

MINERALOGICAL REPORT No. 8808
by Alan C. Purvis, PhD

February 13th, 2006

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YOUR REFERENCE : Order No. 04322

**MATERIAL &
IDENTIFICATION :** Outcrop and Core, NABARLEK
26 samples in all

WORK REQUESTED : Section preparation. Petrographic
description and report.

SAMPLES & SECTIONS : Returned to you with this report.

DIGITAL COPY : CD enclosed with hard copy of this
report.

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SUMMARY COMMENTS

The twenty six samples described from thin section in this report are from the Nabarlek project in the Northern Territory. These samples include sandstones, granule and pebble conglomerates, breccias, low-temperature hydrothermal quartz and basement samples (quartz \pm muscovite \pm biotite \pm feldspar schist and amphibolite), the schists being largely weathered but the amphibolite (core sample) with sericite as the main alteration. The samples are as listed.

Sample	Lithology	Clays etc	Oxides	Accessories
NA050001	Granule conglomerate	Sericite/muscovite	Hematite	
NA050002	Very coarse-grained sandstone	Sericite/muscovite	Limonite/hematite	
NA050003	Granule-bearing sandstone	Sericite-kaolinite	Limonite/hematite	
NA050005	Granule-bearing sandstone			
NA050006	Basalt	Sericite	Limonite/hematite	
NA050007	Breccia - sandstone fragments	Vein quartz	Limonite-clay	
NA050008	Coarse sandstone + laterite	Clays	Limonite/hematite	
NA050009	Laterite	Kaolinite?	Limonite/hematite	
NA050010	Granule-bearing sandstone	Kaolinite?	Limonite/hematite	
NA050011	Very coarse-grained sandstone	Kaolinite?	Limonite	Zircon, rutile
NA050013	Hydrothermal quartz	Sericite	Limonite	
NA050014	Schist or claystone?	Kaolinite?	Limonite	
NA050015	Quartz-muscovite-feldspar schist	Sericite/illite	Hematite	Tourmaline
NA050016	Coarse sandstone	Kaolinite?	Limonite	
NA050017	Pebble/granule conglomerate	Kaolinite?	Limonite	
NA050018	Breccia - sandstone fragments	Kaolinite \pm illite	Limonite	
NA050019	Laterite			
NA050020	Quartz-muscovite-biotite-feldspar schist	Sericite/illite	Hematite	
NA050021	Laterite	Kaolinite pm illite	Limonite	
NA050023	Very coarse-grained sandstone	Sericite/illite	Limonite	
NA050025	Quartz-feldspar-biotite schist	Kaolinite \pm illite	Limonite	
NA050026	Granitic porphyry	Sericite		Zircon, anatase
NA050027	Medium-coarse sandstone	Sericite/muscovite	Limonite	
NA050031	Pebble/granule conglomerate	Sericite	Limonite	

INDIVIDUAL DESCRIPTIONS

SAMPLE	NA050001
ROCK NAME (from TS)	Quartz-rich granule conglomerate or gritty very coarse-grained sandstone with interstitial muscovite/sericite \pm quartz, rare hematite and traces of biotite and apatite (within quartz).
HAND SPECIMEN	Pale competent quartz-rich very coarse-grained sandstone

Field Note: *Sandstone: kaolinite > muscovite*

PETROGRAPHY:

A visual estimate of the modal mineral abundances:

Mineral	Abundance	Origin/location
Single-crystal quartz grains	Dominant	
Polycrystalline quartz -coarse- grained	Very minor	Detrital \pm secondary quartz
Fine- grained polycrystalline quartz	Very minor	
Sericite/muscovite	Very minor	Interstitial (\pm quartz)
Hematite	Trace	Interstitial
Biotite	Rare	Enclosed in quartz
Apatite	rare	Enclosed in quartz

Single-crystal quartz grains to 3mm in diameter indicate quartz-rich granule conglomerate, although there are no well defined cores or overgrowths and some of the grain boundaries may be stylolitic. Rare coarse-grained polycrystalline quartz clasts are disseminated as well as sparse clasts composed of quartz-rich micromosaics. Rare single-crystal quartz grains have inclusions of biotite or apatite and seem to have a metasediment or granitoid origin. Interstitial areas have trellis-like arrangements of fine muscovite or sericite flakes with interstitial porosity or intergrown with fine-grained probably secondary quartz. No kaolinite was seen in the area of the thin section, but rare grains of hematite occur in interstitial sites.

