

## APPENDIX A3

### PETROGRAPHIC DESCRIPTIONS OF POLISHED SECTIONS FROM THE GEORDIE LAKE INTRUSION AND SURROUNDING ROCKS (SYENITE AND KEEWEENAWAN BASALT), NORTHERN ONTARIO

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#### **11AV-M03A (puck) Altered Hornblende-gabbro**

#### **Geordie Lake**

**Description:** ~7 % coarse (up to 3 mm) grains of strongly lobed magnetite are intergrown with even coarser MgFe-silicate (olivine ? – ~12%) altered by very fine-grained secondary magnetite around the edges and along fractures (no cleavage). Abundant euhedral tapered apatite crystals pierce silicate assemblage, which contains extensive alteration patches. Trace sulphides (very fine-grained euhedral secondary pyrite and anhedral chalcopyrite) occur in silicates.

#### **11AV-M03B (PTS) Altered Hornblende-gabbro**

#### **Geordie Lake**

**Description:** medium- to coarse-grained altered gabbro consisting of tabular plagioclase intergrown with MgFe-silicates, lobed magnetite and fairly coarse euhedral apatite. The assemblage shows complex alteration: tabular plagioclase is fractured and altered by albite, K-feldspar and biotite. Anhedral diopside is partially replaced by beige amphibole (amphibole 2); coarse anhedral primary tan edenitic hornblende (amphibole 1) is replaced by secondary, green actinolitic hornblende (amphibole 3). There are extensive magnetite-actinolite-pseudomorphs after a primary MgFe-silicate (olivine), thick brown biotite alteration rims around opaques and magnetite-pseudo-morphs and interstitial pockets of very fine-grained secondary biotite containing aggregates of secondary euhedral green actinolite. Prehnite is intergrown with calcite and pumpellyite in the upper left corner of the section. Two more varieties of pumpellyite occur – an intense green pumpellyite rimming sulphides in circle 4 and a Fe<sup>3+</sup>-rich variety (julgoldite) forming extensive alteration patches. Coarse lobed solid magnetite contains densely spaced ilmenite exsolution lamellae. Two patches of coarse anhedral chalcopyrite contain sphalerite inclusions (transparent deep red-brown) and tiny skeletal sphalerite stars and trace galena. Secondary lace-like pyrite occurs in silicate alteration.

**Plagioclase** (40%) medium- to coarse-grained subhedral fractured, moderately to strongly altered laths

**Diopside** (13 %) medium-grained anhedral brownish grains interstitial to plagioclase, rimmed and veined by fine-grained green alteration (chlorite-actinolite?)

**Calcite** (0.5%) medium-grained anhedral grains in scapolite and other silicates

**Biotite** (9%) primary brown anhedral biotite is rare (tr.) intergrown with magnetite-actinolite pseudomorphs and opaques; very fine-grained coffee brown secondary biotite is abundant as alteration rims on pseudomorphs and intergrown with fine-grained euhedral actinolite in alteration patches and veining fractures in plagioclase

**Hornblende** (3%) tan to greenish brown primary amphibole overgrowing clinopyroxene and itself replaced by green actinolitic hornblende.

**Actinolite** (10%) medium- to fine-grained euhedral pale to intense blue-green pleochroic euhedral overgrowing primary tan hornblende and fine-grained acicular in brown patches of secondary biotite

**Chlorite** ( tr.) pale green in sheaves or radiating aggregates with anomalous blue ifc. associated with actinolite

**Prehnite** (2% ) colourless, low-relief radiating aggregates with 1st order ifc. intergrained with calcite and pumpelleyite

**Julgoldite** (tr.) brownish low-relief micaceous aggregates with very low ifc.

**Pumpellyite** (2%) a) colourless to brownish low-relief micaceous aggregates with very low ifc.; b) blueish green rims around sulphides in circle 4.

**Apophyllite** (tr.) medium-grained blocky low-relief colourless and anhedral reddish tinged masses with low ifc. intergrown with green amphibole and rimming chalcopryrite

**Magnetite-Ilmenite** (15 %) coarse lobed grains with abundant fine oriented ilmenite exsolution lamellae; pierced by apatite; very fine-grained granular secondary magnetite with very fine-grained green actinolite in pseudomorphs after ?

**Apatite** (1%) abundant clear euhedral prismatic crystals ( $\leq 2$  mm long) piercing opaques and silicates

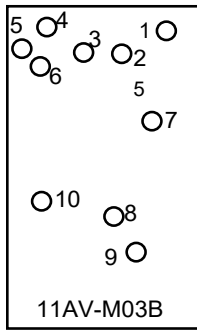
**Chalcopryrite** (5%) anhedral yellow reflectance; two big patches at top of section

**Sphalerite** (tr.) deep red-brown translucent grey reflecting as fine-grained rounded anhedral grains intergrown with chalcopryrite and in alteration; also as very fine-grained skeletal star-shaped inclusion in chalcopryrite

**Pyrite** (tr.) medium-grained blocky fractured grains, partly broken out of section surrounded by alteration; secondary pyrite is lace-like

**Galena** (tr.) rare anhedral silvery grey intergrown with chalcopryrite

**Siegenite** (tr.) fine euhedral light cream reflecting elongate crystal associated with sphalerite



1) pyrite and entlandite fragments surrounded by broken out area and chalcopyrite.

2) blocky apophyllite at rim of chalcopyrite, and micaceous alteration (pumpelleyite)

3) coarse green actinolite hornblende and minor chlorite in reddish apophyllite

4) sphalerite, siegenite and chalcopyrite bits rimmed by blue-green pumpellyite in prehnite and colourless pumpellyite; lacelike pyrite in altered feldspar (intergrown with very fine-grained chalcopyrite ?)

