Applied Petrological Services

PETROLOGICAL STUDIES
OF
DRIL CHIP
FROM
THE BELUGA PROJECT AREA

FOR
NEWMONT EXPLORATION PTY LTD

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SUMMARY

1. At Beluga, arsenic and possible gold mineralisation may primarily be related to magmatic associated hydrothermal histories evident in both a quartz monzonite/monzodiorite and a monzogranite rock, and also in proximally associated thermally metamorphosed sediments. Some mineralisation may primarily be associated with but most likely remobilised by a late structurally controlled and more localised hydrothermal overprint.

2. A bimodal occurrence of igneous rock types, reflected in the aeromagnetic signature for the region, is represented: (1). By a relatively biotite-rich and magnetite bearing, quartz monzonite/monzodiorite; and (2), by a relatively biotite-poor, ilmenite-bearing monzogranite. A biotite quartz monzonite from the Syrene area has a similar aeromagnetic signature to the quartz monzonite/monzodiorite at Beluga. Thermally metamorphosed sedimentary rocks have an aeromagnetic signature intermediate between those of the quartz monzonite/monzodiorite and monzogranite rocks.

3. A basis for interpreting the distribution of igneous rock types in the western Tanami from geophysical data may be provided for in the correlation of petrological and geophysical data of the Beluga and Syrene areas. A possible interpretation of the aeromagnetic and petrological data for the Beluga area is that a circular intrusion complex, comprising an inner domain of monzogranite and outer ring of quartz monzonite, has been bisected and dislocated by a late northwest trending, transcurrent fault.

4. Early magmatic related hydrothermal histories within both the quartz monzonite/monzodiorite and monzogranite rocks are represented to some extent by quartz veining that can be genetically related to host rock and earliest hydrothermal wallrock replacement. Subtle variations in early hydrothermal mineralogy associated with quartz, and variations in fluid inclusion types within the quartz differentiate magmatic hydrothermal alteration within the respective rock types. Biotite dominates the magmatic hydrothermal alteration of the quartz monzonite/monzodiorite rocks, whereas muscovite dominates the magmatic hydrothermal alteration of the monzogranite rocks. From fluid inclusions, magmatic hydrothermal fluids exsolved from the monzogranite are interpreted to have been richer in CO_2 and generally more gas-rich in composition, whereas those exsolved from the quartz monzonite/monzodiorite are interpreted to have been more saline and aqueous-rich in composition.

5. On the scale of petrological investigation it is determined that late, locally intense, texturally destructive sericitic/illitic alteration in both the monzogranite and quartz monzonite/monzodiorite rock is structurally controlled; being mostly associated with shearing and domains of cataclasis. From an interpretation of the aeromagnetic data, it would appear that this later, lower temperature alteration is spatially related to the northwest trending structure (and related structures) bisecting and dislocating the Beluga intrusion complex.

INTRODUCTION

Ten drill chip samples collected from the Beluga project area have been submitted for petrological studies. The Beluga project area, located some 15 kilometres northwest of Twin Bonanza (Figure 1), is primarily defined by an arsenic geochemical anomaly centred upon magnetic and gravity anomalies representative of granitoid intrusions hosted by metasediments (Figure 1). In addition to ten drill chip samples collected from the Beluga project area, a single sample taken from the Syrene intrusion to the east has been submitted for petrological analysis (Figure 1).

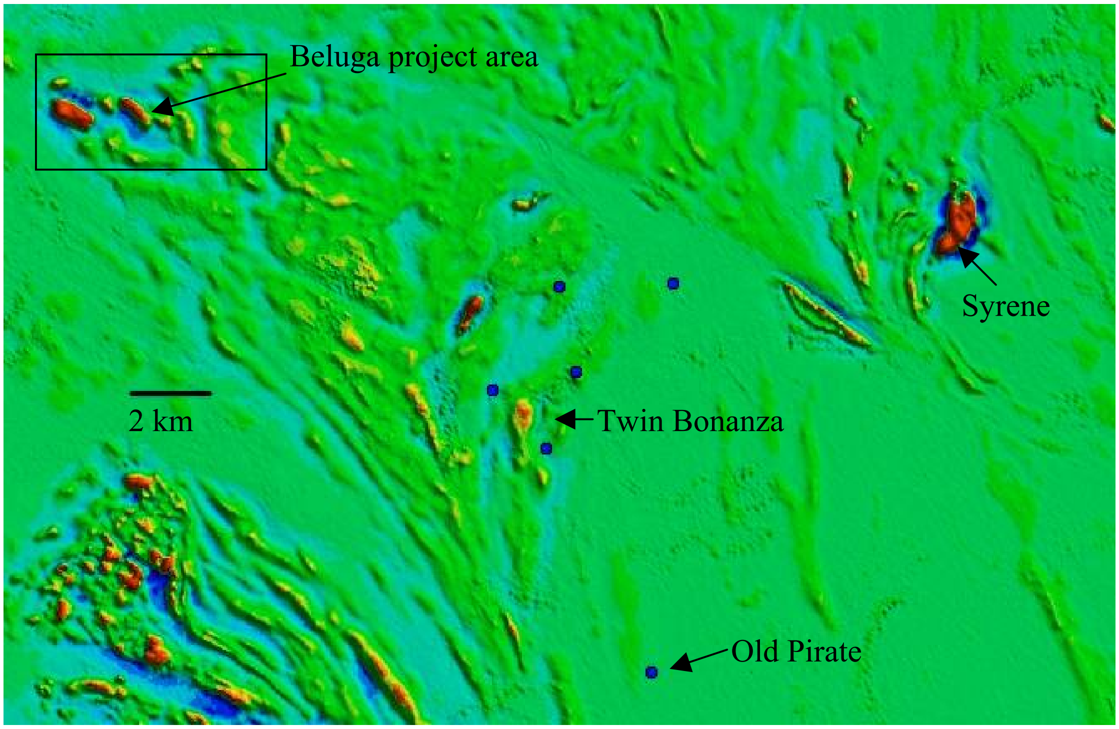


Figure 1a. Beluga project location and aeromagnetic data interpretation.

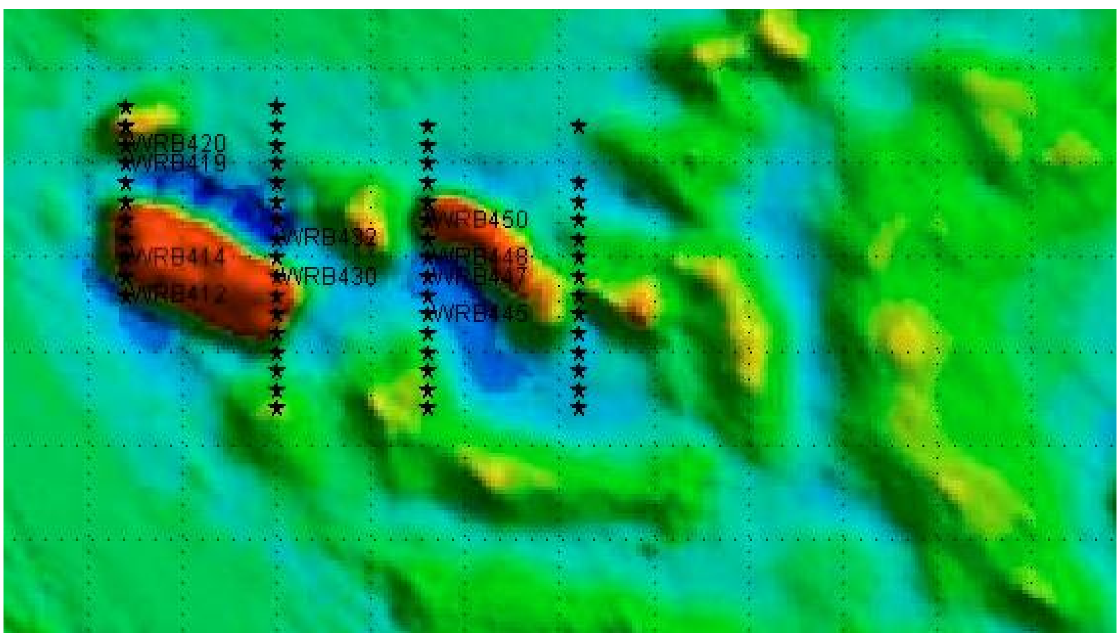


Figure 1b. Beluga project area and drill hole locations and identification of holes from which petrology samples have been taken. Grid spacing at 500 metres.

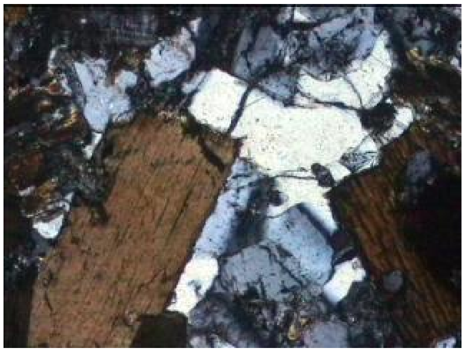
The Beluga petrology samples comprise a representation of igneous rocks, metasediments and quartz veining intersected in RAB drilling. The scope of this study is to provide detailed petrographic and mineragraphic descriptions of the drill chip samples, the descriptions including aspects of primary rock type, hydrothermal alteration or effects, and any mineralisation. From the descriptive database, interpretations and comment will be offered with respect to geology, hydrothermal environment and potential for mineralisation.

RESULTS

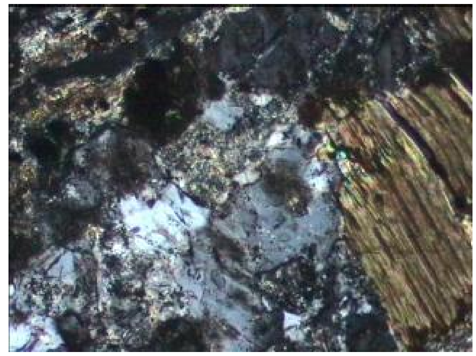
INTERMEDIATE IGNEOUS ROCKS (QUARTZ MONZONITES AND MONZODIORITES)