SAMPLE NA050002

ROCK NAME (from TS) Partly hematite-rich very coarse-grained quartz-rich sandstone with stylolitic grain boundaries and interstitial sericite \pm hematite.

HAND SPECIMEN Friable, partly hematite-rich coarse-grained sandstone, bleached adjacent to joints

Field Note: *Sandstone, kaolinite > muscovite*

PETROGRAPHY:

A visual estimate of the modal mineral abundances:

Mineral	Abundance	Origin/location
Single-crystal quartz grains	Dominant	Detrital
Polycrystalline quartz	Very minor	Detrital
Hematite	Very minor	Interstitial
Muscovite/sericite	Very minor	Interstitial

The single-crystal quartz grains in this sample are poorly sorted and range from 0.25mm to 2mm in diameter (medium to very coarse-grained sandstone), with abundant stylolitic grain boundaries commonly lined by limonite-stained phyllosilicate flakes. Polycrystalline quartz is rare, with coarse and fine-grained clasts as in the previous sample. The phyllosilicate is not identifiable in much of the rock, because of hematite staining, but only sericite (or fine-grained muscovite?) is visible in hematite-poor zones adjacent to fractures. If kaolinite is present it must be in hematite-rich areas.

SAMPLE NA050003

ROCK NAME (from TS) Friable granule-bearing coarse to very coarse-grained quartz-rich sandstone with limonite-rich areas, interstitial sericite \pm quartz or limonite-stained clays and a fractures with plant material.

HAND SPECIMEN Friable quartz-rich very coarse-grained sandstone with possible granules, limonite-rich areas and open microfissures

Field Note: *Sandstone: kaolinite > muscovite*

PETROGRAPHY:

A visual estimate of the modal mineral abundances:

Mineral	Abundance	Origin/location
Single-crystal quartz grains	Dominant	Detrital
Polycrystalline quartz grains	Very minor	
Granules	Very minor	
Sericite/muscovite	Minor	Interstitial
Limonite	Locally minor	
Limonite-stained clay (sericite \pm kaolinite?)	Local, minor	
Plant material (roots?)	Very minor	In fractures

Most of the single-crystal quartz grains in this thin section are less than 1mm in diameter (coarse sand) but there are less abundant grains to 2mm (very coarse sand) and sparse granules to 3mm, one of which is polycrystalline quartz. Polycrystalline quartz also occurs among the smaller grains, but is not abundant. In one area the grains are separated by abundant limonite and seem to be more rounded than those elsewhere in the thin section, where there is little or no limonite. In the other areas there are interstitial patches of sericite, mostly in a trellis arrangement, with sparse porosity or, more rarely, intergrown with fine-grained quartz. Sparse stylolitic grain boundaries occur and there seems to be trace carbonate, but this is highly clouded. Some interstitial areas have limonite-stained contorted phyllosilicate aggregates that may contain some kaolinite as well as or instead of sericite. The fracture visible in the hand specimen has small patches of plant material, probably the roots of a plant that has grown in the sandstone.

SAMPLE NA50005

ROCK NAME (from TS) Granule-bearing very coarse-grained sandstone with stylolitic grain boundaries, partly lined by limonite/hematite and very minor muscovite, mostly as inclusions in quartz.

HAND SPECIMEN Compact very coarse-grained sandstone with granules: one half has interstitial hematite/limonite and one half has little or no limonite

Field Note: *Sandstone: kaolinite*

PETROGRAPHY:

A visual estimate of the modal mineral abundances:

Mineral/component	Abundance	Origin/location
Single-crystal quartz grains	Dominant	Detrital medium to very
Polycrystalline vein and metamorphic quartz	Common	coarse sand and pebbles
Muscovite	Very minor	Mostly enclosed in quartz
Limonite/hematite (\pm clay?)	Minor	Interstitial

There are several granules to 3mm in diameter, composed of polycrystalline vein and metamorphic quartz with rare single-crystal quartz granules, but most of the rock is composed of medium to very coarse-grained sandstone with common stylolitic grain boundaries, lined with limonite in half of the thin section but without limonite or clay in the pale, apparently leached half. Muscovite is obviously present (but not detected by TSA), mostly as inclusions in quartz, but is not abundant and the largest crystal is 0.3mm long and 0.2mm wide. However, no obvious kaolinite was seen.

