink colour.





Figs 34, 35 **DA98B10733** **0.18 mm**

TS. Xnic. Two photos of quartzofeldspathic (lithic) sandstone. A grain of microcline is visible in the centre of Fig 34, with some smaller lithic grains. In Figure 35, the felspar seems to be orthoclase and is rimmed by limonite. A flake of detrital muscovite is seen in the centre of Fig. 35.

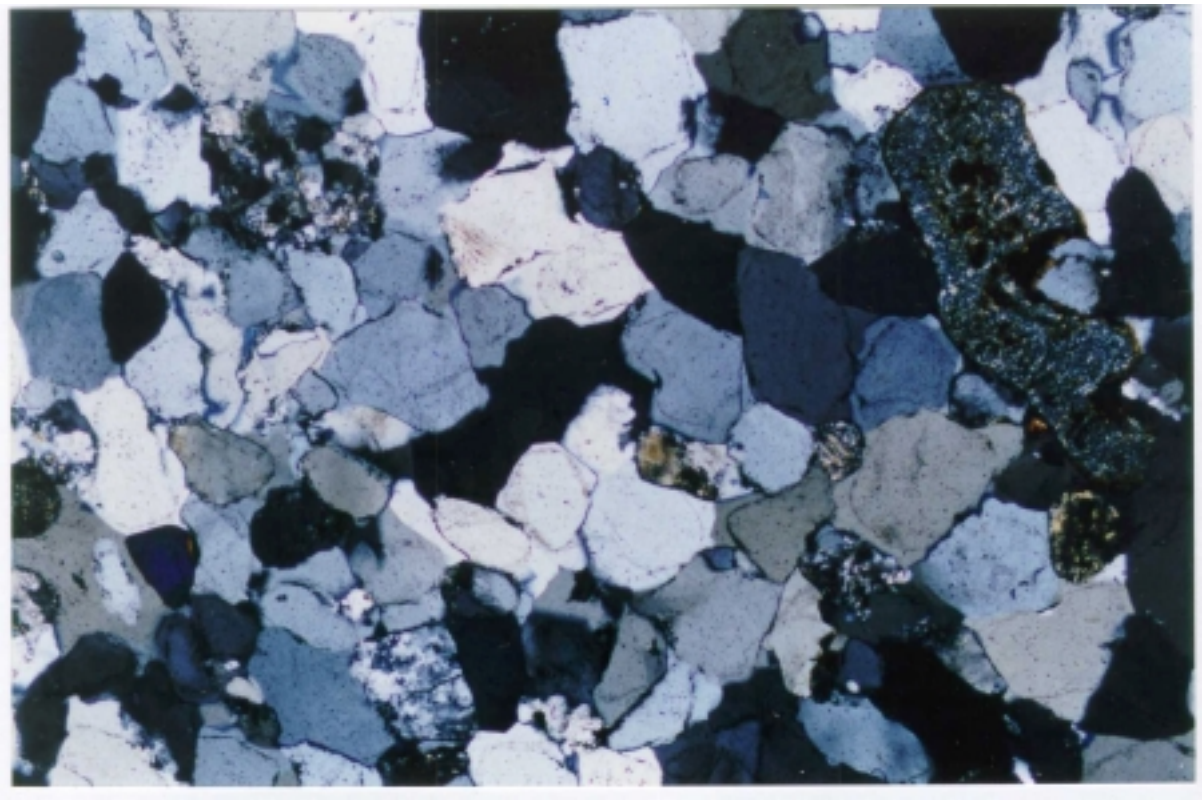
DA98B10734

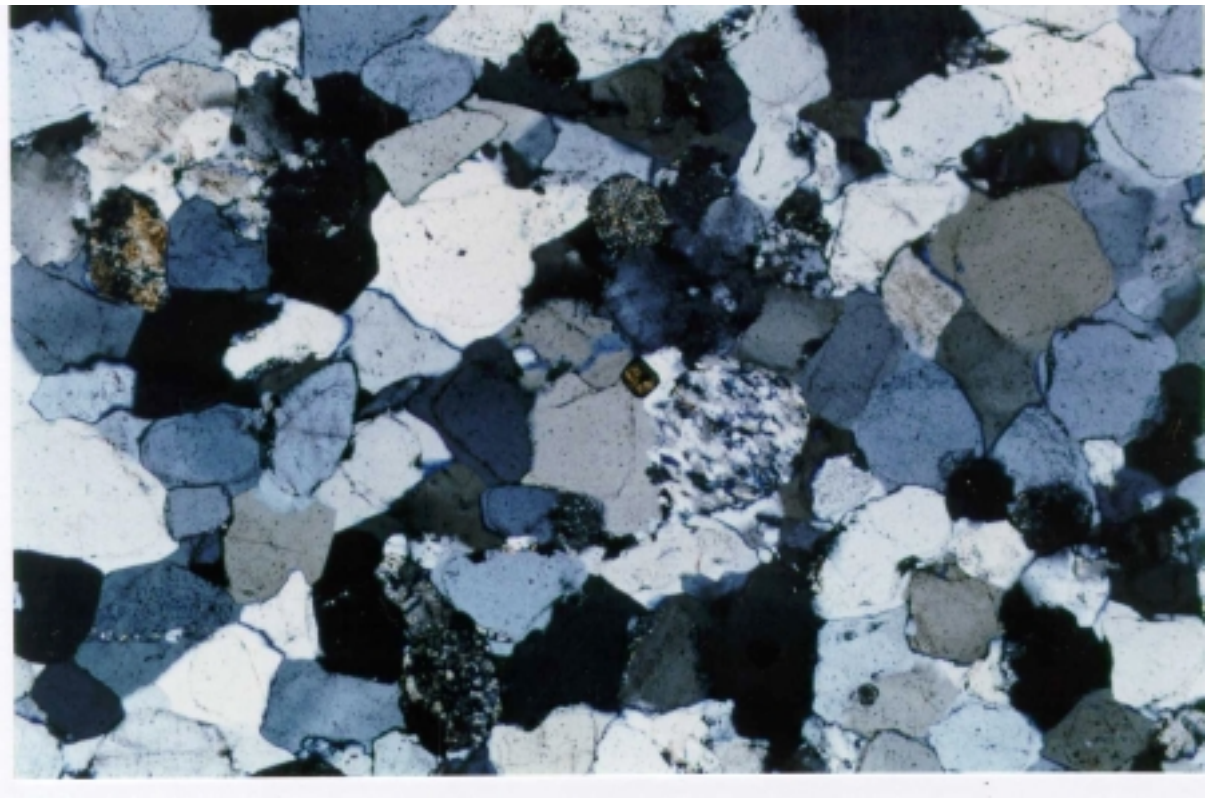
DA98B10734 **Quartz-rich coarse grained sandstone with minor lithic grains (quartz to clay to limonite-rich), accessory leucoxene and tourmaline. Extensive quartz overgrowths forming intergranular silicification, and conversion to orthoquartzite.**

Field Note : *Medium siliceous quartz sandstone. McKay Sandstone.*

In hand-specimen this is a relatively fine-grained quartz-rich sandstone with a pale reddish tinge. In thin section it is seen to be dominated by well-rounded single crystal quartz grains to 0.8 mm in diameter, with only rare grains over 1 mm, indicating a coarse grained sandstone.

Original intergranular porosity is now occupied by merging of extensive optically continuous quartz overgrowths on original, mostly rounded detrital quartz grains. This silicified the rock (producing what is essentially an orthoquartzite). Rounded lithic grains are randomly disposed to form 7-10% of the rock, and consist of variable concentrations of cryptocrystalline silica, clay and limonite. The main accessories are pale brown tourmaline and leucoxene after small opaque oxide grains.





Figs 36, 37 **DA98B10734** 0.18 mm

TS. Xnic. These photos highlight clay-rich (Fig 36 right hand side) to quartz-rich (Fig 37, centre) lithic grains. A small square zircon grain is seen in the centre of Fig 37, adjacent to a quartz-rich lithic grain. Also shown (mostly in Fig 36) are extensive optically continuous quartz overgrowths on original rounded quartz grains, producing an ortho-quartzite.

DA98C10735

DA98C10735 **(Micaceous) siltstone with variably minor to locally abundant extremely fine carbonate (calcite) interstitial, also numerous parallel veinlets of carbonate.**

Field Note : *Pink impure carbonate. McKay Sandstone.*