TABLE 1. PETROGRAPHIC/MINERAGRAPHIC SUMMARY: INTERMEDIATE IGNEOUS ROCKS

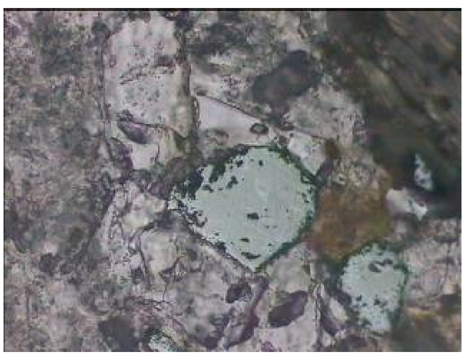
Sample	Comment	Lithology and Replacement	Deposition
26025.01 WRB414/ 50-51	Ilmenite and magnetite are the Ti/Fe-oxide minerals present within the primary assemblage. Biotite comprises up to 20% of the rock, and quartz less than 20% of the rock. Deuteric sericite/muscovite has formed after plagioclase together with minor amounts of epidote. Graphic intergrowths of quartz and K-feldspar are present.	Biotite-rich quartz monzodiorite 1.muscovite, epidote 2.illitic clay 3.kaolin/smectite clay, hematite, goethite	1.(veinlet) hematite, goethite, smectite/kaolin clays
26025.02 WRB450/ 45-48	Early K-feldspar veining and later quartz + epidote veining represent deuteric alteration of the monzodiorite rock. Magnetite is the Fe/Ti-oxide mineral present in the intermediate rock.	Biotite amphibole monzodiorite porphyry and (sparse) granitoid 1.illitic clay 2.kaolin/smectite clays, hematite, goethite	1.(veinlet) K-feldspar, quartz 2.(veinlet) epidote, quartz
26025.05 WRB420/ 47-48	Quartz vein material appears to be igneous in style. Co-existence of the aqueous liquid-rich and gas-rich inclusion indicates phase separation, enhanced by the high salinity of the fluids. Sericitic alteration is centred upon strong shearing and cataclasis.	Strong sheared and fragmented intermediate igneous rock (quartz monzonite?) 1.biotite 2.illitic/sericitic clay 3.kaolin/smectitic clays, goethite, hematite	1.(vein/veinlet) quartz, biotite (→ chlorite → smectite clays), muscovite 2.(veinlet) biotite) 3.(veinlet) quartz, illitic clay
26025.10 WRB430/	Apatite is more abundant than zircon. Early hydrothermal alteration is represented by very fine-grained brown biotite after plagioclase, intergrown with quartz after amphibole, and about the margins of primary biotite. Graphic intergrowths of K-feldspar and quartz are abundant. Magnetite is present.	Biotite quartz monzonite 1.biotite, quartz, muscovite 2.illitic clay 3.smectitic/kaolin clays	1.(veinlet) biotite 2.(veinlet) hematite, goethite
26025.11 Syrene	The rock has less than 10% primary modal quartz. Strong potassic alteration, represented by secondary biotite, is associated with quartz veining. The quartz veining is deformed in association with tectonic overprinting. Compares favourably with the monzonitic rocks from Beluga.	Biotite quartz monzonite 1.iotite, muscovite, magnetite 2.illitic clay 3.smectitic/kaolin clays, goethite, hematite	1.(vein/cement) quartz, biotite (smectite clays), K-feldspar (→ illitic clay); quartz 2.(shear) quartz 3.(veinlet/cement) kaolin/smectite clays, hematite



Left. 26025.01. Minor amounts of anhedral quartz interstitial to framework plagioclase, K-feldspar and biotite. 1200 µm. cpl.
Right. 26025.11. Minor quartz interstitial to plagioclase, K-feldspar and brown biotite. Syrene. 600 µm. cpl.



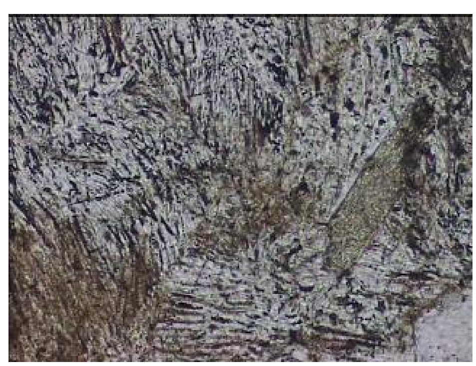
Two groups of igneous rock types are evident amongst the current Beluga petrology suite. The distribution of samples is such that the igneous rock most represented within the petrology suite is a quartz monzonite to quartz monzodiorite lithology. A quartz monzonite is represented in the one sample from Syrene. This intermediate intrusive rock type is characterised by less than 20% modal quartz, typically interstitial to a framework of anhedral to euhedral plagioclase and K-feldspar. Brown biotite is the dominant mafic mineral, present in proportions of up to 20% of the rock, and in some examples occurring together with ghosted/pseudomorphed amphibole (? hornblende). Magnetite with some exsolution of hematite is the dominant iron-titanium oxide mineral, although some amounts of ilmenite are present in some examples of this rock type. Some amounts of zircon are present, but apatite is generally more abundant as an "accessory" mineral.



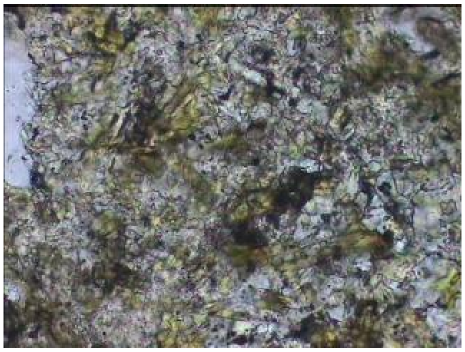
Left. 26025.01. Ilmenite intergrown with primary silicate minerals. 300 µm. ppl/rl.
Right. 26025.02. Magnetite with hematite exsolution lamellae in primary mineralogy. 300 µm. ppl/rl.

Textures amongst these intermediate rocks are predominantly equigranular, hypidiomorphic, with more euhedral plagioclase interposed with less euhedral K-feldspar, mostly microcline, and quartz. In some examples, mostly equigranular-textured rocks have local porphyritic variations, with phenocrysts of plagioclase, biotite and amphibole in plagioclase and K-feldspar-rich groundmasses. In some of these intermediate igneous rocks, there are widespread graphic intergrowths of quartz and K-feldspar, some forming overgrowths to plagioclase crystals.

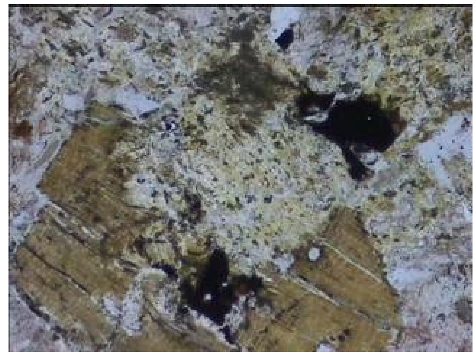
Left. 26025.02. Phenocrysts of ghosted biotite and amphibole in feldspar-rich groundmass. 1200 µm. ppl.
Right. 26025.10. Graphic intergrowth of K-feldspar and quartz interlocking with plagioclase and K-feldspar crystals. 600 µm. ppl.



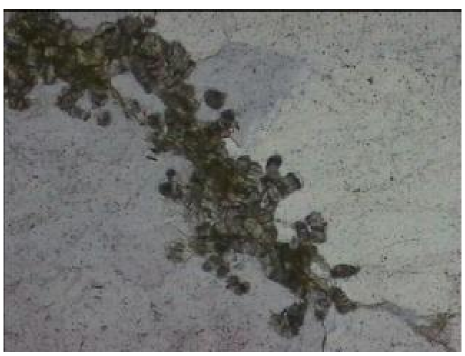
Earliest hydrothermal alteration of the intermediate igneous rocks is represented by secondary biotite, formed after amphibole and plagioclase, and where formed after amphibole is intergrown with very fine grained quartz and some secondary magnetite. Some amounts of muscovite are intergrown with biotite and quartz. In sample 26025.01, earliest hydrothermal effects are represented by muscovite and epidote after plagioclase in close spatial association with discrete quartz + epidote veinlets.



Left. 26025.10. Pervasive secondary biotite intergrown with quartz after amphibole. 600 μm. ppl.
Right. 26025.11. Secondary biotite after amphibole interlocking with primary biotite. 600 μm. ppl.

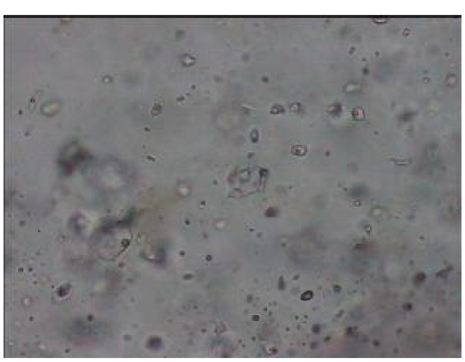


Quartz veining either in the form of drill chip fragments occurring together with intermediate igneous rock fragments or in more discrete form hosted by individual igneous drill chips, comprises mainly fine grained, anhedral to euhedral, tabular to prismatic quartz with some quartz crystal faces evident. Grains of feldspar are interlocking with the quartz and biotite is interstitial to the quartz or localised along discrete stringers. Some very fine to fine grained muscovite occupies the same paragenetic position as biotite.



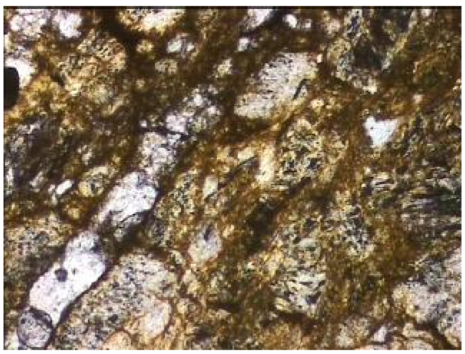
Left. 26025.05. Ghosted biotite intergrown with and interstitial to quartz of quartz veining. 1200 μm. ppl.
Right. 26025.05. Igneous style quartz veining with preservation of quartz crystal faces. 1200 μm. ppl.

Primary and pseudosecondary fluid inclusions hosted by quartz in the vein assemblages, and secondary fluid inclusions hosted by quartz of the wallrock lithology, comprise co-existing gas-rich/filled and aqueous liquid-rich types. Variable CO_2 is present in the gas-rich/filled inclusions and some of the aqueous liquid-rich types. Halite and less abundant hematite daughter crystals are present in the aqueous liquid-rich inclusions.



Left. 26025.05. Halite bearing aqueous liquid-rich inclusions occurring with less abundant gas-rich inclusions. 120 μm. ppl.
Right. 26025.11. Preserved biotite interstitial to quartz of quartz veining. 600 μm. ppl.

Locally strong sericitic or illitic alteration is associated with tectonic deformation of both the intermediate igneous rock and associated quartz vein material. Strongest deformation is represented by cataclastic textures in which angular fragments of relict/residual quartz are remobilised and rotated within shear planes developed with pervasive sericite/illite after plagioclase. Some amounts of preserved K-feldspar are plastically deformed and locally fragmented within the sheared domains. With the deformation, quartz of quartz veining has undulatory extinction, sub-grain boundary development, locally serrate grain boundaries, some recrystallisation along grain boundaries, and recrystallisation along multiple annealed shear planes. Also in association with deformation, mainly aqueous liquid-rich secondary fluid inclusions are localised/concentrated along multiple and penetrative annealed microshears and microfractures. Weaker illitic/sericitic clay alteration of plagioclase is associated with correspondingly weaker deformation. Residual plagioclase is altered mostly to kaolin clays with weathering, whereas K-feldspar is essentially preserved and impregnated with ultra fine-grained hematite.



Left. 26025.05. Late quartz veinlet traversing cataclastic texture and strong illitic clay alteration. 1200 µm. ppl. Right. 26025.11. Shear fabric and fluid inclusion trails overprinting igneous style quartz veining. 1200 µm. cpl.