SAMPLE	NA050006
ROCK NAME (from TS)	Sericite-limonite/hematite-altered plagioclase-porphyritic basalt with crystalline hematite derived from opaque oxide.
HAND SPECIMEN	Red oxidised material with some pale patches

Field Note: *Basalt: muscovite*

PETROGRAPHY:

A visual estimate of the modal mineral abundances:

Mineral	Abundance	Origin/location
Sericite in large aggregates	Common	Ex-plagioclase phenocrysts
Sericite in smaller aggregates	Abundant	Ex-plagioclase laths
Limonite/earthy hematite	Abundant	Interstitial
Crystalline hematite \pm leucoxene	minor	Ex-opaque oxide

This sample has scattered patches of decussate sericite, usually with minor limonite or earthy hematite, derived from plagioclase phenocrysts to 6mm long, as well as abundant sericitised narrow plagioclase laths in altered groundmass material. Interstitial material is mostly limonite or earthy hematite, but may also include sericite highly clouded by oxide, and disseminated crystalline hematite (\pm leucoxene?) has replaced disseminated opaque oxide. A large irregular lens is present, rich in probable hematite, and this may represent a former mafic phenocryst, but this is not entirely certain.

SAMPLE	NA050007
ROCK NAME (from TS)	Breccia of quartz-rich coarse-grained sandstone with interstitial granular to prismatic vein quartz rich in fluid inclusions and euhedral against vugs. Minor limonite-stained clay (kaolinite?) occurs in interstitial porosity and in vugs.
HAND SPECIME	Sandstone, possibly brecciated and vein-quartz with large vugs.

Field Note: *Sandstone: kaolinite*

PETROGRAPHY:

A visual estimate of the modal mineral abundances:

Mineral/component	Abundance	Origin/location
Single-crystal quartz grains, rounded or with stylolitic grain boundaries, and rare polycrystalline quartz	Major	Detrital, in sandstone blocks
Mostly granular to prismatic quartz with abundant fluid inclusions	Major	In irregular veins
Limonite-stained cryptocrystalline, virtually isotropic clay (kaolinite?)	Very minor	Interstitial and in vugs

Unsorted but poorly defined blocks, purplish grey in hand specimen, are seen in thin section to represent sandstone with mostly rounded single-crystal quartz grains to 1mm in diameter (coarse-grained sandstone) and less abundant polycrystalline quartz grains. There are abundant stylolitic grain boundaries but sparse interstitial patches of pale brown cryptocrystalline clay, possibly kaolinite. Zones within and between the sandstone blocks are pale grey to cream in hand specimen, and seem to represent vein-quartz. Some zones, crosscutting sandstone, are similar to the sandstone in texture, with sparry or granular quartz, but have abundant trails of fluid inclusions. Other areas have mostly much coarser-grained granular to prismatic quartz with fluid inclusions throughout or in zones, especially in better defined crystals, which are as much as 5mm long and have pyramidal terminations against irregular vugs to 4 or 5mm long. These vugs are partly filled by pale brown clay, similar to that in interstitial areas, and also possibly kaolinite.

SAMPLE	NA050008
ROCK NAME (from TS)	Lateritised and possibly fragmented coarse-grained sandstone, with limonite \pm clay in oolites, and large leached cavities.
HAND SPECIMEN	Porous limonite-rich material with ooids or pisolites and large cavities

Field Note: *Basalt: diaspora*

PETROGRAPHY:

A visual estimate of the modal mineral abundances:

Mineral	Abundance	Origin/location
Single-crystal quartz grains	Major	Detrital, partly in fragments of sandstone
Limonite/hematite	Major	Interstitial and in pisolites
Clays and indeterminate material	Abundant	Mostly in pisolites
Cavities	common	Leached voids

This sample has probable fragments to 15mm or more in length composed largely of rounded single-crystal quartz grains to 1mm long (coarse-grained sandstone) with mostly minor interstitial limonite or earthy hematite. These pass into areas with less abundant, more angular single-crystal quartz grains, partly etched and/or microfissured, with limonite in the fissures, and much more abundant limonite (\pm clay?). Within these areas there are well-developed oolites or pisolites, locally more than 10mm long, with or without inclusions of quartz or patches of clay (kaolinite?) in limonite \pm clay. These bodies have concentric zoning with limonite-rich and limonite-poor zones, but no obvious diaspora could be confirmed in thin section. This may be due to intense limonite staining, however. Cavities in the hand specimen are as much as 15mm long and seem to develop on the edges of possible sandstone fragments. This sample seems to represent lateritised and possibly fragmented coarse-grained sandstone with limonite \pm clay in oolites and large cavities.

