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Miscellaneous Release—Data 349

Petrology and Geochemistry of the Neoarchean McKenzie Granite, Northwestern Ontario

by A. Hughes[1], P. Hollings[1], M.C. Smyk[2], M.A. Puumala[2], and D.A. Campbell[2]

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This publication can be downloaded from
http://www.geologyontario.mndm.gov.on.ca/mndmaccess/mndm_dir.asp?type=pub&id=MRD349

This digital data release includes whole-rock and trace element analyses for 16 samples of felsic igneous rocks from the Neoarchean McKenzie granite, located near Thunder Bay in northwestern Ontario. The geochemical data are provided in a Microsoft® Excel® 2010 (*.xlsx*) workbook file. A general description of the units sampled is also provided. These results form part of an Honours BSc thesis study that was a collaborative project between Lakehead University and the Ontario Geological Survey (Project NW-16-007).

This release comprises 1 Microsoft® Excel® 2010 (*.xlsx*) workbook file that consists of 2 worksheets. Worksheet "Geochemical Data" includes major and trace element geochemical data, and location data provided in Universal Transverse Mercator (UTM) co-ordinates in Zone 16, NAD83. Worksheet "Abbreviations" contains explanations for all of the abbreviations used in worksheet "Geochemical Data". All analyses were performed at the Geoscience Laboratories, Ontario Geological Survey, Sudbury, Ontario. Analytical methods are described in detail in the GeoLabs brochure, which is included on this release as a portable document format (*.pdf*) file.

Files on this Release

MRD349_Readme.pdf	(this document) Summarizes the geochemistry results, provides a brief interpretation of the data and includes petrographic description of the rocks sampled for this study.
MRD349_Geochemistry.xlxs	Contains results of the major and trace element geochemical analysis and location data.
2017 Geo Labs Brochure.pdf	Geoscience Laboratories' schedule of fees and services, providing information on the analytical methods used by Geoscience Laboratories for this study.

Summary

This readme file summarizes the geochemistry results and provides a brief interpretation of the data. A total of 16 samples were collected from surface exposures in order to characterize the petrology and geochemical footprint of the McKenzie granite and place them within the context of other late granites in the Thunder Bay area of northwestern Ontario.

The McKenzie granite is an approximately 22 km long (east-west) by 3.2 km wide (north-south) igneous intrusion that is located within the Wawa Subprovince, 20 km northeast of Thunder Bay, Ontario. The McKenzie granite (also termed the Mackenzie granite by Scott (1990)) has been divided into 2 segments that are separated by a fault (Scott 1990). The western segment of the intrusion extends eastward from Mount Baldy for 8.5 km, almost to the Shuniah Landfill Road. The eastern segment is 13 km long, and extends from the Shuniah landfill area to Birch Beach. Based on the mapping of Scott (1990), and the interpretation of recently published aeromagnetic data (Ontario Geological Survey 2015), Metsaranta (2015) has suggested that the McKenzie granite comprises multiple distinct intrusive bodies, and refers to the western segment as the Mount Baldy intrusion.

The approximate outlines of the 2 segments of the McKenzie granite are shown on the simplified geological map provided as Figure 1. The map also illustrates the bedrock sampling locations for this study, many of which were collected from outcrops resulting from recent construction along Highway 11/17 near Thunder Bay. Most of the samples are from the Mount Baldy intrusion. Of the 17 samples that were collected, only 16 were submitted for geochemistry.