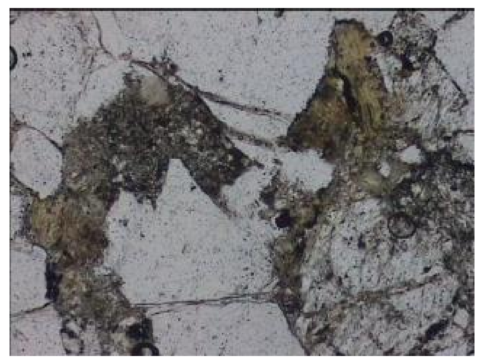
ACID IGNEOUS ROCKS (MONZOGRANITES)

TABLE 2. PETROGRAPHIC/MINERAGRAPHIC SUMMARY: ACID IGNEOUS ROCKS

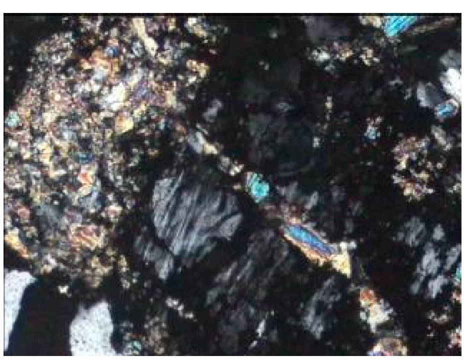
Sample	Comment	Lithology and Replacement	Deposition
26025.04 WRB447/ 42-48	Pseudosecondary and secondary fluid inclusions in quartz probably represent fluid exsolved from the crystallising granite. Abundant CO_2-bearing inclusions are present. There is a close spatial association between fluid inclusions and chalcopyrite inclusions.	Biotite monzogranite 1.muscovite 2.illitic clay 3.kaolin/smectite clays, goethite, hematite	1.(veinlet) hematite, goethite
26025.06 WRB419/	Abundant muscovite representing abundant aqueous fluids exsolved from crystallising rock. Quartz veining merges with quartz in the wallrock assemblage. Probable rock subjected to shearing and cataclasis in sample 26025.05. In this example strong muscovite alteration is not associated with tectonic deformation.	Biotite granitoid (monzogranite) 1.muscovite, biotite, rutile 2.illitic clay, rutile 3.kaolin/smectite clays	1.(veinlet) muscovite, biotite (→ kaolin/smectite clays) 2.(vein/cement) quartz, rutile, muscovite, tourmaline, biotite (→ chlorite/sericite), apatite, xenotime; carbonate 3.(veinlet) hematite, goethite

26025.08 WRB432/ 36-51	Strong shearing and hydrothermal alteration dominated and defined by sericite is locally developed within the granitoid rock. The strain fabric in quartz is represented by recrystallisation of quartz along shears. Some amounts of thermally metamorphosed mudstone are present amongst the drill chip assemblage but are devoid of strong strain fabrics.	Biotite granitoid and metamorphosed sedimentary rock 1.(granitoid) biotite, muscovite 1.(sediment) biotite, muscovite, Al-silicate minerals, tourmaline, ilmenite, rutile 2.sericite, quartz	1.(veinlet) muscovite,, biotite (→ chlorite, sericite), rutile, tourmaline 2.(veinlet) hematite, goethite
26025.09 WRB448/ 39-42	Hydrothermal alteration is represented by fine-grained muscovite after plagioclase and Ti-oxides (rutile) after primary Fe/Ti-oxides. Muscovite is coarser grained where it occurs in early fractures, and differs to pervasive sericite associated with penetrative strain fabrics in other granitoids of this study.	Biotite monzogranite 1.muscovite, pyrite, rutile 2.quartz 3.kaolin/smectite clays, hematite, goethite	1.(veinlet) muscovite 2.(veinlet), kaolin/smectite clays, goethite

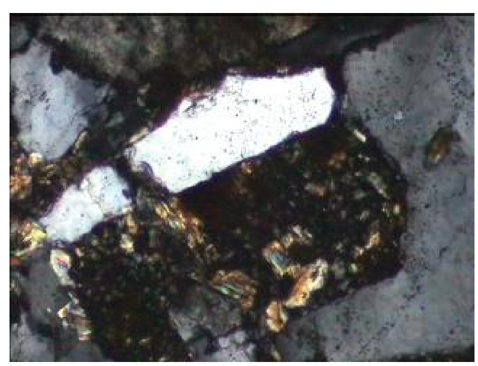
Left. 26025.09. Relatively coarser grained textures and pale red-brown K-feldspar.
Right. 26025.09. Abundant quartz enclosing ghosted euhedral plagioclase and interlocking with K-feldspar and brown biotite. 1200 µm. ppl.



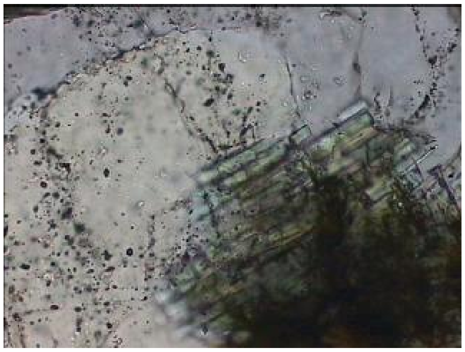
Also present amongst the drill chip petrology samples are medium grained acid igneous rock types characterised by greater than 20% modal quartz. Interlocking tabular to prismatic plagioclase and less euhedral, tabular quartz and K-feldspar (microcline) define crystalline hypidiomorphic textures amongst these rock types. Minor amounts of brown biotite and less abundant muscovite are interlocking with and interstitial to the framework feldspar and quartz. Zircon is present, and the primary iron-titanium mineral is partly preserved to pseudomorphed ilmenite.



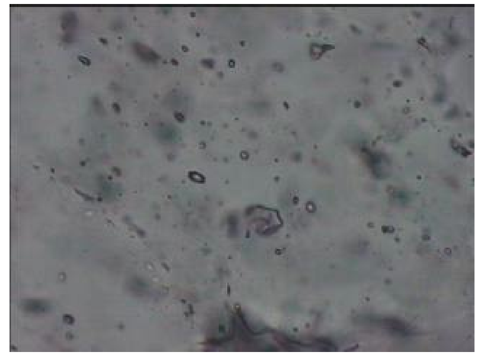
Left. 26025.09. Pervasive muscovite after plagioclase and muscovite veinlet traversing K-feldspar. 1200 µm. cpl.
Right. 26025.06. Relict muscovite after plagioclase amidst more pervasive kaolin clays. 1200 µm cpl.



Pervasive fine-grained muscovite after plagioclase linking with microfractures filled with fine-grained muscovite defines earliest hydrothermal alteration. Grains of ilmenite are altered to aggregates of rutile. Minor amounts of biotite, altered to chlorite and sericite, are intergrown with muscovite and rutile of the replacement and fracture filling assemblages. Grains of pyrite and chalcopyrite occur as inclusions within quartz together with secondary fluid inclusions. Ghosted or leached grains of pyrite are interlocking with the muscovite.



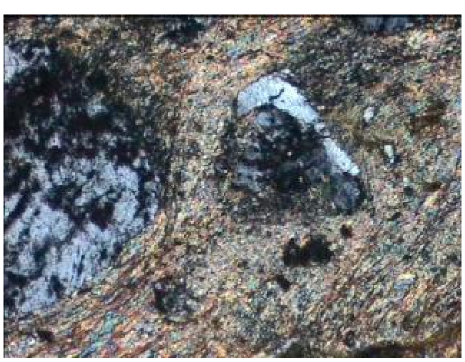
Left. 26025.06. Tourmaline intergrown with quartz in quartz veining with quartz host to abundant fluid inclusions. 300 µm. ppl.
Right. 26025.09. CO_2-rich fluid inclusions in primary quartz. 120 µm. ppl.



Early quartz veining that is genetically related to the early muscovite formed after plagioclase is limited to that observed in drill chip from sample 26025.05. The quartz is mainly anhedral and tabular in form, with some prismatic forms and preserved euhedral crystal faces. Grains and aggregates of tourmaline and muscovite, and less abundant grains of rutile, biotite and apatite are intergrown with or as inclusions within the quartz. Minor to trace amounts of carbonate are interstitial to the quartz. Primary fluid inclusions in the quartz of the quartz vein assemblage and secondary inclusions of the wallrock quartz comprise populations of abundant CO_2-rich/bearing, gas-rich/filled types coexisting with less abundant aqueous liquid-rich types.

Left. 26025.04. CO_2-rich inclusions in primary quartz. 120 µm. ppl.
Right. 26025.04. Chalcopyrite inclusion in primary quartz. 120 µm. ppl/rl.

Hydrothermal overprinting of early alteration represented mainly by muscovite, is dominated by sericitic/illitic clay strongest in domains of cataclasis. Sericitic/illitic clay has formed after muscovite and residual plagioclase, and in places angular, rotated and remobilised fragments of quartz and relict K-feldspar are enclosed by anastomosing selvages of sericitic/illitic clay.

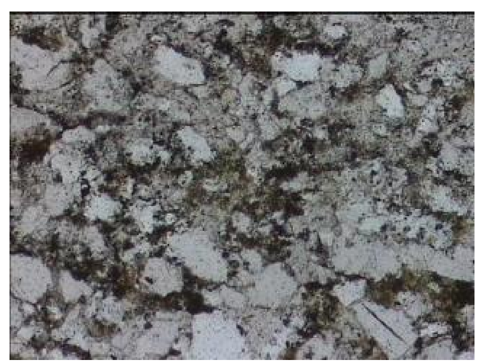


Left. 26025.08. Fragments of granitoid rock, quartz and K-feldspar enclosed within anastomosing sericitic matrix (after plagioclase) defining cataclastic texture. 1200 µm. cpl.
Right. 26025.08. as above. 1200 µm. ppl.

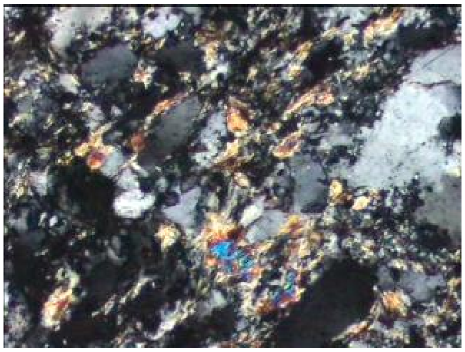
METAMORPHIC ROCKS

TABLE 3. PETROGRAPHIC/MINERAGRAPHIC SUMMARY: METAMORPHIC ROCKS.			
Sample	**Comment**	**Lithology and Replacement**	**Deposition**
26015.03 WRB445/ 42-45	A strain fabric is defined by preferred orientation of muscovite. Quartz veining appears syn to pre thermal metamorphism of the host sedimentary rock. Relict fluid inclusions in deformed igneous style quartz represent fluid flow during thermal metamorphism.	Mudstone and siltstone 1.(met) quartz, muscovite, biotite, Al-silicate minerals, rutile; muscovite 2.illitic clay 3.kaolin/smectite clays, hematite, goethite	1.(vein) quartz 2.(veinlet/vein) quartz, muscovite; quartz chlorite, biotite (→ chlorite)
26025.07 WRB412/ 35-36	Discrete quartz veining appears to have suffered the same degree of metamorphism and deformation as metasedimentary rocks. There is some preservation of euhedral quartz crystal faces amongst the quartz veins.	Sedimentary rock 1.(met) quartz, feldspar, Al-silicate minerals, biotite, tourmaline, rutile 2.illitic clay 3.smectite/kaolin clays, goethite	1.(veinlet) quartz 2.(veinlet) hematite, goethite
26025.08 WRB432/ 36-51	Strong shearing and hydrothermal alteration dominated and defined by sericite is locally developed within the granitoid rock. The strain fabric in quartz is represented by recrystallisation of quartz along shears. Some amounts of thermally metamorphosed mudstone are present amongst the drill chip assemblage but are devoid of strong strain fabrics.	Biotite granitoid and hornfelsed rock 1.(granitoid) biotite, muscovite 1.(sediment) biotite, muscovite, Al-silicate minerals, tourmaline, ilmenite, rutile 2.sericite, quartz	1.(veinlet) muscovite,, biotite (→ chlorite, sericite), rutile, tourmaline 2.(veinlet) hematite, goethite

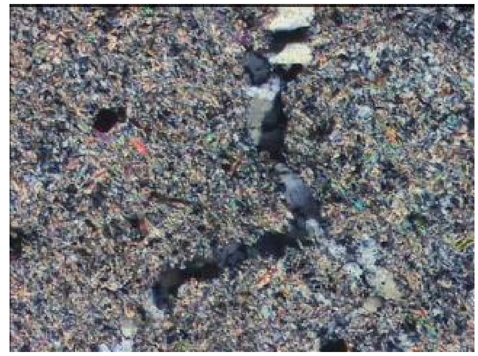
Left. 26025.07. Drill chips comprising metamorphosed sedimentary lithologies. Right. 26025.07. Relict fragmental texture in metamorphosed sedimentary rock. 1200 µm. ppl.



