

MINERALOGICAL REPORT No. 8466
by Alan C. Purvis, PhD.

February 27th, 2004

TO :

Mr Dave Rosewall
Cameco Australia Ltd
66 Winnellie Road
WINNELLIE NT 0821

YOUR REFERENCE :

Order No. 3111

**MATERIAL &
IDENTIFICATION :**

Cadell Drill Hole CDD-001
Various depths between 63.1m and 330.7m (13
in all)

WORK REQUESTED :

Thin section preparation, description and report
with comments and interpretations as specified.

SAMPLES & SECTIONS :

Returned to you with this report.

DIGITAL COPY :

Enclosed with hard copy of this report.

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SUMMARY COMMENTS

Twelve samples from drillhole CDD-001 in the Cadell area of the Northern Territory are described in this report using normal thin sections. One sample (CDD-001, 63.1m) was listed on the submission sheet but not received. The samples are listed on Table 1, below.

Sandstones

The two shallowest samples, from 85.1 and 91.1m, are coarse to very coarse-grained quartz-rich sandstones with optically continuous overgrowths in the shallower sample. The shallower sample is also more weathered, with interstitial limonite-stained clay and scattered voids. The deeper sample has unusually abundant lenses varying from chlorite-rich to apatite-rich as well as very minor limonite or earthy hematite.

Granitoids

The deeper samples are all altered granitoids, passing downwards from foliated granitoid at 109.1m and 112.9m to massive granitoid varieties from 115.1m to 330.7m. Two samples of graphic granite occur, at 115.1m and 134.8m, with quartz diorite at 126m, granodiorite at 151.75m, 165.6m and 283.9m and monzogranite at 294.8m and 330.7m. This indicates increasing fractionation downhole from 126m, apart from the graphic granite samples, with quartz and K-spar both more abundant in the deeper samples. There is also an overall decrease in alteration downhole, with the monzogranite at 298.4m apparently the least altered of the coarse granitoids.

A probable dyke of microsyenogranite at 330.7m is even fresher, but seems to have been intruded into incompletely solidified monzogranite, with a transitional contact. This dyke also contains rare garnet, possibly spessartine, and may be more highly fractionated than the other granitoids.

Many of the granitoids contain muscovite and may be hydrous S-types, but one sample of foliated granitoid (at 112.9m) seems to have contained sphene, which is more typical of I-type granitoids. Rare allanite at 330.7m may also indicate I-type affinities, but many of the samples were biotite-only granitoids of uncertain affinity. Zircon was seen in several samples, usually reasonably coarse-grained, with maximum grainsizes varying from 0.25mm to 0.5mm. Sericite is the main secondary mineral, with chlorite, clays, leucoxene and tourmaline also common, but prehnite was seen only in monzogranite at 330.7m. Veins were noted in two samples, with sericite veins at 115.1m and chlorite-carbonate veins at 298.4m.

Table 1: Samples from drillhole CDD-001, Report No. 8466

Depth	Lithology	Alteration	Secondary or interstitial minerals	Accessories
63.1	Very coarse sandstone	Minor	Clay limonite voids	
91.1	Very coarse sandstone	Abundant	Chlorite apatite limonite	
109.1	Foliated granitoid	Strong	Sericite kaolin hematite leucoxene	Zircon
112.9	Foliated granitoid	Strong	Sericite leucoxene	Zircon, sphene?
115.1	Graphic granite	Strong	Sericite hematite leucoxene tourmaline	
	Veins	Minor	Sericite	
126.0	Quartz diorite	Strong	Sericite hematite leucoxene chlorite	
134.8	Graphic granite	Weak	Sericite quartz chlorite tourmaline	
151.75	Granodiorite	Weak	Sericite clay chlorite tourmaline	
165.6	Granodiorite	Moderate	Sericite clay chlorite	
	Veins	Sparse	Carbonate	
283.9	Granodiorite	Moderate	Sericite clay chlorite leucoxene	Zircon
298.4	Monzogranite	Minor	Sericite albite chlorite leucoxene	Zircon
	Veins	Minor	Chlorite carbonate	
330.7	Monzogranite	Moderate	Sericite clay prehnite leucoxene	
	Microsyenogranite	Weak	Sericite clay chlorite leucoxene	Garnet