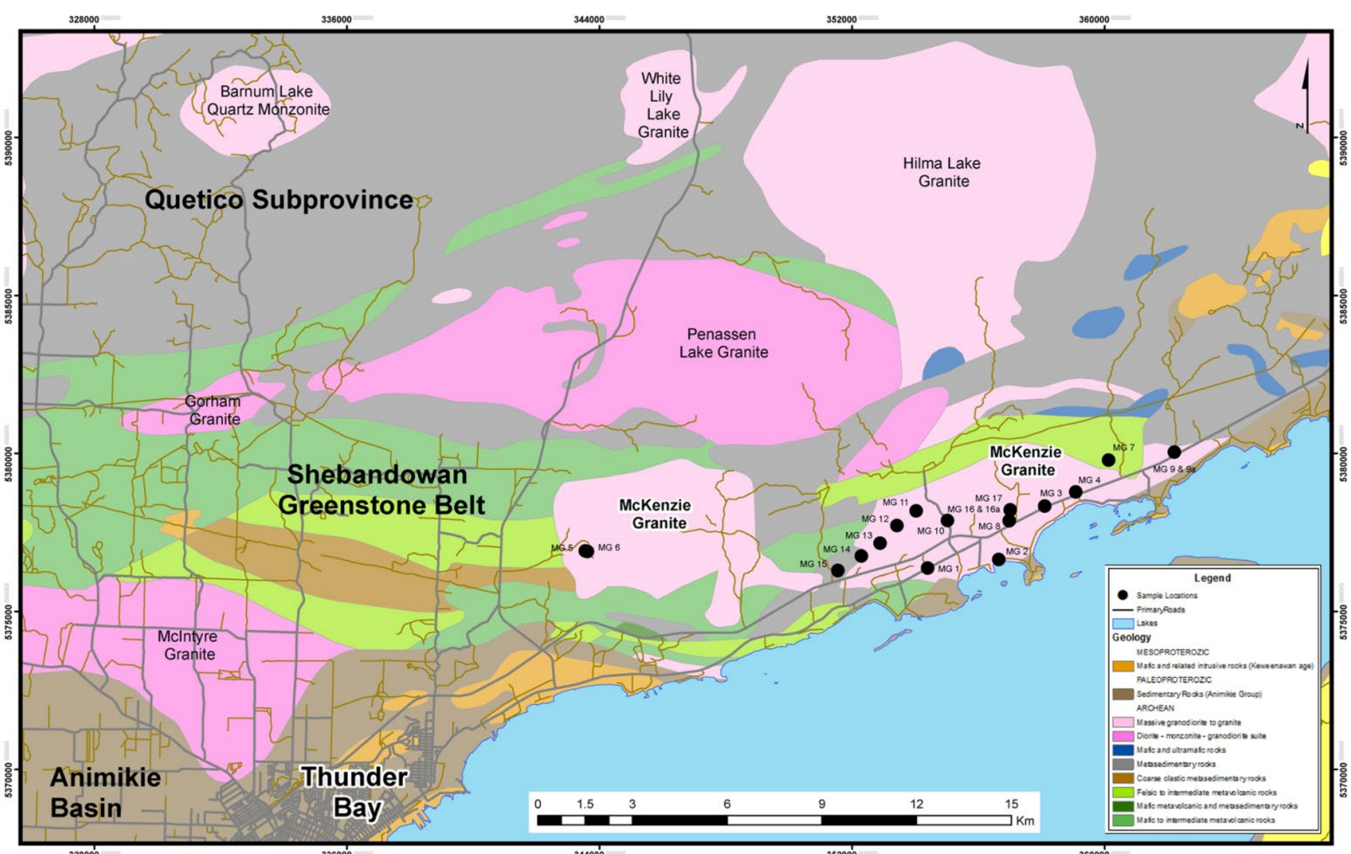

Figure 1. Geological map of the Thunder Bay area showing the location of the McKenzie granite area and sample locations (geology *after* Ontario Geological Survey 2011). Universal Transverse Mercator (UTM) co-ordinates in Zone 16, NAD83.

Petrologic and geochemical data have been used to classify the McKenzie granite as dominantly an S-type granite. The majority of the intrusion is a quartz monzonite, with mineral assemblages characterized by microcline-plagioclase-quartz-muscovite-biotite with minor amounts of inequigranular hornblende, chlorite, titanite and rarely calcite. The McKenzie granite exhibits a peraluminous geochemistry, with SiO_2 contents ranging from 63.8 to 68.2 weight % along with enrichment in light rare earth elements and fractionated heavy rare earth elements, decreasing trends of major oxides, transition metals and high field strength elements. Scattering of the large ion lithophile elements on discrimination diagrams is likely due to remobilization during chlorite, sericite and carbonate alteration.