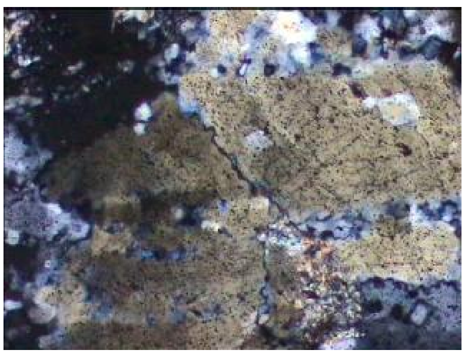
Sedimentary rocks including mudstones and muddy siltstones that are juxtaposed with the igneous rocks have recrystallisation or replacement textures indicative of thermal metamorphism. Detrital quartz is recrystallised or replaced by domains of granoblastic quartz intergrown with muscovite and less abundant biotite after domains of former clay or lower grade, regional metamorphic mica minerals. In some examples, ghosted Al-silicate minerals, altered to early fine-grained muscovite and later illitic clay, are present. Minor to trace amounts of tourmaline and rutile are intergrown with the framework mica and quartz assemblages. Preferred to sub-preferred orientation of muscovite defines penetrative strain fabrics in some parts of some lithologies.



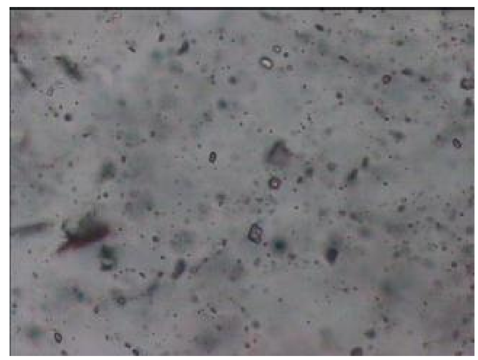
Left. 26025.03. Recrystallised quartz and fine grained muscovite defining metamorphic texture and superimposed strain fabric. 1200 μm. cpl.
Right. 26025.03. Deformed quartz veinlet in muscovite-rich metamorphosed mudstone. 1200 μm.



Quartz veining similar in style to that hosted by the intermediate and acid igneous rocks, is present in the thermally metamorphosed sedimentary rocks; either as discrete veinlets within wallrock chips or as chips of quartz vein material (26025.03). The quartz is mainly anhedral to subhedral in form with some euhedral quartz crystal faces present in some domains. Minor amounts of biotite and chlorite are interstitial to quartz of quartz veinlets. Relic pseudosecondary fluid inclusions in quartz vein fragments of sample 26025.03 comprise populations dominated by CO_2-rich/bearing, gas-rich/filled types co-existing with less abundant aqueous liquid-rich types (similar in proportions to that observed in quartz veining hosted by the granitic rocks.



Left. 26025.03. Deformed igneous style quartz veining, with granoblastic quartz along grain boundaries and shears. 600 μm. cpl.
Right. 26025.03. Locally preserved CO_2-rich fluid inclusions in domains of preserved igneous style quartz. 120 μm. ppl.



Tectonic deformation of the quartz veining together with the metamorphic host rock is evident. Quartz veinlets are monoclinally folded, with local recrystallisation of internal quartz and loss of euhedral quartz crystal faces. Within the more voluminous quartz veining, there is recrystallisation of quartz along penetrative shears and concentrations of secondary aqueous liquid-rich fluid inclusions along annealed micro-shears.

INTERPRETATIONS AND COMMENT

GEOLOGY

1. There is a correlation between geophysical signature and the three basic rock types defined in petrology. The primary and secondary magnetite bearing, relatively quartz-poor and biotite-rich quartz monzonite/monzodiorite rocks correlate with domains of rock with relatively high magnetic response (Figure 2). The primary ilmenite-bearing and quartz-rich monzogranite rock corresponds with domains of relatively low magnetic response (Figure 2). The metasedimentary rock has a magnetic response somewhere in between that of the acid igneous rock and the intermediate igneous rock (Figure 2). The monzonite rock from Syrene (26025.11) correlates with a magnetic signature similar to that for quartz monzonite rock from the Beluga area (Figure 2).

2. The interpretation of geophysical data in terms of the petrology of this study may provide a basis for interpreting the composition and chemistry of intrusions in the western Tanami and possibly other parts of the Tanami. According to the petrology of this study, the more magnetically responsive (and gravity responsive) intrusions may more intermediate in composition, similar to the quartz monzonite/monzodiorite rocks of this study. Furthermore, where magnetically responsive intrusions occur together with intrusions of low magnetic response (and low gravity response), this may provide evidence of some degree of magma differentiation and evolution through crystal fractionation. This appears to be supported by geochemical data (APS 26024).

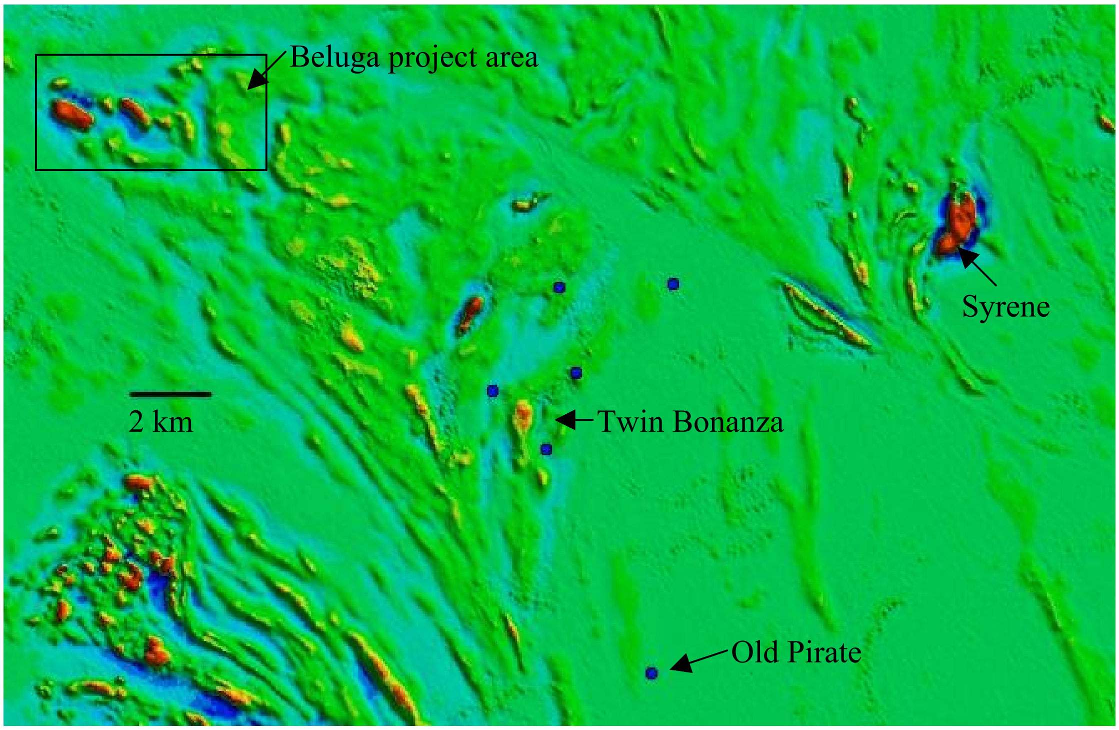


Figure 2a. Beluga project location and aeromagnetic data interpretation.

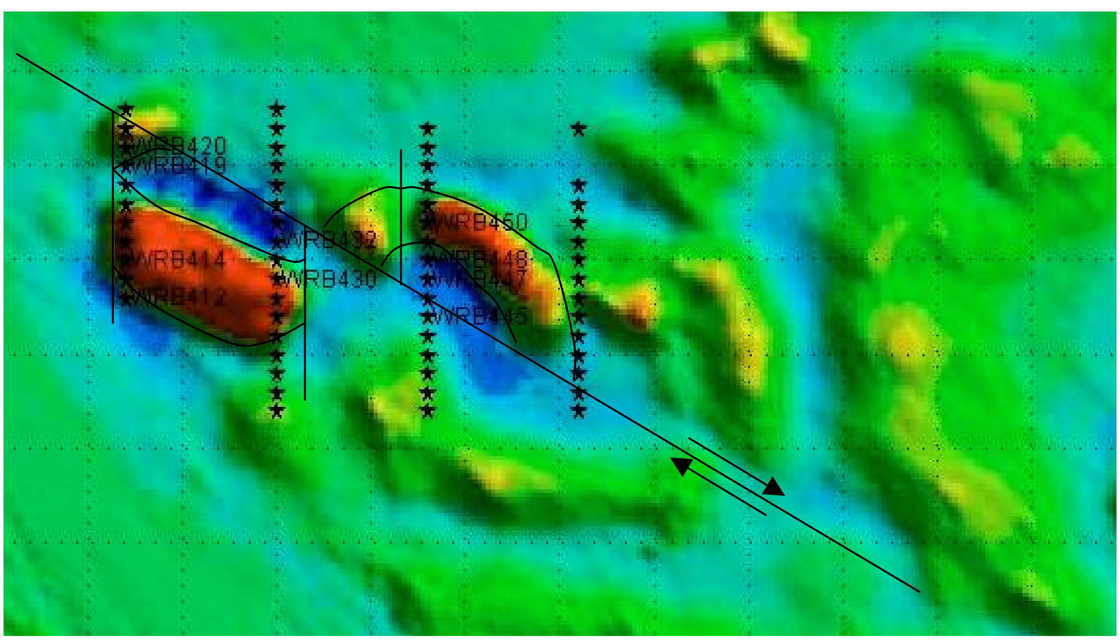


Figure 2b. Beluga project area and drill hole locations, identification of holes from which petrology samples were taken and geological interpretation. Grid spacing at 500 metres.

3. One possible interpretation of the distribution of igneous rock types in the Beluga prospect area, is dislocation of an annular or circular intrusion complex, similar that to which appears to be represented by the geophysical data at the site of the Mavericks intrusion complex (Figure 3 and 4). Part of the Mavericks intrusion complex comprises a magnetite bearing, hornblende and biotite-rich syenogranite (APS 26020), possibly co-existing with a centrally located magnetite-poor and relatively more quartz enriched granitoid. While the Mavericks annular structure is only marginally dislocated by a late northwest-southeast orientated fault, an annular structure at Beluga can be interpreted as bisected by a northwest-southeast orientated structure (Figure 3 & 4).