This sample is seen in hand specimen as an apparent, very fine-grained impure carbonate rock, with a ferruginous, pale orange to reddish colour and minor paler veinlets.

In thin section, at least 50% of the rock is seen to consist of a bedded fairly compact aggregate of siltsize quartz grains, average size about 0.04mm, together with minor fine detrital muscovite. Interstitial clays between these grains may form up to 10% of the rock, but the extensive cloudy iron-staining makes it extremely difficult to specifically resolve this.

Extremely fine interstitial carbonate, also clouded, forms variably from possibly 20% in some areas to over 60% in others. The several conformable pale veins seen in handspecimen are 1 to 3mm wide (thick) and consist of granular to sparry carbonate, also colloform microlayered, areas adjacent to these veins, commonly comprising subparallel carbonate stringers over a centimetre or so, are most enriched in the fine interstitial carbonate. These appear to represent mobilised probable inherent sedimentary carbonate, and related to the (silty) sedimentary limestone C20735. [Alternatively, is the matrix carbonate introduced, as more or less pervasive carbonate alteration, from an external source which also gives rise to the veins?]

Staining of this section offcut with Alizarin Red and Potassium Ferri-cyanide indicates that the carbonate is calcite (limestone).

DA98C20735

DA98C20735 **Massive to weakly bedded, diffusely micritic and weakly silty limestone incorporating irregular lenses containing silt-sized quartz and minor sericite.**

Field Note : *Pink impure carbonate.*

This sample consists essentially of massive, albeit weakly layered, diffusely micritic carbonate with minor poorly defined areas containing disseminated silt-sized quartz grains and some with more abundant limonite than in the bulk of the rock. Staining of the section offcut indicates that the carbonate is calcite, to suggest that the extensive fine carbonate matrix is inherently sedimentary limestone.

The vague layering reflects a weak bedding foliation, defined by microlayers of clear and clouded carbonate. There is also minor disseminated sericite with a foliation parallel to bedding, and two conjugate foliations, but this is visible only in areas from which the carbonate has been leached.