It is proposed that the McKenzie granite formed in a similar way to the model proposed for the later stages of the genesis of the Dog Lake granite chain, which involved partial melting of the mantle wedge beneath the Wawa–Abitibi island arc (Kuzmich et al. 2012). In this model, the mafic melt produced from the subducting oceanic lithosphere would have underplated the Quetico Subprovince, leading to the formation of I-type granitic melts by fractionation. These melts would then have risen through structural conduits at the Quetico–Abitibi subprovince boundary. The majority of the underplated melt would have contributed to the production of the S-type granites that are commonly seen in the Quetico Subprovince. These S-type melts formed from the partial melting of the overlying metamorphosed sedimentary rock, and may have had the opportunity to interact with I-type melts. This model would allow for the variations in geochemical and petrological data that are observed in the McKenzie granite, but that are not common for standard S-type granites.

The proposed late-stage emplacement model is consistent with recent geochronology reported in Puumala et al. (2015), which indicated that the McKenzie granite was emplaced at 2672.6 ± 1.5 Ma (zircon, U/Pb thermal ionization mass spectrometry: Friedman 2014; Puumala et al. 2015, p.37). This is slightly younger than the *circa* 2679 Ma (Kamo 2013) emplacement date for the I-type Trout Lake intrusion of the Dog Lake granite chain that was reported in Metsaranta (2015).

Additional details on the geochemistry and geological significance of the McKenzie granite can be found in Hughes (2016).

Acknowledgments

The work reported herein forms part of an Honours BSc thesis study conducted by Alexander Hughes (Lakehead University) and supervised by Dr. Pete Hollings (Lakehead University) and Mark Smyk, Mark Puumala and Dorothy Campbell (all from the Resident Geologist's Program, Ontario Geological Survey, Thunder Bay). Thanks to the Geoscience Laboratories, GeoServices Section, Ontario Geological Survey (OGS), in Sudbury for in-kind support in the analysis of rock samples for whole rock geochemistry. Also, thanks to Anne Hammond and Kristi Tavener for their assistance in thin section preparation.

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SAMPLE DESCRIPTIONS

NOTE: Sample descriptions were done by A. Hughes.

MG1 – Quartz monzonite

This sample is a fine-grained, green to pink massive quartz monzonite. Coarse-grained microcline has perthitic texture with inclusions of fine-grained plagioclase and chloritized biotite. Coarse-grained plagioclase is altered to sericite (0-50%) and locally displays compositional zoning.

(40%) Plagioclase: Coarse- to medium-grained subhedral crystals with sericitization.

(20%) Microcline: Coarse-grained, perthitic, anhedral crystals. Inclusions of euhedral but altered medium- to fine-grained plagioclase and very fine-grained biotite.

(18%) Quartz: Medium- to fine-grained anhedral crystals with undulose extinction and subgrains.

(10%) Orthoclase: Coarse- to medium-grained anhedral crystals with well-developed exsolution lamellae.

(5%) Biotite: Fine- to very fine-grained anhedral crystals with minor zircon inclusions. Commonly altered to chlorite.

(3%) Chlorite: Light green in plane-polarized light, pale blue in cross-polarized light. Observed as replacement mineral of biotite.

(3%) Amphibole: Light green, highly fractured fine-grained subhedral crystals replaced by chlorite.

(<1%) Epidote: Very fine-grained. Occurs as saussuritization of plagioclase and is associated with chlorite alteration.

MG 2 – Granite

This sample is a coarse-grained pink granite. Orthoclase is very coarse-grained and contains inclusions of altered plagioclase and chlorite. Plagioclase has undergone sericitization and slight saussuritization. Quartz is commonly present as fractured coarse-grained crystals and as fine-grained groundmass in between medium-grained anhedral microcline. Biotite has been almost completely altered to chlorite and is commonly present as clusters with fine-grained opaque minerals.

(35%) Quartz: Coarse- to medium-grained anhedral crystals, fractured, minor undulatory extinction. Subgrain boundaries.

(25%) Orthoclase: Coarse- to medium-grained perthitic subhedral oikocryst with fine-grained inclusions of quartz, altered plagioclase and biotite.

(20%) Microcline: Medium-grained anhedral crystals occurring in clusters along with very fine-grained quartz.

(10%) Plagioclase: Medium- to fine-grained subhedral crystals with intense sericite replacement.

(5%) Chlorite: Replacement of biotite; medium- to fine-grained pseudomorphic texture from alteration. Occurs as inclusions in plagioclase and grouped with chlorite and biotite.