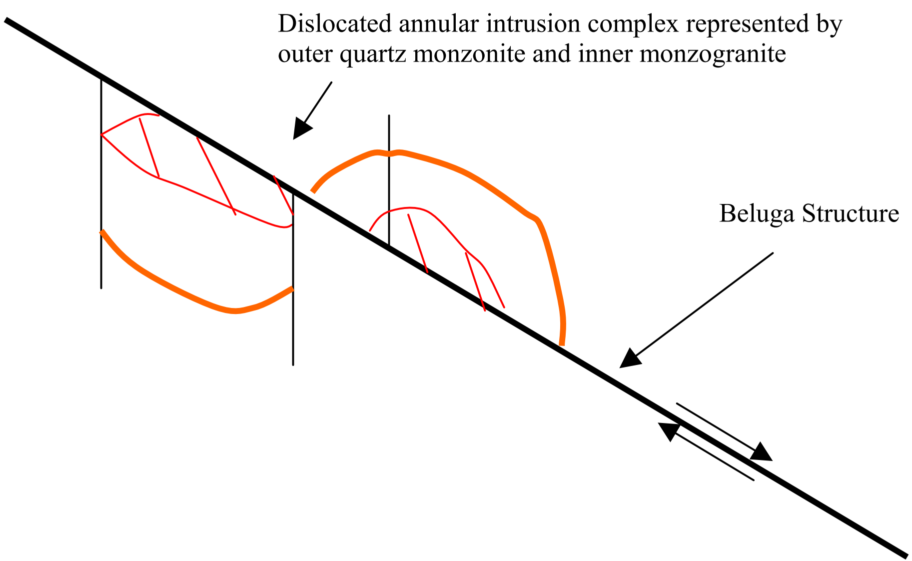


Figure 3. Geological interpretation. Mainly dextral (apparent and/or real) transcurrent offset of annular monzonite-monzogranite intrusion complex with some approximately north-south structural complication.

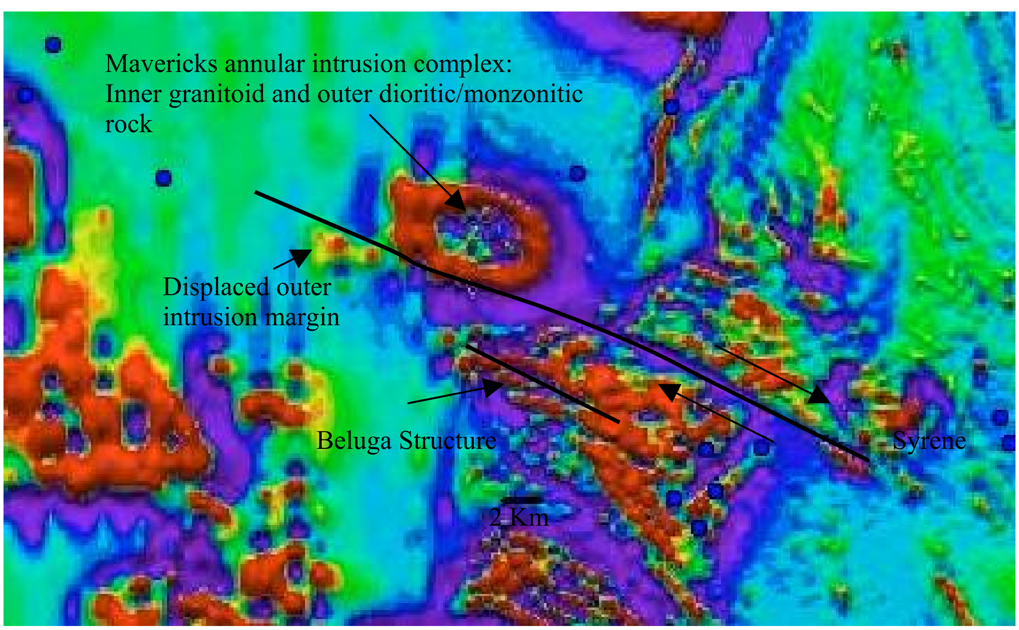


Figure 4. Mavericks, annular intrusion complex with some marginal transcurrent off-set of a more magnetically responsive outer intermediate to acid intrusion.

4. A bimodal occurrence of less evolved, magnetically responsive intrusions and magnetically unresponsive granitoids is also recognised at Twin Bonanza. The relatively magnetic responsive (and gravity responsive) entity to the west of the Beluga project area that is generally considered to be representative of the Balwina "granite", probably represents a mostly magnetite-bearing, melanocratic and relatively quartz-poor intrusion associated with less voluminous, younger and (geophysically less obvious) more evolved intrusions.

5. On a regional scale, fold geometry appears to have controledl the focus of emplacement of some of the smaller volume intrusions. Both the Beluga and Syrene intrusions are apparently positioned along regional fold axes, with later dislocation of both folded rocks and intrusions being along northwest-southeast orientated regional faults (Figure 2 and 4).

HYDROTHERMAL ENVIRONMENT

1. There is petrological evidence for earliest hydrothermal effects, including wallrock replacement and quartz veining, to be genetically related to both types of primary igneous rock type at Beluga: monzogranite and quartz monzonite/monzodiorite. This is also the case for earliest hydrothermal effects at Twin Bonanza, except at Twin Bonanza there is evidence of gold mineralisation associated with the early magmatic related hydrothermal history. Apart from some localised chalcopyrite associated with fluid inclusions in the monzogranite, no connection can be made between mineralisation and earliest hydrothermal fluid flow, at least in the current petrology suite. That the mineralisation is not identified in association with early magmatic hydrothermal fluid flow may be an issue of sampling, and not necessarily that there is no mineralisation associated with the early magmatic hydrothermal stage. Mineralisation may be associated with early magmatic hydrothermal fluid flow in both the monzonite and monzogranite rocks. The petrological data indicate that early magmatic hydrothermal fluid flow extended into the thermally metamorphosed sedimentary rocks.

2. The fluid inclusion data appear to identify a difference between the magmatic hydrothermal fluids associated with the quartz monzonite/monzodiorite rock and the fluids associated with the monzogranite rock. Magmatic fluids associated with the monzonite/monzodiorite rock appear to have been more saline and aqueous-rich, whereas those fluids exsolved from the monzogranite rock appear to have been richer in CO_2. In both examples of magmatic fluids, there is strong evidence for phase separation. The greater abundance of biotite in the hydrothermal alteration and deposition assemblages in the quartz monzonite/monzodiorite rock also appears to define a difference in the nature of early hydrothermal fluids in the two rock types.

3. Locally intense tectonically controlled, late-stage hydrothermal overprinting, represented by pervasive sericitic/illitic clay, has affected both the monzogranite and monzonite/monzodiorite rock types. The more intense sericitic/illitic clay alteration is found in samples most proximal to the northwest-southeast trending (Beluga) structure, which appears to bisect the granitoid intrusion complex. The paragenesis of pervasive sericitic/illitic clay alteration overprint to early magmatic style hydrothermal alteration at Beluga is consistent with a similar structurally controlled sericitic clay paragenesis at other known examples of intrusion related mineralisation: i.e. Twin Bonanza and Galifrey. As at the other locations, while there is some quartz veining associated with the sericitic/illitic clay overprint, it is minimal in comparison to the early magmatic related quartz veining. Mineralisation may be associated with or remobilised by the later structurally controlled hydrothermal stage.

APPENDIX ONE:

PETROGRAPHIC/MINERAGRAPHIC DESCRIPTIONS

SAMPLE NUMBER: 26025.01, 06408
LOCATION: Beluga, WRB0414/50-51
ROCK NAME: Weathered, biotite-rich quartz monzodiorite
FIELD DESCRIPTION: Metamorphic rock; possible hornfels or melanocratic igneous rock

OFFCUT DESCRIPTION:

The sample comprises a selection of angular granule to pebble-sized drill chips. The chips are of pale to medium grey to brown-grey, weathered and oxidised, biotite bearing medium grained granitoid rock.

THIN SECTION DESCRIPTION

LITHOLOGY: PRIMARY MINERALOGY, TEXTURES

The drill chips have primary fine to medium grained hypidiomorphic textures. The rock comprises a framework of tabular to prismatic, subhedral to euhedral plagioclase (oligoclase to andesine). Less abundant grains of anhedral, tabular K-feldspar (microcline), quartz and brown biotite are interlocking with or interstitial to the plagioclase. Quartz, alkali feldspar and plagioclase are present in the proportions: 15/15/70. Quartz has unitary extinction, and there is little evidence for strain in the rock. Apatite and zircon are present as inclusions in silicate minerals.
Grains of partly preserved to pseudomorphed ilmenite are interstitial to, interlocking with and as inclusions within the framework silicate assemblage. Graphic intergrowths of quartz and K-feldspar are present in some places.

ALTERATION

REPLACEMENT

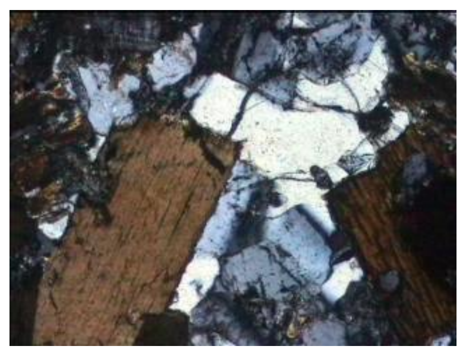
Alteration is moderate. Plagioclase is altered to early sericite/muscovite and epidote, later illitic clay and more pervasive, later kaolin and smectite clays. Biotite is altered to smectite and kaolin clays in some chips. Ilmenite is altered to hematite. K-feldspar is altered to very small amount of illitic clay and is impregnated with trace amounts of ultra fine grained hematite. Trace amounts of epidote have formed after biotite.

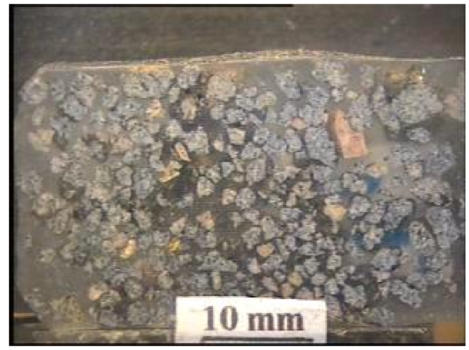
DEPOSITION

Microfractures are filled with hematite, goethite and smectite and kaolin clays.

COMMENTS

The primary lithology is a melanocratic granitoid: a biotite-rich quartz monzodiorite. Ilmenite is the Ti/Fe-oxide mineral present within the primary assemblage. Biotite comprises up to 20% of the rock, and quartz less than 20% of the rock. Deuteric sericite/muscovite has formed after plagioclase together with minor amounts of epidote. Graphic intergrowths of quartz and K-feldspar are present.
Right. Primary rock with biotite interlocking with feldspar and quartz. 1200 µm. cpl.





SAMPLE NUMBER: 26025.02, 06409
LOCATION: Beluga, WRB450/45-48
ROCK NAME: Biotite amphibole monzodiorite porphyry and granitoid
FIELD DESCRIPTION: Granitoid
OFFCUT DESCRIPTION:

The sample comprises a selection of angular granule-sized drill chips. The chips are of pale to medium brown grey to grey, weathered and oxidised, fine grained, biotite bearing intermediate igneous rock. Some veining is present.