5) coarse calcite in prehnite intergrown with titanite, pale brown micaceous julgoldite and green pumpellyite

6) primary tan amphibole replaced by actinolite hornblende, chlorite in altered feldspar (albite), porous ilmenite in amphibole and solid magnetite intergrown with primary hornblende.

7) and 8) primary and secondary biotite intergrained with actinolite surrounded by magnetite-actinolite pseudomorph

9) amphibole replacing clinopyroxene and primary amphibole (?) in plagioclase with euhedral apatite and secondary biotite

10) biotite and prehnite alteration in plagioclase

**Description:** Medium- to coarse-grained altered gabbro similar to 11AV-M03B but with less sulphides and the alteration and hydrothermal phases associated with it: i.e. no carbonate, prehnite, pumpellyite. This section consists of coarse euhedral to subhedral plagioclase laths (surrounded by zones of alteration) intergrown with anhedral clinopyroxene (rimmed and altered by green actinolite and tan secondary biotite), minor anhedral tan to greenish amphibole and red-brown biotite and abundant anhedral pseudomorphs of secondary magnetite and fine-grained green actinolite. Magnetite forms medium-grained extremely lobed grains with abundant tightly spaced ilmenite exsolution lamellae. Interstices between the primary minerals are filled with masses of fine-grained tan biotite and acicular green actinolite crystals. The whole assemblage is pierced by medium-grained elongate apatite crystals. Sulphides are rare and consist of very fine-grained anhedral chalcopyrite in alteration zones around plagioclase and (rarely) in clinopyroxene.

**Plagioclase** (54%) medium- to coarse-grained, euhedral to subhedral fractured, moderately altered laths with extensive alteration zones/interstices around them

**Diopside** (13%) medium-grained anhedral brownish grains interstitial to plagioclase, rimmed and altered by fine-grained green actinolite and secondary biotite

**Biotite** (9%) a) primary: rare medium-grained anhedral deep reddish brown remnants; b) fine-grained coffee brown secondary biotite is abundant as alteration in and around primary minerals and intergrown with fine-grained euhedral actinolite in interstitial alteration patches

**Hornblende** (tr.) fine- to medium-grained tan to olive brown pleochroic anhedral remnants intergrown with clinopyroxene and rimmed by green actinolitic hornblende

**Actinolite** (9%) intense blue-green pleochroic as fine-grained rims around most primary minerals and as euhedral prismatic crystals in interstitial patches of secondary biotite

**Tremolite** (5%) very fine-grained euhedral pale in magnetite pseudomorphs (tremolite)

**Magnetite-Ilmenite** (7%) a) coarse strongly lobed subhedral grains with tightly spaced oriented ilmenite exsolution lamellae; b) very fine-grained granular secondary magnetite intergrown with fine-grained tremolite in anhedral pseudomorphs

**Apatite** (3%) abundant clear euhedral prismatic crystals ( $\leq 5$  mm long) piercing assemblage

**Chalcopyrite** (tr.) anhedral yellow reflecting inclusions in alteration zones of plagioclase and rarely in clinopyroxene and as minute inclusions ( $\pm$ pentlandite, pyrrhotite) in secondary magnetite in pseudomorphs

**Pyrite** (tr.) very fine-grained slightly porous euhedral cubes in aggregates in altered plagioclase

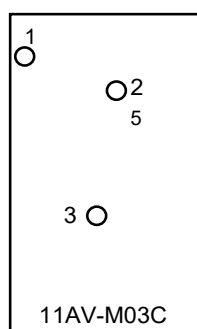
**Sphalerite** (tr.) very fine-grained intergrown with chalcopyrite in altered amphibole

**Cobaltite** (tr.) very fine-grained rounded bright creamy white isotropic grain in secondary biotite-actinolite

1) rounded white cobaltite in secondary actinolite-biotite

2) very fine-grained chalcopyrite inclusions in secondary magnetite

3) chalcopyrite and sph in alt. amphibole/clinopyroxene



**Description:** tabular subhedral to euhedral strongly albite altered plagioclase is intergrown with anhedral clinopyroxene, strongly lobed magnetite, brown and green hornblende and magnetite-actinolite pseudomorphs, all pierced by abundant elongate apatite crystals. Alteration is extensive and comprises red-brown biotite replacing primary brown amphibole; magnetite-actinolite pseudomorphs after an unidentified MgFe-silicate; calcite, titanite and chlorite  $\pm$  actinolite replacing clinopyroxene, actinolite replacing green primary hornblende; kaolinite and a very fine-grained olive green biotite (?) replacing plagioclase. Euhedral actinolite aggregates in extremely fine-grained rust coloured masses of stilpentin and melanophane or biotite occur interstitially to the primary minerals. Coarse calcite and chalcopyrite fill a pocket rimmed by actinolite and chlorite in the center of the section, where acicular actinolite seems to grow from chlorite. Chalcopyrite and bornite occur intergrown with secondary magnetite.

**Plagioclase (Albite)** (50%) medium to coarse-grained euhedral to subhedral fractured, brownish altered laths

**Diopside** (6%) medium-grained anhedral pale brown grains interstitial to plagioclase, altered by chlorite, carbonate, actinolite and titanite

**Biotite** (10%) a) late primary (ca. 2%) deep red-brown euhedral to subhedral intergrown with and possibly replacing primary brown amphibole; b) rusty red, very fine-grained aggregates forming matrix for euhedral actinolite aggregates in interstitial alteration patches and in veins and inclusions in opaques; c) very fine-grained green micaceous aggregates replacing plagioclase

**Edenitic Hornblende** (1%) medium-grained euhedral to subhedral pale to red-brown pleochroic anhedral remnants intergrown with opaques and red-brown biotite (late primary to secondary)