INDIVIDUAL DESCRIPTIONS

CDD-001, 63.1m **Coarse to very coarse-grained sandstone with optically continuous overgrowths and interstitial limonite-stained clay. Scattered voids also reflect weathering.**

Hand Specimen

This sample contains weathered quartz-rich sandstone with orange limonite-stained patches and fractures.

Thin Section

This sample consists of quartz sandstone with poorly sorted single-crystal quartz grains from 0.25mm to 1.5mm in diameter, mostly coarse to very coarse-grained sandstone. Small aggregates, to 5mm long, composed of grains less than 0.5mm in diameter (medium-grained sandstone) may be intraclasts, but this is uncertain. Many of the quartz grains have optically continuous overgrowths and thin lamellae of limonite around the detrital cores, and interstitial limonite-stained clays are also widespread, making up about 3% of the thin section. The thin section also has a number of voids, some of which are more than 2mm long, and open fractures that may have contained limonite and clay, apparently caused by weathering.

CDD-001, 91.1m **Quartz-rich very coarse-grained sandstone with rare zircon and a clast of chlorite-sericite-leucoxene claystone. Lenses and interstitial patches are common and vary from chlorite-rich to apatite-rich, locally with limonite.**

Hand Specimen

This sample is a quartz-rich sandstone with areas rich in interstitial chlorite, mostly towards one end of the core-segment, and a pale clast about 5-6mm in diameter.

Thin Section

Quartz-rich sandstone also dominates this sample, although it also has a small sedimentary clast about 6mm in diameter, possibly an intraclast, but unusually rounded. The sandstone has interlocking quartz grains from 0.25mm to 2mm long, but detrital cores are rarely defined and optically continuous overgrowths are not visible as separate components. One grain has abundant very thin needles, generally considered to be rutile, and has no optically continuous overgrowth. Accessories include tourmaline, rutile and zircon crystals to 0.2mm long. The sandstone was probably mostly coarse to very coarse-grained, as in the previous sample, however. The small clast has about 20% fine sericite, disseminated and in irregular lamellae, as well as lamellae of leucoxene and abundant interstitial chlorite, and seem to represent claystone.

Lamellae and lenses of chlorite are abundant throughout the sandstone, varying from small interstitial patches as little as 0.2mm in diameter to lenses 10-15mm long and 2-3mm wide. Some lenses contain minor to abundant apatite, and there are lenses of fine-grained granular to prismatic apatite to 3mm long, usually with minor chlorite. Minor limonite is seen in the apatite lenses and also within quartz grains. Very minor to minor sericite or illite is also present in the chlorite-rich lenses. The chlorite and apatite-rich lenses seem to comprise about 10% of the area of the thin section.

CDD-001, 109.1m Altered foliated granitoid with sericite and possible kaolinite derived from feldspar and sericite + leucoxene ± hematite derived from biotite. Coarse zircon is present.

Hand Specimen

This core-segment contains altered foliated granitoid with coarser and finer-grained areas. The foliation is at a high angle to the core-axis.

Thin Section

This sample has parallel lenses that are alternately composed of quartz and altered feldspar, as well as minor altered biotite. The original lithology seems to have had 35% quartz, 60-65% feldspar and 2-3% biotite. Most of the quartz and feldspar was apparently less than 5mm in grainsize, but there are interstitial quartz grains, with undulose extinction, that seem to have been 10mm or more in length. Grain-boundaries are not clearly defined in the altered feldspar, however, making it difficult to estimate the original grainsize. The feldspar has been altered to massive sericite but passes into zones with a lower birefringence, apparently rich in kaolinite and/or microcrystalline quartz. Small patches of earthy and microplaty hematite occur in areas of altered feldspar, and sericite-lined fractures cut across the quartz. Biotite flakes, to 4mm long, are poorly oriented and completely altered, mostly to sericite, leucoxene and earthy hematite, but some flakes lack hematite. Rare zircon is present, to 0.5mm in grainsize.

