MINERALOGICAL REPORT No. 8462

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TO : Mr Llyle Sawyer
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66 Winnellie Road
Winnellie NT 0821

YOUR REFERENCE : Order No. 3112

MATERIAL : Drill Core, Arnhem Land, (18 samples in all)

IDENTIFICATION : KLD100, 101, 103

WORK REQUESTED : Thin section preparation and report.

SAMPLES & SECTIONS : Returned to you with this report.

DIGITAL COPY : Enclosed with hard copy of this report.

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SUMMARY COMMENTS

The eighteen core samples described in this report are from three drillholes (KLD100, 101 and 103) in Arnhem Land in the Northern Territory. There is one sample of sandstone in KLD at 55.35m, but four of the other samples from KLD100, and all three samples from KLD101 are altered basalts. Altered granitoids are represented by the deepest sample in KLD100, and by six out of nine samples from KLD103. The remaining three samples from KLD103 include two dolerite samples and a breccia of chloritised material set in microplaty hematite. A list of samples is given below as Table 1, with alteration minerals also listed.

The **sandstone** (KLD100, 55.35m) is mostly fine-grained but includes two thin layers of very fine-grained sandstone, also coarse-grained sandstone including two heavy mineral laminations, one of which is excessively rich in zircon.

The numerous **basalts** include plagioclase-porphyritic and aphyric varieties and are commonly amygdaloidal. Some development of secondary K-spar is seen, probably adularia, in three basalt samples (KLD100, 94.78, 108.25; KLD101, 176.27), highlighted stained yellow by sodium cobalti-nitrite on the section offcuts. Others have alteration assemblages of various proportions of albite, sericite, chlorite, smectites, carbonate and quartz. Sample KLD101, 103.81 has vesicles that were open to the environment and are partly or completely filled by siltstone rather than by hydrothermal or diagenetic minerals. The **dolerites** are less altered, with saussuritic and uralitic alteration as well as rare smectite after olivine.

The original composition of the altered **granitoids** is mostly uncertain, although the freshest seem to have been monzogranite or syenogranite and alteration patterns is several others seem to suggest two types of feldspar in the original lithology. These patterns mostly involve sericite after one type of feldspar (plagioclase?) and chlorite-quartz ± sericite in the other (K-spar?). sericite and leucoxene are the main alteration products of biotite, however.

Table 1: Samples Described in Report No 8462

Drillhole	Depth	Primary Lithology	Alteration, notes				
KLD100	55.35	Sandstone	Sericite	Hematite	Heavy mineral layers (zircon)		
	79.12	Basalt	Sericite	Smectite	Chlorite	Leucoxene	
	94.78	Basalt	K-spar	Sericite	Chlorite	Albite	Leucoxene
		Vesicles	Chlorite	Chalcedony			
	99.67	Basalt	Albite	Sericite	Chlorite	Hematite	Leucoxene
		Vesicles	Chlorite	Smectite			
	108.25	Basalt	K-spar	Sericite	Albite	Hematite	
		Vesicles	Smectite	Carbonate	Quartz		
		Vein	Quartz	Carbonate			
	381.96	Granitoid	Sericite	Quartz	Clay	Hematite	Leucoxene
KLD101	89.47	Basalt	Sericite	Clay	Quartz	Hematite	Leucoxene
		Vesicles	Smectite	Quartz			
	103.81	Basalt	Sericite	Clay	Quartz	Hematite	Leucoxene
		Vesicles	Siltstone	Smectite	Hematite		
		Veins	Smectite	Celadonite	Quartz	Hematite	Carbonate
	176.27	Basalt	K-spar	Chlorite	Quartz	Leucoxene	Hematite clay
		Vesicles	Carbonate	Quartz	Smectite	K-spar	
		Veins	Quartz				
KLD103	85.24	Granitoid	Sericite	Quartz	Chlorite	Tourmaline	
	90.5	Granite	Albite	Sericite	Chlorite	Clay	Fluorite
	100.75	Granitoid	Sericite	Quartz	Clay	Hematite	Tourmaline
	120.85	Granitoid	Sericite	Quartz	Clay	Hematite	Tourmaline
		Veins	Quartz	Clay	Limonite		
	124.3	Dolerite	Sericite	Albite	Actinolite		
		Veins	K-spar	Carbonate			
	127.73	Granitoid	Sericite	Quartz	Chlorite	leucoxene	
		Veins	Quartz	Clay			
	133.1	Granite	Sericite	Hematite			
	205.88	Dolerite	Sericite	Epidote	Actinolite, smectite		
	347	Breccia	Chlorite	Hematite			