SAMPLE NA050009

ROCK NAME (from TS) Heterogeneous laterite with porous zones rich in small pisolites and large irregular nodules plus cavities: largely limonite or earthy hematite and possible kaolinite with sparse nodules of crystalline hematite.

HAND SPECIMEN Heterogeneous hematite-rich rock with earthy hematite \pm clay and sparse nodules of crystalline hematite: possible laterite?

Field Note: *Basalt: kaolinite*

PETROGRAPHY:

A visual estimate of the modal mineral abundances:

Mineral	Abundance	Origin/location
Limonite or earthy hematite	Major	In small pisolites and larger
Clay (kaolinite?)	Major	heterogeneous masses
Crystalline hematite	Minor	In sparse nodules
Voids and porosity	Common	Interstitial to pisolites and more irregular

Parts of this sample are composed of small concentrically zoned pisolites or oolites to 0.5mm in diameter, with zones variously rich in limonite or hematite and yellow, iron-stained clay. These zones have an abundant fine-scale porosity. There are also large, irregular nodules, apparently more than 15mm long, composed of limonite/hematite and clay in irregular arrangements. Sparse nodules occur that seem to be composed of crystalline hematite and there are large voids, from 1-7mm long, between the larger nodules and within pisolitic areas. This sample is heterogeneous nodular laterite and has no residual textures.

SAMPLE	NA050010
ROCK NAME (from TS)	Granule-bearing very coarse-grained sandstone with interstitial limonite/hematite and possible kaolinite.
HAND SPECIMEN	Coherent quartz-rich sandstone with spots of hematite

Field Note: *Sandstone: kaolinite*

PETROGRAPHY:

A visual estimate of the modal mineral abundances:

Mineral	Abundance	Origin/location
Single-crystal quartz grains	Major	Detrital
Polycrystalline quartz	Common	Detrital, partly as granules
Limonite/hematite	Very minor	Interstitial
Kaolinite?	Very minor	Interstitial

There are disseminated granules, 2-4mm in diameter, of coarse-grained polycrystalline quartz in this sample as well as abundant single-crystal and polycrystalline quartz grains from 0.25mm to 2mm in diameter, including fine-grained and coarse-grained polycrystalline quartz (metamorphic and vein-quartz). There are no optically continuous overgrowths and there are some stylolitic grain boundaries, with irregular interstitial areas filled with limonite or earthy hematite and pale, almost isotropic clay, probably kaolinite. The interstitial areas seem to have been modified by weathering, however.

SAMPLE NA050011

ROCK NAME (from TS) Quartz-rich very coarse-grained sandstone with kaolinite as well-formed crystals and minor limonite.

HAND SPECIMEN Pale quartz-rich sandstone with patches containing limonite

Field Note: *Sandstone: kaolinite*

PETROGRAPHY:

A visual estimate of the modal mineral abundances:

Mineral	Abundance	Origin/location
Single-crystal quartz grains	Dominant	Detrital
Kaolinite	Very minor	Authigenic, interstitial
Limonite	Very minor	Weathering
Biotite, muscovite, rutile, apatite and zircon	Trace	Inclusions in quartz and accessories

Most of the single-crystal quartz grains in this sample are less than 1.5mm in diameter (very coarse-grained sandstone) without obvious optically continuous overgrowths and commonly closely appressed or with stylolitic grain boundaries. Inclusions of biotite, muscovite, rutile, apatite and zircon occur within quartz grains, with rare rutile in interstitial areas. Interstitial areas are not abundant, but contain decussate kaolinite that is present as well-formed crystals. In other areas, where the quartz grains are tightly appressed, there are kaolinite crystals to 0.3mm long cutting across the grain boundaries. Limonite is present in some of the kaolinite-filled interstitial areas.

SAMPLE NA050013

ROCK NAME (from TS) Heterogeneous hydrothermal quartz with mostly clouded cryptocrystalline to granular to prismatic quartz, largely limonite-stained sericite and later microfissures with clear quartz \pm sericite.