CDD-001, 112.9m **Altered foliated granitoid gneiss with sericite and leucoxene. Accessories include apatite, zircon and altered possible sphene.**

Hand Specimen

The foliation in this granitoid gneiss is at about 60-70° to the core-axis.

Thin Section

This sample seems to have only about 20% quartz, but this includes irregular interstitial grains to 10 or 15mm long, with undulose extinction as in the previous samples, as well as smaller grains. Most of the quartz has been cut by sericite-filled fractures. The feldspar texture is again poorly preserved, with massive sericite replacing most of the feldspar. Some diffuse zones contain minor fine granular quartz as well as sericite, but there is no suggestion that these areas represent a second type of feldspar. Lenses composed of fine granular quartz also occur, together with accessory apatite, but do not seem to represent altered feldspar. About 4-5% former biotite, mostly in recrystallised lenses defining the foliation, has been altered to sericite and lamellar leucoxene, without the hematite seen in the previous samples. The biotite seems to have been mostly 0.5mm to 3mm in grainsize. Lenses of more dense leucoxene, to 4mm long, may have replaced aggregates of sphene grains or, less probably, opaque oxide. In addition to accessory apatite there is rare zircon to 0.25mm in grainsize.

**CDD-001, 115.1m Sericite-hematite-leucoxene-quartz-altered possible
graphic granite with minor altered biotite and partly
altered tourmaline. Chlorite-rich patches are visible in
hand specimen.**

Hand Specimen

This sample seems to represent a massive granitoid with no foliation visible in hand specimen. The reverse side of the offcut has chlorite-rich patches not captured within the area of the thin section.

Thin Section

The thin section shows a massive granitoid with three domains, each containing large interstitial quartz grains with two separate but related orientations within each domain. The texture is broadly that of graphic granite, but the quartz has undulose extinction suggesting weak deformation. There seems to be about 35% quartz as well as abundant feldspar, altered to massive sericite with spots of microcrystalline hematite and rare lenses containing very fine-grained quartz. Rare biotite, 2.5mm in grain size, has been altered to sericite and lamellar leucoxene, with rare partly resorbed grains of blue or green tourmaline rimmed by sericite-hematite aggregates. Sericite-filled fractures are again seen cutting the quartz.

CDD-001, 126.0m Altered biotite-quartz diorite with sericite, hematite, chlorite, leucoxene and secondary quartz.

Hand Specimen

This sample has a foliation at about 45° to the core-axis, with abundant pale chalky green areas as well as quartz and possible leucoxene.

Thin Section

This sample seems to have been quartz-poor, with 10-15% quartz as well as possibly 10-15% former biotite, suggesting a biotite-quartz diorite. The foliation is largely defined by lenses of altered biotite, although the biotite has been recrystallised and individual flakes are poorly oriented. The quartz is partly interstitial and poikilitic but occurs as grains less than 5mm in diameter. In the altered feldspar aggregates almost total alteration to sericite has obscured grain-boundaries. Minor microcrystalline hematite is disseminated through the altered feldspar and some areas contain very fine-grained quartz. The biotite has been altered to various proportions of sericite, clay (vermiculite?), intermediate or magnesian chlorite and lamellar leucoxene, with lenses of quartz parallel to the cleavage. Small patches of intermediate chlorite occur in the altered feldspar in some areas. There are also large, irregular or vein-like masses composed largely of fine-grained secondary quartz, with disseminated intermediate chlorite and small patches of sericite. The more vein-like masses are semicontinuous over an area 25mm long and 2-3mm wide, with another patch, richer in chlorite, about 10 x 8mm. Very rare chlorite seems to be darker green and more iron-rich. Open fractures are also evident in this sample.