(1%) Opaque minerals: Very fine-grained, occur grouped with biotite, chlorite.

(<1%) Titanite: Medium- to fine-grained euhedral crystals. Larger grains commonly fractured.

(<1%) Epidote: Secondary mineral from alteration of plagioclase (saussuritization).

MG 3 – Quartz syenite

This sample is a medium- to coarse-grained light pink to green quartz syenite. Orthoclase is pegmatitic and has a strong perthitic texture. Plagioclase is commonly sericitized (0-50%) and myrmekitic where in contact with quartz and orthoclase. Biotite is also altered to chlorite (20-50%) and occurs with both apatite and opaque minerals.

(50%) Orthoclase: Very coarse-grained, almost pegmatitic, perthitic, subhedral oikocrystic. Inclusions are commonly altered plagioclase but there are rare epidote veins in quartz. Exsolution lamellae have undergone sericitization.

(24%) Plagioclase: Coarse- to medium-grained subhedral to euhedral crystals. Sericitization common. Rare deformation to twinned grains. Myrmekitic texture is observed along grain boundaries where in contact with quartz.

(10%) Quartz: Commonly coarse- to medium-grained anhedral crystals. Undulose extinction common. Contains fractures infilled with epidote, chlorite and rare inclusions of altered biotite.

(5%) Biotite: Medium-grained subhedral crystals. Contains inclusions of fine-grained plagioclase, zircon halos, opaque minerals and microlites of apatite giving the mineral a felty texture. Choritization is abundant (>40%).

(1%) Opaque minerals: Medium- to fine-grained fractured euhedral crystals. Occur in and around biotite.

(<1%) Apatite: Fine-grained euhedral crystals occur paired with altered biotite.

MG 4 – Quartz monzonite

This sample is a medium-grained, massive green to pink quartz monzonite. Coarse-grained sericitized plagioclase grains overlap with fine-grained quartz filling in interstitial space. Orthoclase occurs as very coarse-grained phenocrysts with minor inclusions of plagioclase and quartz. Contains gabbro xenolith with a network of fine-grained plagioclase laths and interstitial quartz, pyroxene, biotite and amphibole. Distinct grain size difference between the 2 rock types.

(45%) Plagioclase: Coarse- to medium-grained subhedral laths. Grain boundaries are highly deteriorated (serrated habit) and cores contain sericite alteration (>50%) and minor saussuritization (5%).

(25%) Orthoclase: Very coarse-grained euhedral phenocrysts/megacrysts. Well-defined perthitic texture and simple twinning. Contains inclusions of fine-grained plagioclase.

(10%) Quartz: Medium- to fine-grained anhedral crystals. Undulose extinction common with rare subgrains and serrated grain boundaries.

(8%) Biotite: Medium-grained subhedral crystals. Highly altered by chloritization (>50%).

(5%) Chlorite: Alteration of biotite. Occurs rarely as pseudomorphs that completely replace biotite.

(5%) Hornblende: Medium- to fine-grained subhedral crystals. Chloritization common, as is biotitization.

(1%) Apatite: Fine-grained euhedral crystals occur paired with altered biotite and rarely as inclusions in plagioclase.

(1%) Opaque minerals: Very fine-grained anhedral crystals occur near biotite.

MG 5 – Quartz syenite

This sample is a green to pink, massive, medium-grained quartz syenite. The rock contains sericitized plagioclase with slightly deformed twins, simple twins in orthoclase and undulose extinction in quartz. Fine-grained microcline occurs within plagioclase cores. Biotite is commonly altered to chlorite and contains very fine-grained inclusions of microlitic opaque minerals.

(35%) Microcline: Anhedral medium-grained crystals. Fills interstitial space between plagioclase and orthoclase. Slight perthitic texture. Inclusions of altered fine-grained euhedral plagioclase crystals.

(30%) Plagioclase: Coarse- to medium-grained euhedral laths. Sericitization common in crystal cores. Slight bending to the twining. Fine-grained inclusions of muscovite.

(15%) Orthoclase: Coarse-grained euhedral phenocrysts with inclusions of fine-grained euhedral biotite and anhedral plagioclase with muscovite microlites and a strong perthitic texture.