**Magnesio-Hornblende** (4%) medium- to coarse-grained euhedral green pleochroic grains (primary amphibole)

**Actinolite** (12%) pale blue-green pleochroic acicular aggregates mostly around carbonate patches; replacing green primary hornblende. and very fine-grained in magnetite-actinolite pseudomorphs

**Chlorite** (3%) fine-grained pale bluish green micaceous aggregates intergrown with actinolite at rim of carbonate patch and replacing primary clinopyroxene together with carbonate, titanite and actinolite

**Magnetite-Ilmenite** (10%) a) coarse strongly lobed subhedral grains with tightly spaced oriented ilmenite exsolution lamellae; b) very fine-grained granular secondary magnetite intergrown with fine-grained actinolite in anhedral pseudomorphs

**Calcite** (3%) anhedral filling cavity in center of section and at the side of section; replacing clinopyroxene together with chlorite and titanite

**Apatite** (1%) abundant clear euhedral prismatic crystals ( $\leq 2$  mm long) piercing assemblage

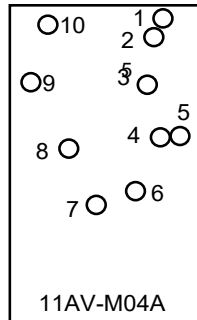
**Chalcopyrite** (2%) anhedral yellow reflecting patches in gangue; coarsest in extension of carbonate patch

**Bornite** (tr.) purplish red-brown reflectance, fine- to medium-grained anhedral intergrown with chalcopyrite

**Sphalerite** (tr.) very fine-grained intergrown with chalcopyrite

**Kotulskite** (tr.) extremely fine-grained white attached to chalcopyrite

**Galena** (tr.) extremely fine-grained inclusions in chalcopyrite/bornite



1) two types of hornblende: brown Ti-hornblende overgrowing green actinolite. hornblende; with secondary magnetite, bornite and altered plagioclase

2) chalcopyrite intergrown with bornite and secondary magnetite interstitial to altered actinolite, hornblende (primary ?), primary magnetite (with ilmenite lamellae) and strongly altered plagioclase (Photo )

3) fine-grained green micaceous alteration (biotite ?) of plagioclase with acicular actinolite adjacent to magnetite-actinolite pseudomorph

4) euhedral actinolite intergrown with rusty acicular mineral (stilpentinomelane ??) and minor secondary magnetite

5) chlorite, titanite, carbonate and actinolite with euhedral apatite repl. clinopyroxene (remnants still present)

6) magnetite-hornblende pseudomorph with remnants of primary dark red-brown biotite and primary magnetite

7) abundant apatite in chlorite-calcite-actinolite matrix

8) olive green hornblende replaced by actinolite and surrounded by chlorite adjacent to carbonate-filled patch with apatite

9) red-brown amphibole intergrown with deep red-brown biotite replacing it and filled apatites adjacent to magnetite pseudomorphs with chalcopyrite

10) similar to 9) but with minor bornite and more chalcopyrite

**11AV-M04B (puck) Strongly altered Hornblende-gabbro****Geordie Lake**

Description: (opaques only) fine- to medium-grained subhedral to anhedral lobed magnetite with ilmenite exsolution lamellae is intergrown with plag and magnetite-dusted pseudomorphs; secondary granular magnetite in aggregates is abundant in interstices and silicate alteration assemblage and intergrown with bornite and chalcopyrite (~1-2% sulphides). One bornite patch contains a rounded medium-sized inclusion of a cream coloured anhedral anisotropic sulphide (circle 1).  
chalcopyrite:bornite= 1:1.

1) anhedral cream coloured Co-millerite in bornite with chalcopyrite exsolutions and surrounded by fine-grained secondary magnetite

Description: the section is dominated by abundant coarse, lobed olivine partially replaced by fine-grained magnetite along edges and cracks. Some grains appear maroon translucent due to abundant oriented exsolutions of very fine-grained hematite flakes. In a few of the pseudomorphs the olivine is altered to Fe-rich serpentine and in others rims are altered to cummingtonite. The magnetite-olivine pseudomorphs are invariably surrounded by a reaction rims of very fine-grained pale greenish phlogopite against plagioclase. Plagioclase forms euhedral to subhedral more or less altered laths intergrown with coarse olivine, medium-grained unaltered diopside, minor orange biotite, rare olive green hornblende and lobed primary magnetite with oriented ilmenite exsolution lamellae. The assemblage is pierced by abundant fine-grained euhedral apatite. Plagioclase alteration is very fine-grained kaolinite (giving the feldspar a brownish hue) or very fine-grained felted masses of tremolite-actinolite. Sulphides are found intergrown with accumulations of secondary magnetite (outside pseudomorphs) and comprise bornite, chalcopyrite, cream coloured anisotropic UM1 and trace galena.

**Plagioclase** (40%) medium- to coarse-grained euhedral to subhedral brownish kaolinite -actinolite altered laths

**Diopside** (5%) medium-grained anhedral pale brown grains interstitial to plagioclase, altered by chlorite, carbonate, actinolite and titanite

**Olivine** (40%) very coarse anhedral, strongly lobed grains with abundant oriented exsolutions of maroon translucent hematite; partially replaced by abundant fine-grained secondary magnetite outlining grain boundaries and fractures; rimmed by colourless cummingtonite and/or Fe-rich serpentine

**Biotite** (1%) primary fine- to medium-grained subhedral to anhedral orange brown grains associated with opaques

**Hornblende** (tr.) medium-grained anhedral olive green pleochroic grains intergrown with clinopyroxene

**Phlogopite** (3%) very fine-grained pale green acicular aggregates rimming pseudomorphs against plagioclase

**Actinolite** (3%) coarser aggregates in plagioclase alteration

**Magnetite-ilmenite** (3%) primary medium-grained, strongly lobed subhedral to euhedral grains with tightly spaced oriented ilmenite exsolution lamellae