INDIVIDUAL DESCRIPTIONS

KLD100, 55.35m **Mostly medium-grained sandstone with layers of fine-grained sandstone and coarse-grained sandstone with heavy mineral laminations on either side of a fine-grained sandstone layer, containing oxides ± minor to abundant zircon.**

This sample is largely composed of medium-grained sandstone with abundant single-crystal quartz grains less than 0.5mm in diameter, but has a narrow layer of fine-grained sandstone, about 3mm wide, with single-crystal quartz grains to 0.25mm and a layer of coarse-grained sandstone with single-crystal quartz grains to 0.7mm in diameter. Rare polycrystalline quartz is present, possibly representing fragments of vein-quartz, and there is very minor detrital muscovite. The single-crystal quartz grains are rimmed by earthy hematite (10%), but there is also abundant interstitial sericite (25%). On either side of the fine-grained sandstone layer the quartz seems to have been cemented by leucoxene and there are heavy mineral laminations rich in oxidised opaque oxide grains. One of the heavy mineral laminations has about twenty-five grains of zircon, from 0.05mm to 0.3mm long, across the thin section, but the other has much fewer zircon grains.

KLD100, 79.12m **Altered sparsely plagioclase porphyritic basalt with abundant vesicles and sericite-smectite ± chlorite-leucoxene alteration.**

This sample is an altered amygdaloidal basalt with sparse plagioclase phenocrysts to 4mm long. The groundmass also has abundant plagioclase laths, mostly less than 1mm long, as well as various altered interstitial phases, possibly including glass as well as olivine and pyroxene. All of the feldspar in this sample (~45%) seems to have been altered to sericite. Very minor probable olivine, to 1.5mm in grainsize (5%), has been replaced by a pale, relatively more birefringent phyllosilicate that that replacing other interstitial materials. Clouded or clear possible smectite and/or chlorite seem to have replaced possible glass/ quenched material (15%) and pyroxene (15-20%) respectively, with microcrystalline leucoxene in the altered pyroxene grains. The clay replacing pyroxene is pale greenish yellow in colour. Small skeletal opaque oxide crystals have all been altered to leucoxene. Amoeboid vesicles are abundant (15-20%) and as much as 2mm long and have zoned infills of pale yellow and colourless phyllosilicates. Trace hematite occurs in the amygdales.

KLD100, 94.78m **K-spar-albite-chlorite-sericite-leucoxene-altered basalt with amygdales rimmed by chlorite and filled by chalcedony. Parallel quartz veins are present with minor hematite.**

This is again an amygdaloidal basalt with varied alteration patterns across the thin section. Plagioclase laths to 1mm long are abundant (45%) and altered variously to K-spar (probably adularia) albite and/or sericite, with K-spar more abundant than albite or sericite, as seen on the stained offcut. Pyroxene grains (15%) have been replaced by pale yellowish chlorite ± smectite, and areas of clay clouded by earthy hematite are common, possibly replacing interstitial material (glass or quench material: 20-25%). Minor skeletal opaque oxide has been replaced by leucoxene (2-3%). Amygdales are again abundant (15%), to 2mm in diameter, with rims of chlorite ± smectite and cores that seem to contain chalcedony. Parallel narrow veins occur with quartz and minor earthy hematite.