HAND SPECIMEN Quartz-rich, hematite-stained rock with irregular quartz vein

Field Note: *Quartz-mica schist and quartz breccia: illite > kaolinite*

PETROGRAPHY:

A visual estimate of the modal mineral abundances:

Mineral	Abundance	Origin/location
Cherty fine-grained quartz	Major	Hydrothermal matrix
Microsparry, sparry and granular to prismatic quartz	Abundant	Fragments, lenses and veins
Sericite with minor limonite	Common	Mostly hydrothermal
Clear quartz \pm sericite	Very minor	Late microfissures

There is no schistosity in this thin section, which has an abundant matrix of microcrystalline, cherty quartz with irregularly disseminated, largely limonite-stained sericite or illite in most areas, but with vein-like cryptocrystalline lenses, locally over 10mm long, without sericite or limonite but cut and offset by narrow veins with quartz, sericite and limonite. Lenses and possible fragments of coarser sparry quartz are abundant as well as complex networks of veins with sparry and granular to prismatic quartz, with blocky or elongate quartz crystals to 1.5mm long. Interstitial sericite, usually limonite-stained, and small patches of coarser-grained muscovite, occur interstitially in many of these veins, but other areas lack sericite. Small patches of dense limonite occur rarely, but do not seem to represent former sulphide. No kaolinite was seen, however.

Most of the quartz in this thin section is clouded with fluid inclusions, but late microfissures contain clear quartz, with sericite in one of these fissures.

SAMPLE	NA050014
ROCK NAME (from TS)	Clay-rich weathered sediment or metasediment with layers rich in fine-grained quartz and disrupted quartz veins. The clay seems to be mostly kaolinite (or halloysite?) with minor illite.
HAND SPECIMEN	Pale pinkish folded fine-grained lithology with asymmetrical folds

Field Note: *Siltstone: Halloysite > Fe-Mg chlorite*

PETROGRAPHY:

A visual estimate of the modal mineral abundances:

Mineral	Abundance	Origin/location
Clays (mostly kaolinite?)	Dominant	Matrix material
Quartz, disseminated	Minor	Detrital?
Quartz, in disrupted veins	Minor	Hydrothermal
Limonite	Minor	Weathering
Illite?	Very minor	Adjacent to veins

Most of this sample is composed of largely foliated microcrystalline clays with the foliation emphasized by lamellae of limonite parallel to the foliation. Some layers in the clay-rich sediment have disseminated quartz to 0.2mm in diameter, possibly modified by metamorphism, but other quartz occurs as separate small blocks along disrupted irregular, folded quartz veins to 2mm wide. Patches of possible illite occur as rims on, and interstitial to fragments of vein-quartz, with less abundant illite in lamellae parallel to the foliation. The clay defining the foliation has a diffuse limonite clouding but seems to be mostly kaolinite, with chlorite unable to be identified in thin section. This sample may represent weathered schistose metasediment but the original mineralogy is uncertain. It seems to have been originally claystone and sandy or silty claystone.

SAMPLE NA050015

ROCK NAME (from TS) Crenulated quartz-muscovite schist (pelitic) with sericite apparently derived from feldspar and fibrolitic sillimanite, rare tourmaline and minor hematite on fractures and grain boundaries.

HAND SPECIMEN Partly crenulated muscovite-rich schist with quartz-rich lenses and minor hematite

Field Note: *Quartz-mica-hematite pelite: illite*

PETROGRAPHY:

A visual estimate of the modal mineral abundances:

Mineral	Abundance	Origin/location
Muscovite	Dominant	Metamorphic, schistose
Quartz	Common	Metamorphic
Sericite/illite	Minor	Ex-feldspar/sillimanite
Hematite	Minor	Marginal to muscovite
Tourmaline	Trace	Metamorphic

Coarse schistose muscovite dominates this sample and defines a partly kinked schistosity with flakes 0.5mm to 1.5mm long. Lenses of recrystallised quartz are also abundant, mostly parallel to the foliation, with quartz to 2mm in grainsize. Sericite, with or without veins of earthy hematite, occurs as blocky masses, apparently derived from feldspar, and as foliated lenses more similar to sericite derived from fibrolitic sillimanite. Hematite is present along fractures and muscovite grain boundaries but seems to be supergene. Rare tourmaline was noted, as seen in many pelitic schists.