**Magnetite** (secondary) (3%) fine-grained granular aggregates intergrown with sulphides (very fine-grained secondary magnetite in pseudomorphs abundances included in pseudomorphs)

**Apatite** (1%) fine-grained clear euhedral prismatic crystals ( $\leq 2$  mm long) piercing assemblage

**Chalcopyrite** (tr.) anhedral yellow reflecting patches intergrown with bornite and secondary magnetite

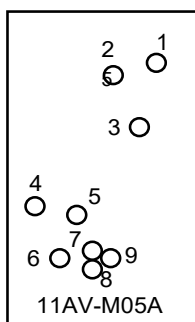
**Bornite** (1%) purplish red-brown reflectance, fine- to medium-grained anhedral intergrown with chalcopyrite, secondary magnetite and tremolite

**Millerite (Co-rich)** (tr.) fine-grained creamy yellow anisotropic bladed aggregates in bornite

**UM1** (tr.) cream-coloured sulphide forming basket weave pattern in bornite or chalcopyrite

**Galena** (tr.) very fine-grained greenish light grey specs attached to chalcopyrite (probably selenian)





1) brown olivine pseudomorph with zones of olive and grass green serpentine alteration, minor biotite inclusions at rim

2) orange biotite intergrown with secondary magnetite-sulphide aggregate in plagioclase alteration patch pierced by apatite

3) fine-grained phlogopite rims around olivine against plagioclase.

4) secondary magnetite aggregate intergrown with bornite, chalcopyrite and actinolite; tiny bright white galena in center; kaolinite altered plagioclase at rim

5) bright creamy yellow anhedral sulphide (millerite) intergrown with bornite, chalcopyrite, secondary magnetite and actinolite, surrounded by very fine-grained pale green alteration and kaolinite altered plagioclase.

6) rare green amphibole and biotite intergrown with secondary magnetite, primary magnetite and diopside; fine-grained acicular actinolite in brownish alteration of plagioclase

7) olivine remnant surrounded by cummingtonite

8) "brown" olivine with abundant hematite exsolutions

9) bornite containing one or two cream-coloured sulphides intergrown with chalcopyrite and primary and secondary magnetite and extensive actinolite

### 11AV-M05B (puck) Altered troctolite

### Geordie Lake

**Description:** similar to A and C: abundant fine to medium-grained subhedral to euhedral lobed primary magnetite ( $\leq 3\text{mm}$ ) intergrown with medium-grained unaltered silicate (clinopyroxene) and coarse olivine ( $\leq 7\text{mm}$  long) outlined and dusted with very fine-grained secondary magnetite. Diffuse patches of very fine-grained semi-massive magnetite are intergrown with bornite, chalcopyrite and rare cream coloured UM1.

Description: similar to 11AV-M05A: abundant coarse, lobed, anhedral magnetite-rich pseudo-morphs intergrown with unaltered subhedral clinopyroxene, euhedral to subhedral more or less altered plagioclase laths, minor orange biotite, rare brown hornblende and abundant lobed magnetite with oriented ilmenite exsolution lamellae. The assemblage is pierced by abundant fine-grained euhedral apatite needles. The pseudomorphs are either black- brown due to abundant oriented rutile flakes or black & white where rutile exsolution is lacking. In many cases the latter surrounds cores of the former. In the brown pseudomorphs the original host mineral (olivine?) is still present. Both types of pseudomorphs are surrounded by a rim of very fine-grained actinolite (or very pale green mica) against plagioclase. Plagioclase alteration is very fine-grained kaolinite (giving the feldspar a brownish hue) or acicular actinolite in very fine-grained felted masses of pale brown to tan mica. Sulphides are found in accumulations of fine-grained secondary magnetite outside pseudomorphs interstitial to primary minerals in a zone that runs diagonally through the section (a diffuse vein ?) and comprise bornite, chalcopyrite, a cream-coloured UM1, trace galena and a bright white PGM.

**Plagioclase** (35%) medium- to coarse-grained euhedral to subhedral brownish kaolinite -actinolite altered laths

**Diopside** (9%) fine- to medium-grained subhedral colourless grains interstitial to plagioclase, unaltered

**Magnetite-altered olivine** (25%) very coarse anhedral, strongly lobed grains with abundant oriented exsolution of maroon translucent hematite flakes; fine-grained secondary magnetite forming thick rims and outlining fractures

**Biotite 1** (1%) primary fine- to medium-grained subhedral to anhedral orange brown grains associated with opaques

**Biotite 2** (4%) secondary biotite forms extremely fine-grained tan masses containing actinolite

**Hornblende** (tr) medium-grained anhedral tan pleochroic grains intergrown with clinopyroxene

**Tremolite-Actinolite** (5%) a) fine-grained bluish green aggregates in secondary biotite; b) very fine-grained colourless tremolite (?) in orthopyroxene pseudomorphs; c) a) very fine-grained pale green acicular aggregates rimming pseudomorphs against plagioclase (could also be mica)

**Magnetite-ilmenite** (9%) primary fine- to medium-grained, strongly lobed subhedral to euhedral grains with tightly spaced oriented ilmenite exsolution lamellae

**Magnetite 2** (9%) a) fine-grained granular aggregates intergrown with sulphides; b) very fine-grained secondary magnetite in pseudomorphs - abundances included in pseudomorphs)

**Apatite** (1%) fine-grained clear euhedral prismatic crystals ( $\leq 1$  mm long) piercing assemblage

**Chalcopyrite** (tr.) anhedral yellow reflectin patches intergrown with bornite in secondary magnetite

**Bornite** (1%) purplish red-brown reflectance, fine- to medium-grained anhedral intergrown with chalcopyrite in secondary magnetite