(10%) Quartz: Medium- to fine-grained anhedral crystals with serrated grain boundaries and undulose extinction. Fills the interstitial space between plagioclase laths and orthoclase grains.

(5%) Biotite: Medium- to fine-grained euhedral laths. Grains are strongly chloritized (30-50%) with pseudomorphic texture in some minerals. Very fine-grained opaque mineral inclusions.

(2%) Muscovite: Very fine-grained euhedral microlite inclusions in plagioclase.

(2%) Amphibole: Euhedral, fine-grained, rhomb-shaped crystals, dark green, almost brown. Occurs as inclusions in biotite.

(1%) Opaque minerals: Fine-grained flecks in altered biotite.

MG 6 – Quartz syenite

This sample is a medium- to coarse-grained, light green to pink, massive quartz syenite. Poikilitic microcline phenocrysts are common, with inclusions of fine-grained plagioclase and fracture infills of calcite. Plagioclase grains are sericitized, with inclusions of muscovite and calcite. Interstitial space is filled with very fine-grained anhedral quartz and plagioclase matrix along with chlorite alteration.

(45%) Microcline: Fractured coarse- to medium-grained anhedral grains with weak perthitic texture. Fractures are filled with calcite. Larger grains are poikilitic, with inclusions of plagioclase.

(30%) Plagioclase: Highly altered medium-grained subhedral grains. Sericite alteration in cores, along with inclusions of muscovite laths and fine-grained anhedral calcite.

(12%) Quartz: Very fine-grained anhedral crystals. Occurs only in between medium- to coarse-grained feldspar crystals as a mixture of fine-grained quartz, plagioclase and microcline.

(7%) Chlorite: Alteration of biotite. Fine-grained polysynthetic twinning. Fine-grained inclusions of lath-like opaque minerals. Occurs in contact with very dark brown euhedral crystals, either amphibole or titanite.

(5%) Calcite: Fine-grained inclusions in plagioclase, and as veinlets in microcline and orthoclase. Occurs rarely as medium-grained anhedral grains near microcline.

(1%) Opaque minerals: Very fine-grained microlites in chlorite.

MG 7 - Quartz monzonite

This sample is a massive, medium- to fine-grained, salmon-pink quartz monzonite. Orthoclase megacrysts are common, with inclusions of plagioclase, quartz and amphibole. Sericitization of plagioclase occurs within the cores of crystals with very fine-grained inclusions of muscovite. Amphibole crystals occur commonly in between plagioclase grains and display biotitization along the rims. Primary biotite is highly chloritized within cleavage planes.

(40%) Plagioclase: Medium-grained subhedral cumulophyric crystal. Highly sericitized core. Very fine-grained muscovite inclusions in sericite.

(20%) Orthoclase: Very coarse-grained euhedral poikilitic megacrysts. Inclusions of fine-grained plagioclase, euhedral amphibole, biotite and quartz. Well-defined perthitic texture and simple twinning.

(15%) Microcline: Medium-grained anhedral crystals with strong perthitic texture and undulose extinction. Inclusions of fine-grained amphibole are common.

(10%) Quartz: Medium- to fine-grained anhedral crystals with undulose extinction and subgrain boundaries.

(10%) Hornblende: Pleochroic pale to dark green. Euhedral medium- to fine-grained crystals with slight biotitization around rim (10%).

(5%) Biotite: Euhedral crystals occurring with amphibole. Chloritization is present along cleavage planes of primary crystals.

MG 8 – Quartz monzonite

This sample is a green to pink massive quartz monzonite. Microcline oikocrysts are perthitic and contain inclusions of amphibole and altered plagioclase. Plagioclase grains are affected by sericitization at approximately 30%. Amphibole has minor saussuritization around rims in contact with biotite and contains inclusions of opaque minerals and apatite. Fine-grained euhedral laths of biotite display undulatory extinction.

(45%) Plagioclase: Subhedral to anhedral. Highly sericitized. Undulatory extinction in some grains. Inclusions of muscovite associated with sericite alteration. Myrmekitic texture where in contact with microcline.

(20%) Microcline: Coarse-grained anhedral oikocryst with slight perthitic texture. Inclusions consist predominantly of plagioclase and rarely amphibole.