SAMPLE NA050016
ROCK NAME (from TS) Quartz-rich coarse-grained sandstone with limonite and kaolinite.
HAND SPECIMEN Quartz-rich competent sandstone with limonite spots

Field Note: *Sandstone: kaolinite*

PETROGRAPHY:

A visual estimate of the modal mineral abundances:

Mineral	Abundance	Origin/location
Single-crystal quartz grains	Dominant	Detrital
Limonite	Very minor	Interstitial, weathering
Kaolinite	Very minor	Interstitial

This sample is dominated by single-crystal quartz grains to 2 in diameter (very coarse-grained sandstone) and abundant planar or stylolitic grain boundaries. Polycrystalline quartz is very minor and rarely more than 2mm in grainsize but there are interstitial areas with massive limonite or limonite-stained microcrystalline kaolinite, mostly decussate in texture.

SAMPLE	NA050017
ROCK NAME (from TS)	Pebble and granule-bearing quartz-rich conglomerate with limonite and kaolinite as well as voids.
HAND SPECIMEN	Partly leached quartz-rich very coarse-grained sandstone with clay patches and irregularly disseminated limonite

Field Note: *Sandstone breccia: Kaolinite > ankerite*

PETROGRAPHY:

A visual estimate of the modal mineral abundances:

Mineral	Abundance	Origin/location
Single-crystal quartz grains	Major	Detrital
Polycrystalline quartz	Abundant	Mostly granules and pebbles
Limonite	Common	Interstitial, weathering
Kaolinite	Common	Interstitial
Voids	minor	Leached

This sample has single-crystal quartz grains from coarse sand to granule size (to 4mm in diameter) as well as mostly granules and pebbles (to 6mm long) of fine-grained and coarse-grained polycrystalline quartz (probably vein and metamorphic quartz). A few single-crystal quartz grains have optically continuous overgrowths, but there are irregular disseminated interstitial patches, from 0.2mm to 4mm long, varying from limonite-rich to clay-rich. The clay is clouded with limonite and is mostly colloform and poorly crystallised but may be kaolinite as indicated by the TSA data, rather than halloysite, for example. However no carbonate can be seen within the area of the thin section. This is a fine-grained conglomerate with limonite and kaolinite as well as voids to 5mm in diameter formed by leaching.

SAMPLE NA050018

ROCK NAME (from TS) Breccia of quartz-rich granule-bearing very coarse-grained sandstone with abundant limonite/hematite possibly obscuring any clay (e.g. kaolinite).

HAND SPECIMEN Limonitised conglomerate or sandstone breccia

Field Note: *Sandstone: kaolinite [sandstone breccia?]*

PETROGRAPHY:

A visual estimate of the modal mineral abundances:

Mineral	Abundance	Origin/location
Single-crystal quartz grains	Major	Detrital material, possibly
Polycrystalline quartz	Abundant	brecciated
Limonite (\pm kaolinite?)	Major	Interstitial
Voids	minor	Leached

This sample has areas with separate quartz grains (single crystal or polycrystalline) to 4mm in diameter (very coarse sand and granules) set in partly porous massive limonite or earthy hematite, and blocky aggregates of quartz-rich granule-bearing very coarse-grained sandstone with less abundant interstitial limonite. The sandstone masses have some well defined margins but on other margins seem to progress into more and more disaggregated areas with more and more abundant interstitial limonite (\pm voids). These eventually pass into limonite-rich areas with isolated single-crystal and polycrystalline quartz grains. Because of the limonite flooding, no clays are visible, but this, rather than NA050017, may be a sandstone breccia.

SAMPLE	NA050019
ROCK NAME (from TS)	Porous limonite (laterite?) with zones containing quartz fragments
HAND SPECIMEN	Massive, porous limonite with quartz grains and fragments

Field Note: *Sandstone: aspectral*

PETROGRAPHY:

A visual estimate of the modal mineral abundances:

Mineral	Abundance	Origin/location
Limonite	Major	Supergene
Pores/vugs	Major	Leached?
Mostly single-crystal quartz grains	minor	Fragments

Most of this sample is weakly laminated brown limonite with roughly parallel pores and voids or vugs from 0.1mm to 5mm long. At one end of the thin section there are partly etched quartz grains to 3mm in diameter and the hand specimen has a fragment 10mm long. This sample is largely supergene in origin with some quartz apparently derived from granule-bearing sandstone or fine conglomerate.

SAMPLE NA050020

ROCK NAME (from TS) Weathered, altered quartz- muscovite-biotite- feldspar schist with sericite and hematite derived from feldspar and biotite and in fractures.