**Ag-bornite** (tr.) bright sky blue anhedral bornite intergrown with secondary magnetite, galena

**Pyrite** (tr.) fine-grained subhedral isometric grain in chalcopyrite-bornite

**UM1** (tr.) remnants of a cream-coloured sulphide with basket weave texture in bornite

**Maucherite** (tr.) creamy white anhedral with good polish, intergrown with bornite

**Menshikovite** [Pd<sub>3</sub>Ni<sub>2</sub>As<sub>3</sub>] (tr.) fine-grained anhedral bright white, skeletal, intergrown with sulphides and secondary magnetite

**Galena** (tr.) very fine-grained greenish light grey specs attached to chalcopyrite (probably selenian)

1 ○	1) white maucherite intergrown with bornite and magnetite adjacent to apatite; also bornite-chalcopyrite-magnetite- patch with small pyrite
2 ○ 5	2) bornite patch surrounded by secondary magnetite with chalcopyrite, grading into blue bornite at rim, UM1 and bright white anhedral menshikovite in same area
3 ○	3) "fresh" olivine-pseudomorph with fine-grained actinolite rim against plagioclase
11AV-M05C	

## 11AV-M05D Altered troctolite

Geordie Lake

Description: similar to 11AV-M05A and C: abundant coarse, lobed, anhedral magnetite-rich pseudomorphs intergrown with unaltered subhedral clinopyroxene, euhedral to subhedral more or less altered plagioclase laths, minor orange biotite, rare olive brown hornblende and abundant lobed magnetite with oriented ilmenite exsolution lamellae. The assemblage is pierced by abundant fine-grained euhedral apatite needles. The pseudomorphs are either black- brown due to abundant oriented rutile flakes or black and white where rutile exsolutions are lacking. In the brown pseudomorphs, the original host mineral (olivine?) is still present. The silicate phase in the black & white pseudomorphs shows parallel extinction when magnetite exsolutions are lined up N-S. Both types of pseudomorphs are surrounded by a rim of very fine-grained actinolite (or very pale green mica) against plagioclase. Plagioclase alteration is very fine-grained kaolinite (giving the feldspar a brownish hue). There is also an extensive chaotic area with bladed blue-green actinolite in very fine-grained felted masses of pale brown to tan mica. Sulphides (bornite, chalcopyrite, a cream coloured UM, trace galena) are found in accumulations of fine granular secondary magnetite associated with the actinolite- biotite alteration.

**Plagioclase** (32%) medium- to coarse-grained euhedral to subhedral brownish kaolinite -actinolite altered laths

**Diopside** (10%) fine- to medium-grained subhedral colourless grains interstitial to plagioclase, unaltered

**Magnetite-altered olivine** (40%) very coarse anhedral, strongly lobed grains with abundant oriented exsolutions of maroon translucent flakes (rutile ?) in olivine (?) matrix and fine-grained secondary magnetite forming thick rims and outlining fractures

**Biotite 1** (1%) primary fine- to medium-grained subhedral to anhedral orange brown grains associated with opaques;

**Biotite 2** (2%) secondary biotite forms extremely fine-grained tan masses containing actinolite

**Hornblende** (tr.) medium-grained anhedral olive brown pleochroic grains intergrown with clinopyroxene

**Tremolite-Actinolite** (7%) a) fine-grained bluish green aggregates in secondary biotite; b) very fine-grained colourless tremolite (?) in orthopyroxene pseudomorphs; c) a) very fine-grained pale green acicular aggregates rimming pseudomorphs against plagioclase (could also be mica)

**Magnetite-Ilmenite** (5%) primary fine- to medium-grained, strongly lobed subhedral to euhedral grains with tightly spaced oriented ilmenite exsolution lamellae

**Magnetite 2** (3%) a) fine-grained granular aggregates intergrown with sulphides; b) very fine-grained secondary magnetite in pseudomorphs - abundances included in pseudomorphs

**Apatite** (tr.) fine-grained clear euhedral prismatic crystals ( $\leq 1$  mm long) piercing assemblage

**Chalcopyrite** (tr.) anhedral yellow reflecting patches intergrown with bornite in secondary magnetite

**Bornite** (tr.) purplish red-brown reflectance, fine- to medium-grained anhedral intergrown with chalcopyrite in secondary magnetite

**UM1** (tr.) basket-weave remnants of a cream-coloured sulphide in bornite

**11AV-M05E Altered gabbro****Geordie Lake**

similar to 11AV-05A,B,C,D but more fine-grained and less altered.

**11AV-M06A Syenite****Geordie Lake**

**Description:** semi-massive medium-grained K-feldspar (reddish brown due to kaolinite alteration and Fe-staining) encloses a few coarser rounded plagioclase grains, quartz remnants and irregular patches of more fine-grained green clinopyroxene ± actinolitic hornblende intergrown with granular orange allanite and fractured magnetite rimmed by pale brown titanite. Fine-grained euhedral apatite pierces the assemblage. Minor amounts of fine-grained anhedral chalcopyrite occurs disseminated in K-feldspar matrix.