(10%) Quartz: Inequigranular anhedral crystals. Undulose extinction and subgrain boundaries common. Where in clusters, the crystals are coarse-grained and rarely occur as very fine-grained groundmass in between feldspars.

(10%) Orthoclase: Medium- to fine-grained. Rounded and anhedral. Well-developed perthitic texture. Myrmekitic texture where in contact with microcline.

(7%) Hornblende: Medium- to fine-grained euhedral crystals and rarely laths. Rare inclusions of fine-grained euhedral apatite and fine-grained opaque minerals. Occurs paired with biotite. Slight saussuritization.

(5%) Biotite: Fine-grained, euhedral laths. Slight chloritization around rims (>5%). Slight undulatory extinction.

(2%) Epidote: Secondary mineral from alteration of amphibole via saussuritization. Fine-grained and anhedral grains occur along contacts between biotite and amphibole.

(1%) Opaque minerals: Fine-grained, anhedral inclusions in medium-grained amphibole crystals.

MG 9 – Quartz monzonite

This sample is a green, slightly pink, medium-grained quartz monzonite. Sericitization is moderate in plagioclase (40%). Weak chloritization in biotite whereas amphibole grains appear to be unaltered. Opaque minerals are clustered in biotite and amphibole grains.

(50%) Plagioclase: Medium-grained euhedral laths with adcumulate texture. Intensely altered to sericite and contains inclusions of muscovite.

(20%) Microcline: Coarse-grained anhedral oikocrysts. Inclusions of mostly fine-grained subhedral plagioclase and rare biotite.

(15%) Quartz: Medium-grained. Anhedral. Moderate undulose extinction and subgrain boundaries. Fractures filled with muscovite.

(5%) Biotite: Commonly medium- to fine-grained poikilitic laths. Inclusions of rounded opaque grains. Some grains show chloritization along cleavage planes.

(2%) Muscovite: Occurs as very-fine grained subhedral inclusions in plagioclase. May also occur as infill of fractures in quartz.

(5%) Amphibole: Fine-grained euhedral crystals in contact with biotite.

(3%) Opaque minerals: Very fine-grained inclusions in biotite. Commonly occur clustered together.

MG 10 – Quartz monzonite

This sample is a coarse- to medium-grained, slight green to pink, massive quartz monzonite. Moderate sericitization of plagioclase laths (30-50%) and weak alteration in microcline megacrysts (5-10%). Moderate chloritization of biotite but weak in amphibole. Primary pyroxene is rare and is replaced by amphibole. Slight deformation twins present in plagioclase whereas amphibole contains simple twins.

(45%) Plagioclase: Medium-grained subhedral laths. Sericitization of all grains and with inclusions of muscovite. Compositional zoning observed in the majority of crystals.

(25%) Microcline: Coarse-grained anhedral, poikilitic megacrysts. Inclusions of fine-grained plagioclase and biotite. Well-developed perthitic texture and minor sericitization (5-10%).

(15%) Quartz: Inequigranular anhedral crystals. Well-defined undulatory extinction, subgrain boundaries and grain boundary migration.

(7%) Hornblende: Medium- to fine-grained euhedral grains. A few amphibole grains contain relict fine-grained pyroxene that is partially replaced by amphibole. Simple twinning common along with slight chloritization.

(5%) Biotite: Brown fine-grained laths. Inclusions of opaque minerals and very fine-grained apatite. Chloritization common in most grains at about 30%.

(3%) Opaque minerals: Very fine-grained subhedral inclusions in biotite.

MG 11 – Quartz monzonite

This sample is a massive, green to pink, medium-grained quartz monzonite with muscovite phenocrysts. All plagioclase grains are altered to sericite and contain inclusions of very fine-grained muscovite. Compositional zoning is common and slight deformation of twins was observed. Quartz is highly deformed and has a moderate foliation with undulatory extinction, subgrain boundaries and grain size reduction. Primary pyroxene and amphibole are rare, with both having undergone biotitization. Additional chloritization of ferromagnesian minerals is moderate and is observed in biotite.

(50%) Plagioclase: Medium-grained subhedral laths. Minor deformation twins and rare simple twinning. Moderate zoning. Sericitization in all grains (>60%). Inclusions of muscovite due to alteration.