HAND SPECIMEN Laminated quartz- muscovite schist \pm biotite (oxidised)

Field Note: *Quartz-mica semipelite: illite > Mg chlorite*

PETROGRAPHY:

A visual estimate of the modal mineral abundances:

Mineral	Abundance	Origin/location
Quartz	Major	Metamorphic
Muscovite	Major	Metamorphic, deformed
Sericite	Abundant	Ex-plagioclase, in fractures
Hematite-sericite (\pm leucoxene?)	Abundant	Ex-biotite
Hematite	Common	In fractures

This sample has lamellae from 0.5mm to 2mm wide that are variously rich in quartz, sericitised plagioclase, sericite to hematite-rich altered schistose biotite and coarse-grained muscovite. The quartz is partly blocky and partly as grains to 3mm long parallel to the layering, with sericitised granular feldspar and sericite along fractures in the quartz. The biotite seems to have been mostly schistose, to 2mm grainsize, but some flakes have been shredded and infilled with sericite. The muscovite flakes, to 4mm long, are physically elongate parallel to the layering but their cleavage planes are largely oblique to, or almost normal to the layering. Those flakes with oblique cleavage planes are more deformed than those with their cleavage normal to the layering. There are also hematite lamellae on quartz and muscovite grain boundaries and in crosscutting fractures, locally with sericite. No chlorite is evident within the area of this thin section, however.

SAMPLE	NA050021
ROCK NAME (from TS)	Porous sandy limonite (laterite?) with sparse clay (kaolinite \pm illite?)
HAND SPECIMEN	Massive, weakly porous limonite with sparse quartz grains

Field Note: *Sandstone: aspectral*

PETROGRAPHY:

A visual estimate of the modal mineral abundances:

Mineral	Abundance	Origin/location
Limonite	Dominant	Supergene
Voids	Common	Leached or clay-filled
Quartz	Locally common	Fragments
Clay (kaolinite \pm illite?)	Minor	In voids

This sample is similar to NA050019 but has smaller, less elongate voids partly filled by fine-grained decussate clay (possibly kaolinite \pm illite) as well as zones containing etched and microfissured single-crystal quartz grains to 1.5mm in diameter. The voids seem to have a roughly parallel arrangement, but this sample seems to represent sandy porous laterite.

SAMPLE NA050023

ROCK NAME (from TS) Coarse to very coarse-grained sandstone with zones containing minor to abundant interstitial limonite and/or sericite/illite.

HAND SPECIMEN Mostly coherent sandstone with a zone rich in limonite

Field Note: *Sandstone: Illite*

PETROGRAPHY:

A visual estimate of the modal mineral abundances:

Mineral	Abundance	Origin/location
Single-crystal quartz grains	Dominant	Detrital
Limonite	Minor	Interstitial, supergene
Clay (illite?)	Minor	Interstitial

Most of the quartz in this thin section is less than 1mm in grainsize (coarse sand) but there are sparse larger grains to 2mm in diameter (very coarse sand). Four different textures are seen. In a few areas there are optically continuous overgrowths, but in other areas there are stylolitic grain boundaries with little or no interstitial material or with films of limonite and/or sericite/illite. There are also large zones with subrounded single-crystal quartz grains and abundant interstitial material varying from limonite-rich to sericite/illite-rich. This interstitial material makes up possibly 5-15% of areas where it is abundant

SAMPLE NA050025
ROCK NAME (from TS) Weathered laminated quartz-feldspar-biotite schist with limonite and clays (sericite and kaolinite?)
HAND SPECIMEN Weathered laminated schist (metasediment)

Field Note: *Siltstone (kaolinite > muscovite)*

PETROGRAPHY:

A visual estimate of the modal mineral abundances:

Mineral	Abundance	Origin/location
Limonite ± leucoxene	Abundant	Ex-biotite, feldspar
Clays (illite/sericite and kaolinite?)	Abundant	Ex-feldspar, biotite
Quartz	Minor	Metamorphic

This sample is totally weathered and altered but has fine-grained granular quartz disseminated and in diffuse layers to 2mm wide alternating with bands to 1mm wide rich in mostly lamellar limonite ± clay, apparently derived from schistose biotite. Bands to 2mm wide with abundant massive limonite-flooded clay aggregates as well as quartz seem to have been largely feldspathic, but there are also layers with abundant limonite-free clay material in addition to quartz, which may have replaced fine-grained feldspar. This sample seems to represent weathered quartz-biotite-feldspar schist of semipelitic origin.