CDD-001, 134.8m **Graphic granite with sericite replacing plagioclase lamellae in very coarse-grained perthitic orthoclase, passing into a sheared and brecciated area with sericite, quartz and pale magnesian chlorite as well as K-spar. Very minor tourmaline is present.**

Hand Specimen

This sample has large areas of pale pink K-spar as well as quartz-rich and sericite-rich areas.

Thin Section

Abut $\frac{3}{4}$ of this thin section is occupied by a pale pink grain of orthoclase with dendritic inclusions of quartz defining a graphic texture. The orthoclase has lamellae of dense sericite that seem to have replaced exsolved plagioclase, indicating former perthite. Very minor tourmaline in the graphic granite has nearly colourless cores and green or blue rims. The other $\frac{1}{4}$ of the thin section has zones containing residual orthoclase enclosed in sericite and minor quartz and also has sheared and brecciated lenses with fragments mostly composed of quartz in a sericite-rich matrix. The sericite-rich areas pass into zones with very fine-grained pale magnesian chlorite as well as or instead of sericite. The overall abundance of quartz is about 15-20%.

CDD-001, 151.75m Weakly altered biotite-tourmaline granodiorite, fine-grained with sericite and clay \pm chlorite alteration.

Hand Specimen

This sample seems to be fine-grained and less highly altered than the previous samples. It seems to be a very fine-grained granitoid.

Thin Section

This sample is a fine-grained granodiorite with most grains between 0.2mm and 2mm in size. The visually estimated mineralogy indicates 25% quartz, 50% plagioclase, 20% microcline, 4% tourmaline and 1% altered biotite. The texture is allotriomorphic granular with slightly irregular grains of tourmaline and thin flakes of biotite. Sericite alteration in the plagioclase varies from mild to intense, with sericite or possible chlorite \pm smectite as well as leucoxene replacing the biotite. The tourmaline has brownish and greenish or bluish zones and may be of deuteric or pneumatolytic origin. It seems to be unusually abundant.

CDD-001, 165.6m Foliated granodiorite with large K-spar crystals and mild to intense alteration involving sericite, clay and chlorite. Narrow carbonate veins are present.

Hand Specimen

Well-oriented large crystals of K-spar are present in this core-segment as well as plagioclase, quartz and biotite. The foliation is at a high angle to the core axis (60-70°). The visually estimated mineralogy includes 25% quartz, 50-55% plagioclase, 20% K-spar and 2-3% biotite. This indicates a foliated granodiorite.

Thin Section

Elongate grains of microcline in this sample are locally as much as 15mm long and have a subparallel orientation. Plagioclase, as exsolution lamellae and small inclusions, has clay-sericite alteration, and small lenses of chlorite occur in some of the microcline grains. Anhedral, partly interstitial quartz grains are as much as 10mm long and have undulose extinction. Plagioclase, to 8mm in grain size, has mild to intense sericite alteration and is mostly subhedral. Biotite lenses to 10mm long are mostly elongate parallel to the foliation, but are recrystallised with individual flakes to 1.5mm long that are less strongly oriented. The biotite is altered variously to vermiculite, sericite and chlorite, with lamellar leucoxene and lenses of sericite or quartz parallel to the cleavage. Apatite and zircon occur as accessories, with zircon to 0.4mm in grain size.

Very narrow crosscutting fractures are present and are filled with carbonate.

CDD-001, 283.9m

Altered foliated granodiorite with sericite, clays, chlorite and leucoxene: cut by quartz veins containing sericite.

Hand Specimen

This sample seems to have abundant clay-rich patches as well as pink K-spar and interstitial quartz. The K-spar occurs as grains to 10mm long with a parallel orientation suggesting a flow foliation. The visually estimated mineralogy includes about 30-35% quartz, 45-50% plagioclase, 18-20% K-spar and 1-2% biotite, indicating a foliated granodiorite.