THIN SECTION DESCRIPTION

LITHOLOGY: PRIMARY MINERALOGY, TEXTURES

The drill chips have moderately well preserved primary porphyritic textures. Tabular to prismatic, ghosted to partly preserved plagioclase and less abundant hornblende comprise the phenocrysts. Abundant tabular to prismatic, anhedral to euhedral plagioclase (andesine) dominates the groundmass texture. Grains of brown biotite are present in the groundmass and as phenocrysts. Very fine grained anhedral quartz (5%) and K-feldspar (10%) are interstitial to plagioclase and intergrown with biotite. In places the texture is more equigranular or pilotaxitic in nature. Coarser grained K-feldspar includes microcline. Biotite comprises 5 to 10% of the rock. Apatite is present. Abundant Fe/Ti-oxides present are partly preserved as magnetite. The magnetite has exsolution lamellae of hematite.

Present are sparse fragments of hypidiomorphic textured rock. Euhedral grains of plagioclase (oligoclase to albite) are interlocking with anhedral quartz and K-feldspar (microcline). Quartz, alkali feldspar and plagioclase are present in proportions: 35/25/40. Grains of biotite are present.

ALTERATION

REPLACEMENT

In early alteration of the intermediate igneous rock, epidote has formed after amphibole. For most of the rock, kaolin and smectite clays overprint some illitic clay after plagioclase. Kaolin and smectite clays have also formed after amphibole and biotite. Hematite has formed after magnetite.

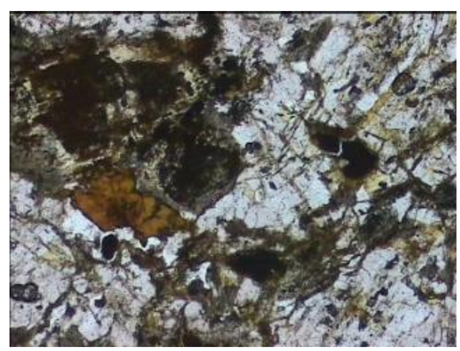
Within the acid igneous rock, illitic clay has formed after plagioclase, and K-feldspar is impregnated with ultra fine grained hematite.

DEPOSITION

Earliest microfracturing is filled with very fine grained K-feldspar and quartz. Later microfracturing is filled with epidote + quartz

COMMENTS

The predominant rock type is a biotite amphibole (hornblende) monzodiorite or monzodiorite porphyry. Minor amounts of granite are present in the drill chip assemblage. Early K-feldspar veining and later quartz + epidote veining represent deuteric alteration of the monzodiorite rock. Magnetite is the Fe/Ti-oxide mineral present in the intermediate rock.



Right. Ghosted hornblende phenocrysts in plagioclase-rich groundmass. 1200 µm. ppl.

SAMPLE NUMBER: 26025.03, 06410
LOCATION: Beluga, WRB445/42-45
ROCK NAME: Thermally metamorphosed, quartz veined mudstone and siltstone
FIELD DESCRIPTION: Metasediment and quartz veining
OFFCUT DESCRIPTION:

The sample comprises a selection of angular granule to pebble-sized drill chips. The chips are of pale brown-grey to grey-brown, weathered and oxidised metasedimentary rock and brown-grey quartz vein fragments.

THIN SECTION DESCRIPTION

LITHOLOGY: PRIMARY MINERALOGY, TEXTURES

For most metasedimentary rock fragments, poorly sorted, matrix to framework clast supported populations of silt-sized detrital fragments defines primary fragmental textures. Quartz dominates the detrital framework clast assemblages. Ghosted and poorly resolvable feldspar and rock fragments are present in some detrital framework clast assemblages. Detrital muscovite, tourmaline and zircon are present. Silt-sized detrital framework clasts, mainly quartz, are relatively few in some drill chip fragments representing metamorphosed mudstone lithologies.

ALTERATION

REPLACEMENT

Replacement or recrystallisation of the sedimentary rocks is strong to complete. Quartz is partly to mostly recrystallised. The quartz is intergrown with fine grained muscovite, which in places has a preferred or sub-preferred orientation defining a penetrative strain fabric. Mostly ghosted or partly preserved and more randomly orientated grains of biotite are interlocking with the quartz and muscovite. Ghosted Al-silicate minerals or feldspar is present in places. Rutile is present.

Al-silicate minerals are altered to very fine grained muscovite.

Biotite is altered to kaolin and smectite clays, whereas muscovite is masked and overprinted by ultra fine grained hematite and hydrated Fe-oxides.

DEPOSITION

Microfractures within the metamorphosed sedimentary rock are filled with very fine grained quartz. The quartz is anhedral and tabular in form and with undulatory extinction and sub-grain boundaries.

Vein fragments amongst the drill chips comprise fine to very fine grained anhedral, tabular quartz. The quartz has undulatory extinction and sub-grain boundaries. Recrystallisation along quartz grain boundaries and penetrative shears is represented by very fine grained granoblastic quartz. In some places the very fine grained granoblastic quartz is concentrated along penetrative shears and microshears (along which fluid inclusions are concentrated). Some more extensive domains of very fine grained granoblastic quartz are present in places, and serrate grain boundaries are present where recrystallisation is incipient. Chlorite and chlorite after biotite are interstitial to the quartz; some intergrown with granoblastic quartz.

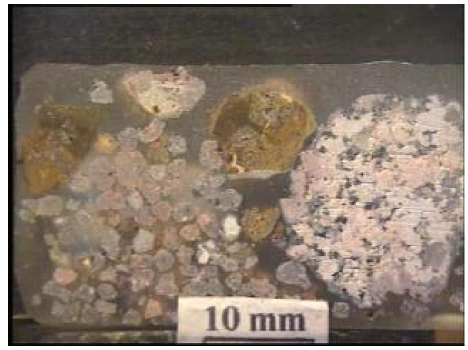
Abundant secondary fluid inclusions are concentrated along annealed microshears and microfractures that cross-cut host quartz grain boundaries. Domains of relict primary and pseudosecondary fluid inclusions comprise CO_2-bearing gas-rich and aqueous liquid-rich types.

COMMENTS

The drill chip is representative of thermally metamorphosed mudstone and muddy siltstone. A strain fabric is defined by preferred orientation of muscovite. Quartz veining is syn to pre thermal metamorphism of the host sedimentary rock. Relict CO_2-bearing/rich fluid inclusions in quartz represent fluid flow during thermal metamorphism rather than tectonic overprinting.

Right. Plastically deformed and folded quartz veinlet in metamorphosed mudstone. 1200 μm. ppl.

SAMPLE NUMBER: 26025.04, 06411
LOCATION: Beluga, WRB447/42-48
ROCK NAME: Biotite monzogranite



FIELD DESCRIPTION: granitoid

OFFCUT DESCRIPTION:

The sample comprises a selection of angular granule to pebble-sized drill chips. The chips are of pale grey to brown-grey, weathered and oxidised, fine to medium grained granitoid rock. Most of the chips comprise quartz with less abundant feldspar.

THIN SECTION DESCRIPTION

LITHOLOGY: PRIMARY MINERALOGY, TEXTURES

Primary hypidiomorphic textures are more evident within the pebble-sized drill chips fragments. Assemblages of interlocking, tabular, subhedral to euhedral plagioclase, and anhedral to subhedral quartz and K-feldspar (microcline) define the hypidiomorphic textures. Quartz, alkali feldspar and plagioclase are present in the proportions: 35/30/35. Grains of variably preserved brown biotite are interstitial to and interlocking with the quartz + feldspar assemblage. Quartz has undulatory extinction and some sub-grain boundary development, but no recrystallisation along grain boundaries. Ghosted or partly preserved ilmenite is interstitial to or as inclusions within the silicate assemblage. Zircon is present. Quartz is host to inclusions of chalcopyrite.

ALTERATION

REPLACEMENT

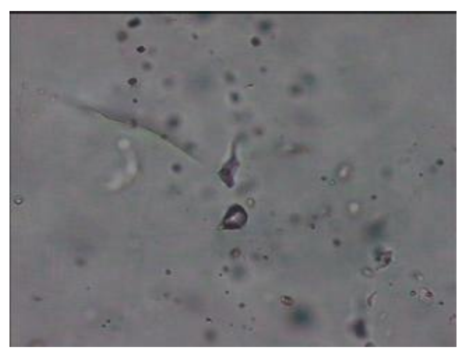
Plates or aggregates of sericite or fine grained muscovite have formed after plagioclase in some places (drill chips). More pervasive illitic clay and later kaolin clays have formed after plagioclase. Smectite and kaolin clays and ultra fine grained goethite have formed after biotite. Ultra fine grained hematite and goethite mask the primary silicate framework clast assemblage in some places.

DEPOSITION

Pseudosecondary and secondary fluid inclusions concentrated along annealed shears and microshears in quartz comprise co-existing, CO_2-bearing gas-rich/filled and aqueous liquid-rich types. Halite daughter salts are present in some aqueous liquid-rich inclusions.
Late microfractures and fractures are filled with hematite and goethite.

COMMENTS

The rock represented by drill chip is a biotite syenogranite. Early sericite/muscovite represents deuteric alteration. Pseudosecondary and secondary fluid inclusions in quartz probably represent fluid exsolved from the crystallising granite. Abundant CO_2-bearing inclusions are present. There is a close spatial association between fluid inclusions and chalcopyrite inclusions.
Right. CO_2-rich (gas + liquid) secondary inclusion in framework quartz to granite lithology. 120 μm. ppl.



SAMPLE NUMBER: 26025.05, 06412
LOCATION: Beluga, WRB420/47-48
ROCK NAME: Hydrothermally altered, sheared and deformed, quartz veined, intermediate to acid igneous rock
FIELD DESCRIPTION: Metasediment and quartz vein material.

OFFCUT DESCRIPTION:

The sample comprises a selection of angular pebble-sized drill chips. The chips are of pale brown-grey to yellow-grey, strongly weathered, and sheared deformed igneous rock. Also present are fragments of grey quartz vein material.

THIN SECTION DESCRIPTION

LITHOLOGY: PRIMARY MINERALOGY, TEXTURES

Fragments of wallrock lithology have very poorly preserved primary equigranular textures. Ghosted, interlocking felsic minerals (feldspar and/or Al-silicate minerals), biotite and relict quartz define the equigranular textures. Quartz is estimated to have comprised no more than 10 to 15% of the rock. Ghosted Fe/Ti-oxides are evenly distributed about the rock.

The rock has been strongly sheared and deformed, resulting in a cataclastic texture. Primary quartz has been fragmented; smeared and remobilised within multiple shear-planes the focus of abundant secondary clay minerals.

ALTERATION

REPLACEMENT

With the exception of quartz, replacement is complete. Some amounts of ghosted, early biotite are present, locally intergrown with muscovite after plagioclase. Most felsic mineralogy (feldspar?) is altered to pervasive illitic/sericitic clay and later kaolin clays. Primary and secondary biotite is altered to early sericite and chlorite, and later smectite and kaolin clays and hydrated Fe-oxides.