KLD100, 99.67m **Albite-sericite-chlorite-hematite-leucoxene-altered basalt with abundant amygdales containing possible chlorite-smectite (e.g. corrensite).**

Sparse plagioclase phenocrysts to 1.5mm long occur in this sample as well as abundant smaller laths, all altered to albite ± sericite. The original feldspar content was apparently about 45%. Minor pyroxene (~10-15%), to 0.5mm in grainsize, has been replaced by Al-poor chlorite with a blue anomalous interference colour. Most of the remaining interstitial material (25-30%) has been flooded with earthy hematite, but also contains leucoxene derived from very small opaque oxide grains. The abundant (15%) amygdales in this sample are largely bounded by plagioclase crystal faces and seem to contain possible chlorite-smectite (e.g. corrensite) with a greenish anomalous interference colour, but a uniaxial negative character. Pure chlorite with this type of interference colour is usually optically positive. The amygdales rarely also contain quartz.

KLD100, 108.25m **K-spar-albite-sericite-hematite-altered basalt with clays and carbonate ± quartz in large amygdales. A crosscutting quartz vein is also present with minor carbonate.**

Very large amygdales occur in this basalt, mostly filled by bluish-green phyllosilicates, locally with minor to abundant carbonate as well as phyllosilicate. These amygdales make up 30-35% of the thin section. The basalt is dark red in hand-specimen and seems to be rich in earthy hematite. Within the host-rock there are disseminated former plagioclase laths to 1mm long that have been altered to various combinations of K-spar, sericite, albite and probable smectite. Smectite has also replaced small crystals that may include olivine as well as pyroxene, but could have been entirely pyroxene. Most of the interstitial material is earthy hematite or essentially isotropic clay, with very little visible leucoxene. The abundant amygdales in this sample range from 2mm to 15mm long. Most have a zoned smectite infill with two layers of foliated, possibly fibrous smectite separated by a zone of microspherulitic smectite with a darker yellow-green colour. Some of the amygdales also contain minor to abundant carbonate ± quartz, and there is a 2mm-wide crosscutting vein with abundant granular to prismatic quartz and minor carbonate.

KLD100, 381.96m **Sericite-quartz-clay-hematite-leucoxene-altered very quartz-rich granitoid**

This is a very quartz-rich granitoid with possibly 55% primary quartz as well as abundant altered feldspar and biotite. Most of the feldspar, to 4 or 5mm in grainsize (~30%), has been altered to sericite, with minor earthy hematite in irregular lenses. However, other grains of possible feldspar (slightly less than 1/3 of the feldspar or 10-15% of the rock) have been replaced by quartz-rich aggregates, usually with two different orientations of quartz grains as seen in some greisens, locally with probable chlorite or other clays and earthy or crystalline hematite. One grain has abundant nearly parallel narrow prisms of quartz about 0.4mm long as well as less abundant clay and oxide. All of the biotite (~2-3%) has been altered to sericite with lamellar leucoxene, and was present as flakes to 2mm long, usually crumpled as a result of alteration. It may be that the sericite-rich altered feldspar was plagioclase, but the quartz-rich altered feldspar was K-spar, but there is no fresh material remaining in this sample.

KLD101, 89.47m **Sheared and altered amygdaloidal basalt with sericite-clay-hematite-leucoxene-quartz alteration.**

Anastomosing millimetre-scale lamellae of schistose probable sericite are abundant (~20%) in this sample, but are separated by lamellae which retain a basaltic texture. The outlines of former plagioclase laths (~30%) are preserved mostly in sericite-rich patched with 15% interstitial earthy hematite and 25% interstitial clay. Irregular vesicles, to 4mm long, are also abundant (10%) and are largely filled with microcrystalline quartz, but larger vesicles also contain lenses of probable smectite. Traces of leucoxene occur in areas that lack hematite and seem to have replaced very small opaque oxide crystals.