SAMPLE NA050026

ROCK NAME (from TS) Altered granitic quartz-feldspar-porphyry with sericite/illite, limonite and anatase: very minor zircon is disseminated.

HAND SPECIMEN Pale massive rock with quartz phenocrysts

Field Note: *Nabarlek Granite: Illite*

PETROGRAPHY:

A visual estimate of the modal mineral abundances:

Mineral	Abundance	Origin/location
Quartz phenocrysts	Abundant	Phenocrysts
Dense sericite as blocky masses	Common	Ex-feldspar phenocrysts
Sericite	Abundant	In groundmass
Fine-grained quartz	Abundant	In groundmass
Limonite	Minor	Disseminated, in fractures
Anatase	Accessory	Disseminated, ex-biotite
Zircon	Trace	Accessory

Abundant subhedral, partly resorbed quartz phenocrysts, to 6mm long, are disseminated through this thin section and are accompanied by dense sericite after less abundant former feldspar phenocrysts, also to 6mm long and rare quartz-sericite patches, with lamellar leucoxene, derived from biotite microphenocrysts. The quartz phenocrysts have narrow optically continuous overgrowths and are enclosed in a heterogeneous aggregate of quartz and sericite/illite with minor anatase and limonite. Patches of sericite with granular anatase may represent mafic microphenocrysts other than biotite, possibly amphibole or pyroxene. There is rare zircon to 0.15mm in diameter. Irregular microfissures contain limonite but appear to be related to weathering. This sample seems to represent altered microgranite porphyry with a shallow emplacement level.

SAMPLE NA050027

ROCK NAME (from TS) Medium to coarse-grained sandstone, quartz-rich with areas containing limonite ± optically continuous overgrowths, areas with sericite parallel to or crosscutting grain boundaries and narrow layers with sericite-rich stylolites.

HAND SPECIMEN Relatively fine-grained sandstone with limonite along the margins (adjacent to fractures?)

Field Note: *Sandstone: muscovite*

PETROGRAPHY:

A visual estimate of the modal mineral abundances:

Mineral	Abundance	Origin/location
Single-crystal quartz grains	Dominant	Detrital ± overgrowths
Limonite	Very minor	Interstitial
Sericite/illite/muscovite?	Very minor	Interstitial

This sandstone has largely single-crystal quartz grains from 0.25mm to 0.6mm long (medium to coarse sand), typically with a parallel elongation apparently defining a bedding-parallel foliation. Most areas have closely appressed grains or stylolitic grain boundaries, but in some of the limonite-rich areas the limonite, which seems to be staining minor phyllosilicate, lies on the margins of detrital cores and there are irregular optically continuous overgrowths, nor necessarily in continuity with the most obvious adjacent quartz grain. In other areas there is minor sericite (muscovite or illite) along or crosscutting grain boundaries. There is also a largely layer-parallel zone with sericite-rich stylolites, with sericite also parallel to or crosscutting the stylolite and partly cutting adjacent quartz.

SAMPLE	NA050031
ROCK NAME (from TS)	Pebbly, granule-bearing very coarse-grained sandstone with limonite and sericite as well as rare optically continuous overgrowths.
HAND SPECIMEN	Heterogeneous very coarse-grained sandstone with sparse pebbles

Field Note: Sandstone: *paragonite* > *halloysite*

PETROGRAPHY:

A visual estimate of the modal mineral abundances:

Mineral	Abundance	Origin/location
Single-crystal quartz grains	Major	Detrital
Polycrystalline quartz grains	Abundant	Detrital, partly coarse
Limonite	Minor	Interstitial
Sericite	Minor	Interstitial

Most of the single-crystal quartz grains in this sample are from 0.5mm to 2.5mm in maximum diameter, just entering the size-range of granules, but mostly very coarse-grained sand. On the back of the offcut there is a quartz-rich pebble 10mm long, but no such pebbles are seen in the thin section. Grains of polycrystalline quartz have the same size-range as the single-crystal quartz grains, with some grains having a micromosaic texture as well as clasts with larger or more irregular quartz grains, suggesting metamorphic, vein and plutonic quartz. There are rare small optically continuous overgrowths, but most interstitial areas are occupied by limonite and/or phyllosilicate. The phyllosilicate is optically sericite and there is no objective reason for suspecting paragonite, and no halloysite was identified, although limonite-stained clays could include halloysite.