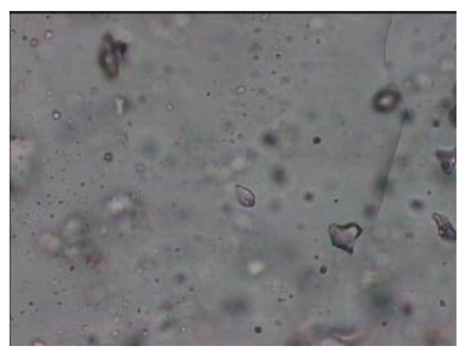
DEPOSITION

Angular vein fragments comprise mainly fine grained, anhedral to subhedral tabular quartz. Some faceted quartz crystal faces are present. Selvages of biotite (→ chlorite) are interstitial to quartz, and biotite stringers are present. The quartz has undulatory extinction and sub-grain boundary development, but there is no recrystallisation except along discrete penetrative shears. Selvages of biotite (→ smectite/kaolin clays) are present at wallrock-vein margins. Selvages of muscovite are interstitial to quartz in places.

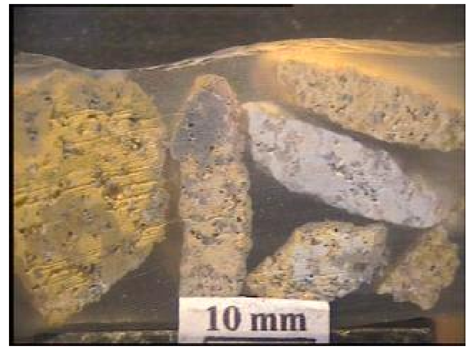
The quartz is host to pseudosecondary and secondary fluid inclusions comprising co-existing aqueous liquid-rich and CO_2-bearing, gas-rich/filled types. Aqueous liquid-rich inclusions contain halite and hematite daughter minerals. Other transparent daughter minerals are present. Some CO_2 is present in halite-bearing aqueous liquid rich inclusions.

COMMENTS

The poorly preserved primary equigranular textures may be interpreted in terms of hypidiomorphic (igneous intrusion) textures. Quartz vein material appears to be igneous in style. Co-existence of the aqueous liquid-rich and gas-rich inclusion indicates phase separation, enhanced by the high salinity of the fluids. Sericitic alteration is centred upon strong shearing and cataclasis. Quartz veining similar in style to that from Syrene.



Right. Halite daughter salt in aqueous liquid-rich fluid inclusion. 120 µm ppl.



SAMPLE NUMBER: 26025.06, 06413
LOCATION: Beluga, WRB419
ROCK NAME: Quartz veined and hydrothermally altered acid igneous rock.
FIELD DESCRIPTION: Porphyry textured rock
OFFCUT DESCRIPTION:

The sample comprises a selection of angular to subangular pebble-sized drill chips. The drill chips are of pale to medium brown grey to brown, weathered and oxidised, medium to fine grained metamorphic or igneous rock. Quartz veining is present in some drill chip fragments.

THIN SECTION DESCRIPTION

LITHOLOGY: PRIMARY MINERALOGY, TEXTURES

The drill chips have poorly preserved crystalline, equigranular to inequigranular textures. The rock is composed mainly of interlocking quartz, alkali feldspar (microcline) and (ghosted/pseudomorphed) plagioclase in proportions of approximately: 25/30/45. Partly preserved to ghosted crystals of brown biotite are interlocking with quartz and feldspar. Ghosted/pseudomorphed grains of ilmenite are present. Plagioclase is preserved as inclusions in quartz. Grains of zircon are present. In places plates of muscovite are enclosed by granoblastic textured quartz. Ghosted biotite grains poikilitically enclose quartz and muscovite. Quartz has undulatory extinction and sub-grain boundary development, triple-point junctions, but no recrystallisation along grain boundaries.

ALTERATION

REPLACEMENT

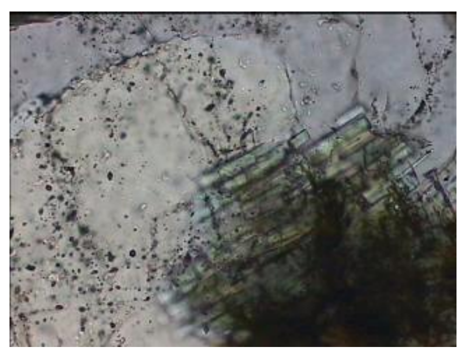
Alteration is strong. Plagioclase is replaced by pervasive aggregates of muscovite and ghosted biotite. Biotite is altered to pervasive kaolin and smectite clays.
Hematite and hydrated Fe-oxides form overprints to early mica and late clay minerals.

DEPOSITION

Early microfractures are filled with muscovite and more abundant biotite (→ kaolinite/smectite).
Irregular fractures are host to fine to very fine grained anhedral to euhedral quartz. Some euhedral quartz crystal faces are present. The quartz has undulatory extinction and some sub-grain boundary development but no recrystallisation along grain boundaries or serrate grain boundaries. Grains of rutile are interlocking with and as inclusions within quartz. Grains of biotite (→ chlorite/sericite), muscovite and tourmaline are intergrown with and as inclusions within the quartz. Grains of carbonate, xenotime and apatite occur as inclusions within the quartz.
Quartz (of vein and wallrock) is host to mainly CO_2-bearing gas-rich/filled primary and pseudosecondary fluid inclusions co-existing with minor amounts of aqueous liquid-rich inclusions.
Late microfracturing is filled with hematite and goethite.

COMMENTS

The rock is a strongly metasomatised monzogranite or endoskarn. Abundant muscovite representing abundant aqueous fluids exsolved from crystallising rock. Quartz veining merges with quartz in the wallrock assemblage. In this example strong muscovite alteration is not associated with tectonic deformation.
Right. Tourmaline intergrown with and interstitial to quartz. Abundant pseudosecondary gas-rich/filled inclusions are present. 300 µm. ppl.



SAMPLE NUMBER: 26025.07, 06414
LOCATION: Beluga, WRB412/35-36
ROCK NAME: Thermally metamorphosed and deformed quartz veined sedimentary rock.
FIELD DESCRIPTION: Metasedimentary rock

OFFCUT DESCRIPTION:

The sample comprises a selection of angular pebble-sized drill chips. Drill chips comprise pale to medium red-brown to yellow-brown, oxidised and weathered, metasedimentary rock. Discrete quartz veining is present in some drill chip fragments.

THIN SECTION DESCRIPTION

LITHOLOGY: PRIMARY MINERALOGY, TEXTURES

The drill chips have variably well preserved primary fragmental textures. Moderately well sorted, matrix to framework clast supported populations of ghosted silt-sized framework clasts defines the fragmental textures. Amongst the coarser grained fragmental textures, quartz dominates the detrital framework clast assemblages. Ghosted feldspar and rock fragments are present amongst the framework clast assemblages. Chert rock fragments are present. Within the finer grained fragmental textures, minor amounts of silt-sized detrital quartz fragments are interposed with a metamorphosed clay assemblage. Detrital muscovite and zircon are present.

ALTERATION

REPLACEMENT

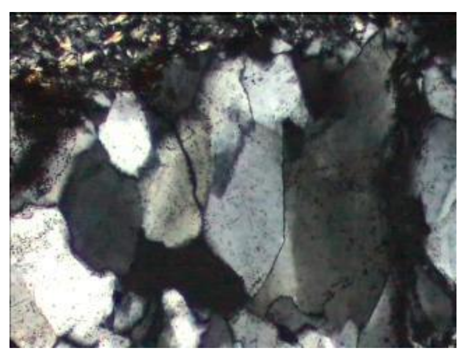
Metamorphic replacement/recrystallisation is complete. In the coarser grained lithologies, detrital quartz is recrystallised and intergrown with feldspar and/or Al-silicate minerals. Quartz is granoblastic in texture in places. Feldspar and Al-silicate minerals are altered to early illitic clay and later smectite/kaolin minerals. Grains of biotite are present and altered to smectite and kaolin clays and goethite. Within the finer grained lithologies, pervasive sericite or fine grained muscovite has formed after early mica or clay minerals. Grains of secondary tourmaline are present. Quartz has undulatory extinction and some sub-grain boundary development. Grains of rutile are present.

DEPOSITION

Microfractures are filled with fine to very fine grained quartz. The quartz is anhedral to subhedral in form, has undulatory extinction and sub-grain boundary development. There is extensive recrystallisation along grain boundaries and discrete shears. Some relict euhedral quartz crystal faces are present.
Late fracturing is filled with hematite and goethite.

COMMENTS

Discrete quartz veining appears to have suffered the same degree of metamorphism and deformation as sedimentary rocks. There is some preservation of euhedral quartz crystal faces amongst the quartz veins.



Right. Partly preserved euhedral quartz crystal faces amongst plastically deformed quartz of quartz veinlets. 600 µm cpl.

SAMPLE NUMBER: 26025.08, 06415
LOCATION: Beluga, WRB432/36-51
ROCK NAME: Locally sheared and hydrothermally altered, biotite granitoid and hornfelsed rock
FIELD DESCRIPTION: Granitoid and quartz vein material
OFFCUT DESCRIPTION:

The sample comprises an assemblage of mainly granule-sized angular drill chip fragments. The chips are of medium grey to brown grey, oxidised and weathered, fine grained granitoid and less abundant metasedimentary rock.

THIN SECTION DESCRIPTION

LITHOLOGY: PRIMARY MINERALOGY, TEXTURES

The predominant rock type represented by the drill chip assemblage is hypidiomorphic in texture. Interlocking anhedral quartz, subhedral to anhedral K-feldspar and tabular to prismatic plagioclase comprise the framework assemblage. Quartz, alkali feldspar (microcline) and plagioclase are present in the proportions: 35/30/35. Grains of biotite are interlocking with the quartz and feldspars. Quartz has undulatory extinction and sub-grain boundary development. Grains of zircon are preset. Ghosted grains of ilmenite are interlocking with or as inclusions within the framework silicate assemblage. Quartz is host to abundant pseudosecondary and secondary fluid inclusions. Abundant CO_2-bearing gas-rich/filled and less abundant co-existing aqueous liquid-rich inclusions comprise the fluid inclusion types.

Present are drill chip fragments with relict primary fragmental textures (metasediments). Secondary mica minerals replace a former detrital clay or low-grade mica assemblage.

ALTERATION

REPLACEMENT

Alteration of the igneous rock is weak to moderate. Plates of brown biotite and muscovite have formed after plagioclase. In some places muscovite is pervasive after plagioclase where there is strong shearing and local cataclasis. The pervasive sericite is locally intergrown with very fine to ultra fine grained quartz. Residual plagioclase is altered to kaolin and smectite clays overprinted by goethite. K-feldspar is locally impregnated with ultra fine grained hematite. Ilmenite is altered to hematite.

Plastic deformation of quartz is characterised by undulatory extinction, sub-grain boundary development, recrystallisation along grain boundaries and shears, and crenulate grain boundaries.

Metamorphic replacement/recrystallisation of the sedimentary lithologies is complete. Interlocking brown biotite, muscovite and ghosted Al-silicate minerals dominate replacement. Minor amounts of equigranular quartz are present. Grains of tourmaline, ilmenite and rutile are present. Al-silicate minerals are altered to sericitic/illitic clay.

DEPOSITION

Abundant muscovite and biotite (→ chlorite and sericite) have formed along some shears and microfractures. Grains of rutile and tourmaline are intergrown with the mica minerals.

Late microfractures and residual cavities are filled with hematite and goethite.