(25%) Microcline: Very coarse-grained poikilitic megacrysts. Inclusions of less-altered, fine-grained plagioclase, quartz and euhedral amphibole. Moderately developed perthitic texture and minor sericitization.

(15%) Quartz: Medium- to very fine-grained. Highly deformed with weak foliation. Undulatory extinction, subgrain boundaries and grain size reduction.

(5%) Biotite: Medium- to fine-grained subhedral laths. Strong chloritization in most grains giving pseudomorphic texture. Occurs paired with rare relict pyroxene.

(3%) Opaque minerals: very fine-grained inclusions in biotite, hornblende, chlorite and pyroxene clusters. Commonly present as inclusions in biotite.

(2%) Amphibole: Rare, euhedral grains. Most grains altered by biotitization. Can occur in biotite clusters. Grains commonly anhedral and chloritized with undulatory extinction.

MG 12 – Quartz monzonite

This sample is a medium-grained, dark pink, massive quartz monzonite. Intense sericite alteration occurs in plagioclase (40-80%) and weakly in microcline (5-20%). This alteration also seems to be associated with calcite inclusions in plagioclase. This sample has been moderately deformed, with quartz having a well-defined foliation along with undulatory extinction and subgrains. Amphiboles appear to have undergone some biotitization. Rare euhedral amphibole grains occur clustered with biotite and amphibole.

(40%) Plagioclase: Medium- to fine-grained subhedral laths. Moderate sericite alteration (30-50%). Inclusions of muscovite and calcite are associated with sericite. Rare deformation twins, undulatory extinction and myrmekitic texture where in contact with microcline and orthoclase.

(20%) Microcline: Very coarse-grained, anhedral poikilitic phenocrysts. Inclusions of euhedral plagioclase laths and rare, relict primary pyroxene moderate perthitic texture and weak sericitization.

(10%) Orthoclase: Coarse- to medium-grained subhedral crystals. Perthitic texture and undulatory extinction are common.

(10%) Quartz: Medium-grained. Anhedral. Strong foliation with undulatory extinction, subgrain boundaries and grain size reduction.

(10%) Biotite: Medium- to fine-grained subhedral laths. Inclusions of opaque minerals, apatite and euhedral amphibole grains. Zircon halos common.

(5%) Hornblende: Medium- to fine-grained, poikilitic ehuedral grains with inclusions of biotite, opaque minerals and apatite. Biotitization common. Relict pyroxene grains occur in some amphibole grains.

(1%) Opaque minerals. Very fine-grained, subhedral inclusions within ferromagnesian minerals.

(<1%) Apatite: Very fine-grained euhedral grains as inclusions in ferromagnesian minerals.

(<1%) Calcite: Fine-grained, anhedral, associated with sericitization.

MG 13 – Quartz monzonite

This sample is a massive, green to pink, coarse- to medium-grained quartz monzonite. Alkali feldspar phenocrysts have weak sericitization, moderate perthitic texture and contain inclusions of plagioclase and amphibole. Plagioclase is compositionally zoned with strong sericitization. Quartz shows a weak foliation with undulatory extinction and subgrains. Amphibole is typically altered to biotite with inclusions of apatite and opaque minerals.

(40%) Plagioclase: Medium- to fine-grained subhedral laths. Strong sericitization (30-50%). Inclusions of muscovite are associated with sericitization.

(20%) Microcline: Coarse-grained anhedral phenocryst with inclusions of euhedral fine-grained plagioclase laths and biotite. Weak sericitization. Moderately developed perthitic texture.

(15%) Orthoclase: Similar habit to microcline. Contains moderate sericitization, strong perthitic texture and simple twinning.

(10%) Quartz: Medium-grained. Anhedral with weak foliation and undulatory extinction, subgrain boundaries, and grain size reduction.

(10%) Biotite: Alteration product of amphibole. Medium- to fine-grained subhedral laths. Weakly chloritized. Occurs with highly altered amphibole.

(5%) Hornblende: highly altered to biotite. Subgrains common with inclusions of chloritized biotite, rare relict pyroxene, and very fine-grained apatite and opaque minerals.

(<1%) Apatite: Very fine-grained anhedral inclusions within hornblende and biotite.