Thin Section

Large crystals of microcline in this thin section are as much as 10 x 3mm, but nearby crystals are locally in optical continuity, suggesting that they may have broken up during late stages in magma crystallisation. Staining by brown clay is common. Some of the plagioclase could be as much as 10mm in grainsize but has been altered to massive sericite with rare chlorite and clouded clay. Some interstitial quartz grains may be more than 15mm in diameter, but others are less than 5mm, with undulose extinction throughout. The very minor biotite shows clay-chlorite-leucoxene alteration, locally with lenses of quartz parallel to the cleavage. Apatite and zircon occur as accessory phases, with zircon to 0.2mm in grainsize.

Abundant subparallel veins, cutting the rock, contain clouded sparry quartz, with sericite in some segments, but are mostly less than 0.4mm wide.

CDD-001, 298.4m

Altered quartz-rich monzogranite with albite-sericite-chlorite-leucoxene alteration and chlorite-carbonate veins.

Hand Specimen

Pink K-spar and white or pale lemon yellow plagioclase are visible in this core-segment as well as abundant quartz. Narrow fractures occur as well as planar veins apparently rich in chlorite. The visually estimated mineralogy includes 40-45% quartz, 25% plagioclase, 30% K-spar and 1-2% biotite, indicating a quartz-rich monzogranite.

Thin Section

The thin section shows subhedral microcline to 15mm in grainsize, anhedral quartz to 10mm in grainsize and mostly anhedral plagioclase to 8mm in grainsize, altered to various proportions of albite and sericite. The K-spar has a pale brown clay staining with rare patches of intermediate chlorite, and the minor biotite has chlorite-leucoxene alteration. Most of the biotite is in small, poorly oriented lenses with a decussate texture, but there does not seem to be a well-defined foliation in this sample. Apatite and zircon occur as accessories, with zircon to 0.25mm.

Veins less than 1mm wide are common and contain various proportions of chlorite and carbonate, with dull grey-green, nearly isotropic intermediate chlorite.

CDD-001, 330.7m

Contact between weakly altered monzogranite and a dyke of microsyenogranite with rare garnet. Weak sericite, clay, chlorite and prehnite alteration is seen.

Hand Specimen

This is a pale-coloured granitoid with white feldspar crystals, but has been cut by a fine-grained pink dyke. The largest feldspar crystals are K-spar, but plagioclase is also abundant in the coarse-grained granitoid. The visually estimated mineralogy for the coarse-grained granitoid includes 35-40% quartz, 30% plagioclase, 30% microcline and 2-3% biotite, indicating monzogranite. The fine-grained dyke is rich in K-spar, however.

Thin Section

The coarse granitoid has microcline as subhedral crystals to 15mm long, anhedral quartz to 7mm and plagioclase as largely anhedral grains to 4 or 5mm long. There is also minor biotite to 1mm grain size, mostly in small decussate aggregates. Rare altered possible allanite is disseminated, partly over 1mm in grain size. The plagioclase has strong or total alteration to sericite, with albite remaining in incompletely sericitised grains, and the biotite has mostly clay alteration, locally with prehnite parallel to the cleavage. Chlorite is rare, however.

The contact with the fine-grained rock is sharp but some grains in the coarse-grained granite have optically continuous overgrowths in the fine-grained rock. The incoming of small (<0.4mm in diameter) quartz and microcline grains marks the beginning of the fine-grained rock, although rare larger grains of quartz, plagioclase and microcline occur, to 4mm in diameter. The visually estimated mineralogy includes 25% quartz, 60% microcline, 10-15% plagioclase, 2-3% biotite and <1% garnet, indicating microsyenogranite or granitic aplite. The plagioclase has only weak sericite alteration, but the biotite has clay-chlorite-leucoxene alteration. The garnet occurs as a grain 2mm in diameter and may be rich in manganese.