KLD101, 103.81m **Sericite-clay-hematite-leucoxene-quartz-altered basalt with amygdales partly filled by siltstone, partly by various clays ± hematite. Clay-filled parallel veins are abundant, with minor carbonate, quartz and hematite in some of the narrower veins. The widest vein has celadonite, quartz, hematite and shreds of wall rock.**

This is again an altered basalt, but has abundant parallel veins of varying widths and also has some amygdales that were open to the environment and are filled with siltstone rather than with hydrothermal minerals. The siltstone contains fine-grained quartz and detrital mica as well as clays and hematite. Other amygdales are mostly filled with probable smectite, but a few have cores of smectite and rims of siltstone. Rare small vesicles are seen with probable celadonite as the main filling, with probable smectite and microplaty hematite is some of these. Some of the vesicles have rims of altered quenched basaltic material and may be classified as segregation vesicles.

The host basalt has abundant altered plagioclase laths from 0.2mm to 0.8mm long, mostly altered to probable smectite and sericite. Interstitial areas are heterogeneous, with varied clays and possible microcrystalline quartz as well as hematite and leucoxene after dendritic opaque oxide crystals. Pyroxene and glass seem to have been the most probable components other than plagioclase and opaque oxide.

The narrower veins, mostly less than 1mm wide, are mostly filled with foliated clay, possibly smectite or halloysite, locally with a more highly birefringent clay (sericite or smectite), carbonate and microplaty hematite in various combinations. The widest vein is 8-10mm wide and has zones of celadonite as well as lenses and zones containing sparry quartz and microplaty hematite. Small shreds of wall rock seem to include altered basalt and minor siltstone from within some of the amygdales.

KLD101, 176.27m **K-spar-chlorite-quartz-leucoxene-hematite-clay-altered amygdaloidal basalt with irregular vesicles containing quartz, carbonate, adularia and hematite as well as spherical vesicles with chlorite ± smectite, rare K-spar and carbonate and very rare quartz. A quartz vein is also present.**

This basalt has small amygdales filled with dark green clay and larger amygdales, to 20mm in diameter, filled by quartz, carbonate, K-spar and hematite. Amygdales make up 35-40% of the thin section.

The stained offcut indicates three zones: a largely glassy or devitrified zone adjacent to the largest amygdale, with abundant K-spar disseminated and in sparse feldspar sites; a more holocrystalline zone with K-spar only in feldspar sites and a slightly sheared zone with K-spar in feldspar sites and interstitial sericite. In thin section the zone adjacent to the largest amygdale has relatively abundant former plagioclase replaced by hematite-stained K-spar. Interstitial areas have been devitrified and have chlorite-altered mafic microlites, feathery K-spar and leucoxene after skeletal opaque oxide. Possible pyroxene has been altered to chlorite and possible olivine to quartz. The amount of earthy hematite reaches a maximum in the intermediate zone and may have obscured the yellow K-spar-stain seen elsewhere in the offcut, but this is in relatively sharp contact with the third area, with interstitial clay, including possible sericite, rather than hematite. These areas also contain chlorite and quartz derived from mafic crystals.

The largest amygdale has patches of very coarse-grained quartz and of granular carbonate, as well as irregular masses of coarse-grained granular adularia, heavily iron-stained apart from optically continuous overgrowths with crystal faces. Minor microplaty hematite occurs in small lamellae between the adularia and the quartz. Smaller amygdales include more spherical varieties filled with chlorite ± smectite and more amoeboid types rimmed by hematite or sericite-clouded adularia and filled with quartz. Some of the more spherical amygdales also contain carbonate, adularia or hematite, but rarely contain quartz.

There is a narrow crosscutting quartz vein with minor sericite and hematite.