COMMENTS

The main rock type is a biotite granite. Strong shearing and hydrothermal alteration dominated and defined by sericite is locally developed within the granitoid rock. The strain fabric in quartz is represented by recrystallisation of quartz along shears. Some amounts of thermally metamorphosed mudstone are present amongst the drill chip assemblage but are devoid of strong strain fabrics. Many CO_2-filled inclusions are present in igneous quartz.

Right. Pervasive sericite, shearing and cataclastic textured domain in granite. 1200 μm. ppl.

SAMPLE NUMBER: 26025.09, 06416
LOCATION: Beluga, WRB448/39-42
ROCK NAME: Weathered, hydrothermally altered and muscovite veined biotite monzogranite
FIELD DESCRIPTION: Granitoid/porphyry rock

OFFCUT DESCRIPTION:

The sample comprises a selection of angular pebble-sized drill chips. Drill chips are of mottled pale to medium brown-grey to grey-brown, oxidised and weathered, medium to fine grained granitoid. K-feldspar is pale brown in colour.

THIN SECTION DESCRIPTION

LITHOLOGY: PRIMARY MINERALOGY, TEXTURES

The drill chips have moderately well preserved primary hypidiomorphic textures. Interlocking anhedral, tabular quartz, tabular, anhedral K-feldspar (microcline) and ghosted/pseudomorphed, subhedral plagioclase, comprise the hypidiomorphic assemblage. Euhedral grains of ghosted plagioclase are partly to totally enclosed by anhedral quartz. Quartz, alkali feldspar and plagioclase occur in proportions: 35/25/40. Grains of anhedral biotite are interlocking with the quartz and feldspar crystals. Ghosted Fe/Ti-oxides (ilmenite) are present. Relict grains of zircon are also present as inclusions within silicate minerals. Quartz has weak undulatory extinction and some localised sub-grain boundary development. Euhedral biotite occurs as inclusions in quartz and ghosted plagioclase.

ALTERATION

REPLACEMENT

Replacement is strong. Plagioclase is altered to early fine grained muscovite and later, more pervasive kaolin clays. Kaolin clays have formed after fine grained muscovite. Biotite is partly altered to smectite and kaolin clays intergrown with goethite. K-feldspar is impregnated with ultra fine grained hematite. Primary Fe/Ti-oxides are altered to Ti-oxides including rutile. Quartz is recrystallised along grain boundaries in places in associated with deformation overprinting. Secondary muscovite is locally deformed in association with tectonic overprinting.

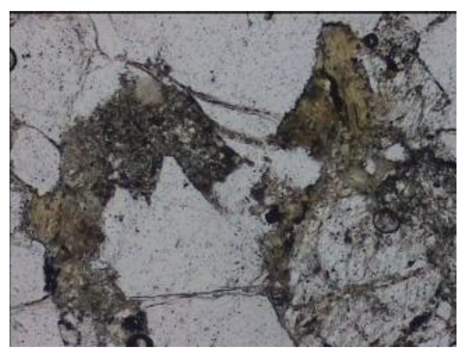
Quartz is host to abundant secondary/pseudosecondary CO_2-rich gas-rich/filled inclusions co-existing with less abundant aqueous liquid-rich inclusions. Pyrite inclusions are present with the fluid inclusions.

DEPOSITION

Early microfracturing is filled with fine grained muscovite.

Late microfracturing is filled with kaolin and smectite clays and goethite.

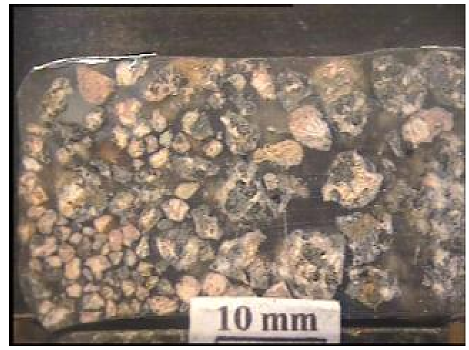
COMMENTS



The rock is a monzogranite. Hydrothermal alteration is represented by fine grained muscovite after plagioclase and Ti-oxides (rutile) after primary Fe/Ti-oxides. K-feldspar is mostly preserved and only impregnated with ultra fine grained hematite as part of the weathering overprint. Muscovite is coarser grained where it occurs in early fractures, and differs to pervasive sericite associated with penetrative strain fabrics in other granitoids of this study.

Right. Interlocking euhedral, ghosted plagioclase and less euhedral preserved quartz, K-feldspar and biotite. 1200 µm. ppl.

SAMPLE NUMBER: 26025.10, 06417
LOCATION: Beluga, WRB430
ROCK NAME: Locally potassic altered, biotite quartz monzonite
FIELD DESCRIPTION: Thermal metamorphic or igneous rock
OFFCUT DESCRIPTION:



The sample comprises a selection of angular, mainly granule-sized drill chips. The chips are of medium brown-grey to brown, oxidised and weathered, biotite-bearing/rich, fine grained intermediate igneous rock. K-feldspar is pale to medium brown in colour.

THIN SECTION DESCRIPTION

LITHOLOGY: PRIMARY MINERALOGY, TEXTURES

The drill chips have moderately well preserved primary hypidiomorphic textures. Interlocking quartz, alkali feldspar (microcline) and plagioclase (andesine) are present in the proportions: 15/50/35. Euhedral, tabular to prismatic, partly preserved plagioclase is interlocking with or enclosed by more abundant, anhedral, tabular K-feldspar. Relatively minor amounts of anhedral quartz are interstitial to the feldspar crystals. Domains of graphically intergrown K-feldspar and quartz are present in many places. Brown biotite (up to 20% of the rock) is interlocking with quartz and feldspar crystals, integral to the framework assemblage. Ghosted amphibole crystals are interlocking with other silicate minerals. Grains of euhedral apatite occur as inclusions within the silicate minerals. Less abundant grains of zircon are present. Ultra fine grained pyrite occurs as inclusions in quartz of graphic quartz + K-feldspar intergrowths. Grains of partly preserved magnetite are interstitial to and as inclusions within framework silicate minerals. Trace amounts of chalcopyrite occur as inclusions in silicate minerals. Quartz has only weak undulatory extinction and sub-grain boundary development. Graphic intergrowths of quartz and K-feldspar form overgrowths to euhedral plagioclase crystals.

ALTERATION

REPLACEMENT

Alteration is moderate to strong. Aggregates of secondary, very fine grained biotite have formed after plagioclase in some places. Plagioclase is more pervasively altered to illitic clay. Some very fine grained secondary biotite has formed about primary biotite margins. Aggregates of secondary biotite are locally abundant, totally replacing plagioclase crystals. Intergrowths of very fine grained biotite and quartz replace amphibole. Fine grained muscovite is intergrown with biotite in some places. Smectite clays and goethite have formed after primary and secondary biotite.

Secondary and pseudosecondary fluid inclusions in quartz comprise mainly aqueous liquid-rich types co-existing with less abundant CO_2-bearing gas-rich/filled types. In some drill chips the aqueous liquid-rich inclusions contain halite and hematite daughter minerals. Magnetite is mostly altered to hematite.

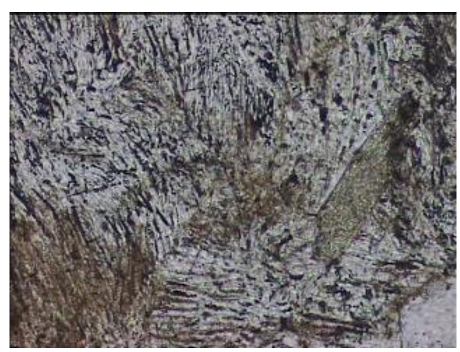
DEPOSITION

Early microfracturing is filled with very fine grained platy biotite.
Late microfracturing is filled with hematite and goethite.

COMMENTS

The rock is a biotite quartz monzonite. Apatite is more abundant than zircon. Early hydrothermal alteration is represented by very fine grained brown biotite after plagioclase, intergrown with quartz after amphibole, and about the margins of primary biotite. Saline, aqueous liquid-rich inclusions are more abundant than gas-rich inclusions.

Right. Graphic intergrowths of quartz and K-feldspar (impregnated with ultra fine grained hematite). 300 μm. ppl.



SAMPLE NUMBER: 26025.11, 06418
LOCATION: Syrene
ROCK NAME: Sheared/deformed, illitic clay altered, potassic altered and quartz veined biotite quartz monzonite
FIELD DESCRIPTION: Porphyry/granitoid
OFFCUT DESCRIPTION:

The sample comprises a selection of angular to subangular granule to pebble-sized drill chips. The chips comprise pale to medium grey-brown, weathered/oxidised fine grained intermediate igneous rock and equally abundant grey to brown-grey quartz vein fragments.

THIN SECTION DESCRIPTION

LITHOLOGY: PRIMARY MINERALOGY, TEXTURES

Drill chips with igneous lithologies have moderately well preserved primary hypidiomorphic to porphyritic textures. Variably preserved phenocrysts are contained in fine grained, equigranular textured groundmasses. Partly preserved plagioclase, ghosted amphibole and well-preserved brown biotite and K-feldspar (sanidine) comprise the phenocrysts. The groundmass is composed mainly of equigranular, anhedral K-feldspar and more euhedral plagioclase (andesine). Grains of brown biotite are interlocking with the feldspar. Grains of anhedral quartz are present. Euhedral apatite occurs as inclusions within the silicate minerals. Grains of magnetite or partly preserved magnetite are disseminated about the silicate assemblage.

ALTERATION

REPLACEMENT

Alteration is strong. Secondary, fine to very fine grained brown biotite has formed after amphibole and plagioclase. In places the biotite appears to be intergrown with very fine grained muscovite. Some grains of secondary magnetite are associated with the secondary biotite. Illitic clay has formed after some residual plagioclase. Smectitic and kaolin clays have formed after early and late biotite and any remaining plagioclase. Smectitic and kaolin clays are pervasive after domains of strong brittle deformation. Magnetite is altered to hematite.

DEPOSITION

Fractures within the igneous rock are filled with and the vein lithologies of drill chips mainly comprise, fine to medium grained, tabular to prismatic, subhedral to anhedral quartz. Plates and selvages of brown biotite are interstitial to and interlocking with the quartz. Grains of anhedral K-feldspar are interlocking with the quartz.

The quartz together with biotite and K-feldspar has been deformed. Undulatory extinction and sub-grain boundary development mostly defines the deformation. Grain boundaries are serrate to crenulate in form in places. Fluid inclusions have been locally decrepitated. Preserved fluid inclusions comprise co-existing CO_2-bearing gas-rich/filled types and aqueous liquid-rich types. Halite daughter minerals are present in the aqueous liquid-rich types. Late secondary fluid inclusions are concentrated along discrete, annealed, penetrative shears within the quartz. There is recrystallisation of quartz along these shears also. Aqueous liquid-rich inclusions are concentrated along late annealed shears.

Late microfracturing is filled with and brecciation cemented with smectite and kaolin clays intergrown with goethite. Some microfractures are filled with colloform banded hematite.

COMMENTS

A biotite quartz monzonite. The rock has less than 10% primary modal quartz. Strong potassic alteration, represented by secondary biotite, is associated with quartz veining. The quartz veining is deformed in association with tectonic overprinting. Compares favourably with the monzonitic rocks from Beluga.

Right. Biotite interstitial to and interlocking with quartz.