**K-feldspar ± albite** (75%) medium-grained, massive with diffuse grain boundaries, Fe<sup>3+</sup>-stained alteration, in perthitic intergrowth with (or being replaced by) albite

**Plagioclase** (3%) coarse rounded inclusions in K-feldspar, less Fe-stained, moderately altered, albite lamellae barely visible

**Quartz** (5%) clear, anhedral remnants of interstitial quartz and graphic intergrowth with K-feldspar

**Alkali-Hornblende** (2%) fine-grained green pleochroic in patches intergrown with allanite, clinopyroxene, titanite and magnetite, inhomogeneous with very F- and Cl-rich areas

**Hedenbergite** (9%) fine granular, pale green, medium-high relief intergrown with amphibole and magnetite

**Allanite** (tr.) fine-grained orange to red-brown anhedral medium-relief grains intergrown with amphibole and titanite

**Titanite** (1%) fine-grained anhedral pale brown with very high relief and ifc. rimming magnetite and intergrown with clinopyroxene, inhomogeneous zoned, with Nb-rich cores

**Apatite** (tr.) fine-grained clear, elongate prismatic subhedral grains in K-feldspar and opaques

**Magnetite** (5%) fine-grained anhedral granular and fractured grains intergrown with Fe-silicates

**Chalcopyrite** (tr.) fine-grained anhedral, disseminated in K-feldspar matrix

**Chlorite** (tr.) rare, fine-grained olive green alteration in plagioclase

**11AV-M06B (puck) Syenite****Geordie Lake**

**Description:** mostly reddish K-feldspar intergrown with irregular patches of MgFe-silicates ± titanite ± fine-grained fractured, subhedral to anhedral magnetite rimmed by titanite. Fine-grained euhedral apatite pierces the assemblage. Trace amounts of very fine-grained anhedral chalcopyrite occurs disseminated in K-feldspar matrix.

**Description:** similar to A but K-feldspar is more diffuse (lacking grain boundaries) and amphibole dominates over clinopyroxene. Also chalcopyrite is much more abundant. Semi-massive medium-grained K-feldspar (brownish due to alteration and Fe-staining) encloses a few coarser rounded plagioclase grains, quartz remnants and irregular patches of more fine-grained green actinolitic hornblende ± clinopyroxene intergrown with rusty brown allanite, pale brown titanite and opaques. Euhedral apatite occurs as well. Opaques are fine- to medium-grained euhedral to fractured magnetite intergrown with patches of anhedral chalcopyrite in a diffuse vein running diagonally NE-SW through section.

**K-feldspar** (75%) medium-grained, massive with diffuse grain boundaries, Fe<sup>3+</sup>-stained alteration

**Plagioclase** (1-2%) coarse rounded inclusions in K-feldspar, less Fe-stained, moderately altered, albite lamellae barely visible

**Quartz** (5%) clear, anhedral remnants of interstitial quartz and graphic intergrowth with K-feldspar

**Alkali-Hornblende** (7%) fine-grained green pleochroic in patches intergrown with allanite, clinopyroxene, titanite and opaques

**Hedenbergite** (2%) fine granular, pale green, medium-high relief, intergrown with amphibole and opaques

**Chlorite** (tr.) rare, fine-grained olive green alteration in plagioclase

**Allanite** (tr.) rusty brown zoned anhedral medium relief mineral intergrown with amphibole and titanite (very inhomogeneous)

**Titanite** (tr.) fine-grained anhedral pale brown with very high relief and ifc. intergrown with allanite (inhomogeneous, Nb-rich cores)

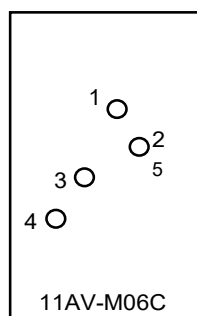
**Apatite** (tr.) fine-grained clear, elongate prismatic subhedral grains in K-feldspar

**Magnetite** (6%) fine-grained euhedral (where surrounded by chalcopyrite) to anhedral granular and fractured grains intergrown with Fe-silicates and chalcopyrite

**Chalcopyrite** (1%) fine-grained anhedral yellow reflectance, intergrown with magnetite

**Sphalerite** (tr.) fine-grained anhedral intergrown with chalcopyrite

**Galena** (tr.) tiny ( $\leq 2 \mu\text{m}$ ) grains in chalcopyrite and gangue



1) red-brown allanite (in center) intergrown with magnetite, amphibole, titanite, clinopyroxene and chalcopyrite (with sphalerite at rim) in altered K-feldspar intergrown with albite, quartz

2) coarse plagioclase remnant with granular clinopyroxene/amphibole at rim

3) clinopyroxene intergrown with magnetite, chalcopyrite (with sphalerite), actinolitic hornblende, allanite, etc.

4) similar to (1)

**Description:** Fine- to medium-grained strongly altered semi-massive K-feldspar (brownish and cloudy) enclosing rare lighter coloured coarser tabular to rounded plagioclase; with interstitial patches of fine-grained blue-green Na-amphibole + very fine-grained red-brown biotite with magnetite, apatite and rare zircon. No quartz. Veined by aegirine-chalcopyrite-bornite veinlets. Opaques are fine- to medium-grained euhedral to fractured magnetite  $\pm$  ilmenite intergrown with patches of anhedral chalcopyrite and bornite (some showing graphic intergrowth, some bornite is blue possibly due to Ag) (section wedge shaped from left to right).

**Albite** (75%) medium-grained, massive, slightly altered

**Plagioclase** (1-2%) coarse rounded inclusions in albite, less Fe-stained, moderately altered, albite lamellae barely visible

**Quartz** (tr.) rare, clear, anhedral rims around chalcopyrite-bornite in vein

**Alkali-Hornblende** (10%) fine- to medium-grained intense green pleochroic in patches intergrown with opaques (very inhomogeneous with Fe-K-Cl-rich and F-rich domains).