KLD103, 85.24m **Sericite-quartz-chlorite-tourmaline-altered granitoid, possibly monzogranite.**

This sample is a highly altered quartz-rich granitoid, with about 40% quartz as well as altered feldspar and mafic minerals. The grainsize varies from 1 to 5mm and, in addition to weakly deformed granular quartz, the other components are: feldspar #1, probably plagioclase, altered to sericite and clouded clays, locally with blue tourmaline; feldspar #2 (possibly K-spar) altered to quartz, chlorite and sericite and biotite altered to sericite with lamellar leucoxene. Possibly primary muscovite is also disseminated, with rare altered oxide and sparse zircon crystals to 0.1mm long. The visually estimated original mineralogy includes 35% plagioclase, 20-25% possible K-spar and 2-3% mica, in addition to the 40% quartz noted above, suggesting that this sample was a monzogranite rather than a tonalite, but the original feldspar composition is unclear.

KLD103, 90.5m **Albite-sericite-chlorite-clay-altered monzogranite with small patches of fluorite.**

This is also an altered quartz-rich granitoid and has two clearly visible types of altered feldspar. In this sample, the feldspar is less altered compared to the previous sample, with sparse phenocrysts of orthoclase to 10mm long and smaller grains of both plagioclase and orthoclase to 4mm in grainsize. Albite and minor to abundant sericite have replaced the plagioclase, but the orthoclase is fresh or clouded by brown iron-stained clay. Muscovite and sericite-chlorite-leucoxene altered biotite are disseminated and there are several small patches of fluorite, partly colourless and partly purple. The visually estimated primary mineralogy includes 45% quartz, 25-30% plagioclase, 25% or and 2-3% mica, indicating a former monzogranite.

KLD103, 100.75m **Sericite-quartz-clay-hematite-tourmaline-altered granitoid with greisen-like alteration.**

This quartz-rich granitoid has more highly altered feldspar compared to the previous sample and seems transitional towards greisen. Primary quartz is abundant as undeformed grains to 3mm long. Within the altered feldspar aggregates, textural preservation is poor and grain boundaries are difficult to discern. There may have been two feldspar species, as in the previous samples, but there is a wide range of alteration products. Massive sericite, clays, microcrystalline and granular quartz and very minor pale blue tourmaline occur in various proportions in what seem to be different grains, with possibly very minor kaolinite in some grains. Small patches of limonite or earthy hematite are disseminated and there are rare flakes of muscovite. Altered possible biotite is also rare, with lamellar sericite and rare leucoxene. This sample seems to have had 35-40% quartz as well as abundant feldspar and rare mica.

KLD103, 120.85m **Sericite-quartz-clay-hematite-tourmaline-altered granitoid with narrow quartz veins and a clay-limonite-filled fracture.**

This quartz-rich granitoid has slightly less altered feldspar compared to the previous sample about also seems transitional towards greisen. Primary quartz is abundant as undeformed grains to 3mm long. Within the altered feldspar aggregates, textural preservation is poor and grain boundaries are difficult to discern, but there may have been two feldspar species, as in the previous samples, with more abundant quartz in altered possible K-spar. Massive sericite, clays, microcrystalline and granular quartz and very minor pale green tourmaline occur in various proportions in what seem to be different grains, with possibly very minor kaolinite in some grains. Small patches of limonite or earthy hematite are disseminated and there are rare flakes of muscovite. Altered possible biotite is also rare, with rare possible vermiculite as well as lamellar sericite and rare leucoxene. This sample seems to have had 40% quartz as well as abundant feldspar and rare mica. It seems that plagioclase was more abundant than K-spar, if the interpretation of original feldspar species is correct, indicating a former monzogranite transitional towards granodiorite. Narrow quartz veins are present as well as clay-limonite-filled, possibly shear-related fractures.