**Biotite** (tr.) fine-grained anhedral pale brown surrounding amphibole

**Apatite** (tr.) fine-grained clear, elongate prismatic subhedral grains in K-feldspar

**Calcite** (tr.) rare, fine-grained anhedral associated with opaques

**Magnetite** (8%) medium-grained subhedral fractured primary magnetite and anhedral granular magnetite intergrown with chalcopyrite-bornite

**Ilmenite** (tr.) rare, anhedral intergrown with primary magnetite

**Chalcopyrite** (1%) fine-grained anhedral yellow reflectance, intergrown with magnetite

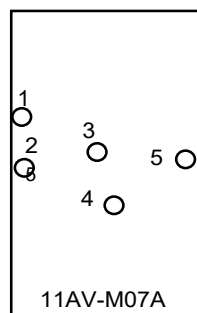
**Bornite** (1%) medium-grained anhedral intergrown with chalcopyrite in quasi-graphic textures; rare blue bornite in gangue

**Ag-bornite** (tr.) sky blue anhedral bornite associated with galena and secondary magnetite

**Sphalerite** (tr.) fine-grained anhedral intergrown with chalcopyrite

**UM1** (tr.) cream-coloured remnants in chalcopyrite

**Galena** (tr.) fine-grained soft light grey inclusion in bornite



1) green amphibole intergrown with primary magnetite and fine-grained biotite with apatite and trace carbonate in centre of opaques and minor chalcopyrite

2) similar to (1) more biotite, less magnetite

3) blue bornite in center of circle in altered albite, reddish bornite (with galena inclusion) intergrown with magnetite

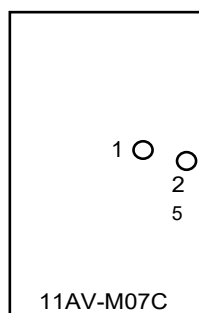
4) UM1 intergrown with chalcopyrite and bornite in magnetite bordering granular vein

5) fine-grained blue bornite associated with galena in centre in gangue associated with coarse bornite-chalcopyrite in sulph-amphibole vein

**11AV-M07B (puck) Syenite Dyke****Geordie Lake**

**Description:** semi-massive K-feldspar intergrown with interstitial patches of Fe-silicates and magnetite, apatite and rare zircon. Chalcopyrite and bornite are intergrown with each other in more or less graphic texture and host fine-grained euhedral; white euhedral rectangular to rhomb-shaped PGM and a cream-coloured sulphide and galena. Some bornite is more bluish than others possibly indicating trace Ag content. Oxides are fine- to medium-grained euhedral to fractured magnetite  $\pm$  ilmenite intergrown with patches of anhedral chalcopyrite and bornite.

- 1) coarse chalcopyrite-bornite intergrowth with basket weave cream coloured UM1 and subhedral magnetite grains
- 2) blue vs. purple bornite intergrown with magnetite
- 3) fine-grained chalcopyrite and blue bornite intergrown with gangue, possibly tiny euhedral cobaltite in chalcopyrite
- 4) euhedral rectangular cobaltite in bornite intergrown with chalcopyrite and magnetite

**11AV-M07C Syenite Dyke****Geordie Lake**

Description: same as 11AV-M07A

- 1) galena in bornite intergrown with magnetite in K-feldspar-amphibole matrix with minor brown biotite, apatite
- 2) soft white galena intergrown with actinolite, secondary magnetite and bn in altered K-feldspar

**11AV-M07D Syenite Dyke****Geordie Lake**

coarser, distinctive bornite-amphibole veins with fine-grained chamosite or biotite alteration



**11AV-M01 Keweenawan basalt****Keweenawan**

**Description:** fine-grained basalt or micro-gabbro with abundant fine-grained euhedral plagioclase laths intergrown with pale rose brown clinopyroxene (augite) and abundant anhedral magnetite, pierced by subhedral to euhedral apatite and overprinted by emulsion textured intergrowths of clinopyroxene<sup>2</sup> and ilmenite and flakes of very fine-grained biotite alteration. Fine granular clinopyroxene<sup>2</sup> and opaques are introduced through diffuse thin veinlet.

**Plagioclase** (65%) colourless subhedral elongate tabular laths intergrown with clinopyroxene, magnetite

**Augite** (18%) pale rose-brown anhedral grains intergrown with plagioclase in sub-ophitic texture; fractures filled with biotite

**Clinopyroxene<sup>2</sup> ?** (5%) colourless anhedral strongly poikilitic grains disintegrating into granular masses intergrown with biotite and opaques (might be secondary clinopyroxene)

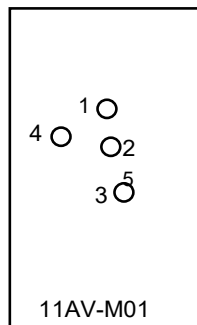
**Magnetite + Ilmenite** (5%) subhedral blocky grains of magnetite with thick, irregular ilmenite lamellae and irregular intergrowths; ilmenite also as very fine-grained emulsion textured intergrowth with epidote

**Biotite** (5%) very, very fine-grained red-brown flakes altering clinopyroxene and plagioclase

**Apatite** (1%) elongate subhedral to euhedral grains piercing all other minerals

**Chalcopyrite** (tr.) very rare, intergrown with oxides

**Chlorite ?** (%) olive grey green felted masses, alteration product



1) poikilitic ilmenite/magnetite and trace chalcopyrite intergrown with clinopyroxene<sup>2</sup> in biotite altered plag with anh clinopyroxene and apatite

2) emulsion textured clinopyroxene intergrown with opaques biotite and plagioclase

3) solid clinopyroxene intergrown with feldspar

4) veinlet with emulsion textured clinopyroxene<sup>2</sup> and opaques and alteration

## 11AV-M11A Keweenawan basalt

## Geordie Lake Hanging Wall

Description: dark, fine-grained basalt consisting of abundant euhedral to subhedral mottled (more or less altered) plagioclase laths with interstitial greenish amphibole (actinolite) dusted by fine granular Ti-magnetite in a dark impenetrable matrix. Conspicuous amygdules up to 2.5 mm across are filled with medium-grained euhedral pale green bladed tremolite-actinolite with much darker green interstitial acicular actinolite (2) ± euhedral titanite and oxides (euhedral magnetite, ilmenite, rutile).

**Plagioclase** (50%) fine- to medium-grained colourless to slightly brownish due to kaolinite alteration, euhedral elongate tabular laths

**Actin. Hornblende** (17%) fine-grained pale greenish subhedral to anhedral grains intergrown with plagioclase; contains very fine-grained opaque inclusions

**Tremolite-actinolite** (4%) colourless to pale green medium-grained euhedral bladed aggregates filling amygdules and open interstices in matrix

**Actinolite 2** (tr.) fine-grained dark olive green acicular aggregates filling interstices between tremolite blades in amygdules; rimmed by secondary magnetite

**Ti-Magnetite** (5%) very fine-grained subhedral to skeletal grains with pinkish grey reflectance dusting silicates, secondary magnetite rimming and replacing amphibole phenocrysts; rare solid euhedral grains in amygdules contain fine-grained sulphide inclusions

**Titanite** (tr.) fine-grained pale brown euhedral to subhedral high relief grains intergrown with actinolite in amygdules and disseminated in matrix interstitial to plagioclase

**Apatite** (tr.) elongate subhedral to euhedral grains piercing all other minerals

**Rutile** (tr.) fine-grained anhedral, intergrown with titanite in amygdule

**Chalcopyrite** (tr.) very fine-grained rounded inclusion. in magnetite

**Bornite** (tr.) very fine-grained with chalcopyrite in inclusions in magnetite

O5	1 ○	1) magnetite with sulphide inclusions intergrown with titanite and rutile in amphibole filled amygdule
	2 ○	2) amygdule filled with pale coarse euhedral actinolite and interstitial fine-grained acicular aggregates of darker colour and magnetite with tiny sulphide inclusions.
	5	
	3 ○	3) similar to 1) there is very fine-grained red biotite intergrown with titanite
	4 ○	4) and 5) amphibole phenocryst with magnetite inclusions intergrown with plagioclase
11AV-M11A		

**11AV-M11B Keweenaw basalt (puck)****Geordie Lake Hanging Wall**

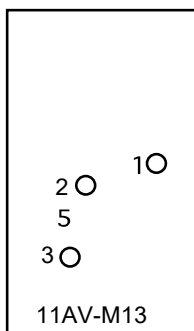
**Description:** Fine-grained solid euhedral to subhedral (Ti-)magnetite (pinkish grey reflectance) contains tiny pin prick inclusions of sulphides (chalcopyrite and bornite). Abundant very fine-grained (Ti-)magnetite is dusting silicates and forming delicate skeletal star-like arrangements. It also occurs in aggregates and as partial pseudomorphs rimming and gradually replacing a primary MgFe-mineral (amphibole or pyroxene) from the outside while retaining some of its texture. Some of the ilmenite is altered by white reflecting hematite and/or light grey rutile. Euhedral titanite is visible in amphibole filled amygdules.

**11AV-M12B (puck only) Keweenaw basalt****Geordie Lake Hanging Wall**

**Description:** similar to 11AV-M11: ~50% euhedral to subhedral plagioclase laths intergrown with anhedral Mg-Fe-silicate (presumably amphibole) and fine-grained skeletal hematite altered magnetite. Smaller amygdules are filled with anhedral titanite, larger ones are rimmed by anhedral titanite and goethite altered chalcopyrite.

**11AV-M13 Keweenaw basalt (PTS only)****Geordie Lake Hanging Wall**

**Description:** similar to 11AV-M11 and M12: Conspicuous dark pseudomorphs of magnetite, titanite, hematite, rutile and actinolite after primary amphibole or pyroxene phenocrysts appear as dark grains in a matrix of fuzzy metamorphosed plagioclase and interstitial MgFe-silicate ± skeletal magnetite. Large amygdules are filled with pale green, euhedral bladed, actinolite, anhedral titanite, chalcopyrite rimmed by goethite and in rare cases colourless anhedral sphalerite. The matrix is pretty altered and contains additional green actinolite and probably secondary feldspar.



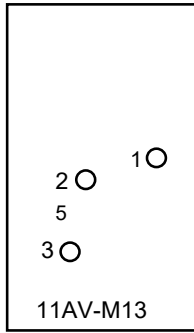
- 1) large amygdule with actinolite, **chalcopyrite, sphalerite**, what is silicate interstitial to actinolite outside chalcopyrite ?
- 2) magnetite-titanite-actinolite-rutile pseudomorph inn matrix
- 3) titanite-magnetite-actinolite pseudomorph

**11AV-M12B (puck only) Keweenaw basalt****Geordie Lake Hanging Wall**

**Description:** similar to 11AV-M11:~50% euhedral to subhedral plagioclase laths intergrown with anhedral Mg-Fe-silicate (presumably amphibole) and fine-grained skeletal hematite altered magnetite. Smaller amygdules are filled with anhedral titanite, larger ones are rimmed by anhedral titanite and goethite altered chalcopyrite.

**11AV-M13 Keweenaw basalt (PTS only)****Geordie Lake Hanging Wall**

**Description:** similar to 11AV-M11 and M12: Conspicuous dark pseudomorphs of magnetite, titanite, hematite, rutile and actinolite after primary amphibole or px phenocrysts appear as dark grains in a matrix of fuzzy metamorphosed plagioclase and interstitial MgFe-silicate  $\pm$  skeletal magnetite. Large amygdules are filled with pale green, euhedral bladed, actinolite, anhedral titanite, chalcopyrite rimmed by goethite and in rare cases colourless anhedral sphalerite. The matrix is pretty altered and contains additional green actinolite and probably secondary feldspar.



- 1) large amygdule with actinolite, **chalcopyrite, sphalerite**, what is silicate interstitial to actinolite outside chalcopyrite ?
- 2) magnetite-titanite-actinolite-rutile pseudomorph inn matrix
- 3) titanite-magnetite-actinolite pseudomorph