KLD103, 124.3m **Sericite-albite-actinolite-altered plagioclase-porphyritic dolerite with narrow veins.**

This sample is a plagioclase-porphyritic basalt or dolerite with sparse glomeroporphyritic aggregates of sericitised plagioclase to 8mm in diameter in a partly fresh dolerite groundmass. Adjacent to the largest aggregate there is a single large mafic phenocryst altered to chlorite, carbonate and oxide, with a rim of fibrous tremolite. The groundmass has abundant small plagioclase laths, altered variously to albite and sericite, as well as largely fresh clinopyroxene. Aggregates of actinolite are abundant and seem to have replaced pyroxene, with less abundant largely fresh opaque oxide. Small fractures occur, apparently with adularia and carbonate.

KLD103, 127.73m **Sericite-quartz-chlorite-leucoxene altered granitoid with a zoned quartz vein containing clays.**

This sample is a highly altered quartz-rich granitoid, with about 40% quartz as well as altered feldspar and mafic minerals. The grainsize varies from 1 to 5mm and, has: feldspar #1, (probably plagioclase), altered to sericite and clouded clays, feldspar #2 (possibly K-spar) altered to quartz, chlorite and sericite, and biotite altered to sericite with lamellar leucoxene. Very minor possible vermiculite occurs in some of the sericite-leucoxene patches derived from biotite. Possibly primary muscovite is also disseminated. The visually estimated original mineralogy includes 35% plagioclase, 20-25% possible K-spar and 2-3% mica, in addition to the 40% quartz noted above, suggesting that this sample was a monzogranite, but the original feldspar composition is unclear.

This sample contains a quartz vein, about 2mm wide, with an outer zone of granular to prismatic quartz and an inner zone of cherty to microsparry and fine prismatic quartz. Zones of sericite an brown clay separate the inner and outer zones.

KLD103, 133.1m **Weakly sericitised alkali feldspar granite.**

This sample seems to be a largely K-spar-dominated granitoid and has abundant reddish-brown stained orthoclase (or adularia?) to 4mm in grainsize, commonly cut by a network of small sericite-filled fractures. Much less abundant sericitised plagioclase is also present but is mostly less than 2mm in grainsize, with sericite-leucoxene after biotite also to 2mm but partly in aggregates. The abundant quartz, to 4mm in grainsize, is partly euhedral against K-spar and this may suggest a relatively shallow depth of emplacement. The visually estimated primary mineralogy includes about 40-45% quartz, 45% K-spar, 5% plagioclase, 4% biotite and <1% muscovite, indicating an alkali feldspar granite.

KLD103, 205.88m **Weakly altered plagioclase-porphyritic dolerite with weak saussuritic alteration and minor actinolite.**

This sample has a single large glomeroporphyritic aggregate of plagioclase phenocrysts about 10mm in diameter in an ophitic dolerite groundmass. Sparse patches of saussuritic alteration are seen in the plagioclase, which also has sparse inclusions of pyroxene and altered olivine. The groundmass has abundant fresh grains of ophitic clinopyroxene, to 6mm in diameter, enclosing weakly sericitised or saussuritised plagioclase laths to 1mm long. Sparse grains of olivine occur, to 0.5mm in diameter, and are partly altered to smectite with rims and fractures containing oxide material. Actinolite and biotite are minor components, with granular and platy opaque oxide (magnetite and ilmenite?) as well as accessory apatite. The visually estimated primary mineralogy includes 45% plagioclase, 45% clinopyroxene, 2-3% olivine, 4% actinolite 1% biotite and 2-3% oxides + apatite.

KLD103, 347m **Breccia of chlorite-rich fragments of uncertain original lithology in microcrystalline hematite.**

This sample is a breccia of chloritised fragments separated by very fine-grained microplaty hematite. Larger fragments, from 5 to 25mm long, are separated areas rich in fragments less than 1mm long and also enclose small aggregates of hematite. There is no textural preservation within the fragments and the lack of leucoxene suggests that the original mineralogy is not of mafic igneous origin. This sample is considered to be enigmatic and there is no easily interpreted evidence in the thin section as to the original lithology or lithologies represented by the fragments.