(<1%) Opaque minerals: Very fine-grained inclusions in hornblende and biotite.

MG 14 – Quartz monzonite

This sample is a green to dark pink, fine-grained massive quartz monzonite. Plagioclase is highly sericitized (40-50%) with inclusions of muscovite and calcite. Microcline commonly occurs as anhedral oikocrysts with inclusions of plagioclase, quartz and biotite. Quartz shows strong undulose extinction and sub-grain boundaries. Amphibole and biotite have been altered to chlorite and are spatial associated with euhedral opaque minerals.

(40%) Plagioclase: Coarse-grained. Subhedral poikilitic laths with strong sericitization. Inclusions of muscovite and calcite are associated with sericite alteration. Weak deformation twins.

(30%) Microcline: Coarse- to fine-grained. Inequigranular anhedral oikocrysts. Inclusions of plagioclase, quartz, muscovite and biotite. Well-developed perthitic texture and simple twinning.

(15%) Quartz: medium- to fine-grained. Anhedral. Well-developed undulatory extinction and subgrain boundaries.

(5%) Biotite: Medium- to fine-grained. Euhedral laths. Most grains (40%) show abundant chloritization. Zircon radiation halos common. Inclusions of opaque minerals.

(5%) Chlorite: Alteration product of amphibole and biotite. Medium- to fine-grained.

(3%) Hornblende: Fine-grained euhedral crystals rare. Highly chloritized along with biotite. Occurs grouped with biotite and opaque minerals.

(2%) Opaque minerals: Spatially associated with ferromagnesian minerals, typically as inclusions.

MG 15 – Quartz monzonite

This sample is a fine-grained, light pink to green, massive quartz monzonite. Microcline phenocrysts contain inclusions of quartz and plagioclase with a perthitic texture and undulatory extinction. Plagioclase is highly altered to sericite in crystal cores. Biotite and amphibole have altered to chlorite. Primary biotite is rare and exhibits undulatory extinction. Amphibole is poikilitic with inclusions of chlorite, quartz and biotite.

(35%) Plagioclase: Medium-grained, subhedral poikilitic laths with intense sericite alteration and weak deformation twins. Very fine-grained inclusions of muscovite associated with sericite alteration.

(25%) Microcline: Coarse- to fine-grained. Inequigranular anhedral oikocryst. Inclusions of plagioclase, quartz, muscovite and biotite. Well-developed perthitic texture. Simple twinning and undulatory extinction are observed in larger grains.

(15%) Quartz: Medium- to fine-grained. Anhedral. Strong undulatory extinction and subgrain boundaries.

(7%) Hornblende: Coarse- to fine-grained, poikilitic subhedral grains with moderate chloritization. Inclusions of biotite, chlorite and quartz.

(6%) Biotite: Primary biotite is rare. Fine-grained euhedral laths with undulatory extinction. Majority of grains are altered to chlorite.

(7%) Chlorite: Associated with alteration of biotite and hornblende. Fine-grained and anhedral clusters within biotite and amphibole.

(1%) Titanite: Fine-grained subhedral crystals occur as inclusions in feldspars.

MG 16 – Quartz monzonite

This sample is a medium-grained, green to slight pink, massive quartz monzonite. Plagioclase laths are altered to sericite. Muscovite occurs as very coarse-grained oikocrysts with inclusions of finer grained plagioclase and rarely biotite. Relict pyroxene is spatially associated with amphibole because of partial alteration.

(50%) Plagioclase: Coarse- to medium-grained euhedral tabular laths with intense sericitization and compositional zoning along with simple twins. A few crystals contain muscovite inclusions that are associated with sericitization.

(20%) Muscovite: Very coarse- to medium-grained oikocrysts with a well-developed perthitic texture and simple twins. Inclusions of smaller plagioclase laths and rare amphibole.

(15%) Quartz: Medium- to fine-grained, anhedral crystals with undulatory extinction, subgrains and grain boundary migration.

(5%) Hornblende: Fine-grained subhedral crystals. Inclusions of chlorite and relict pyroxene from uralitization.

(5%) Biotite: medium- to fine-grained subhedral laths with inclusions of very fine-grained apatite and opaque minerals. Secondary biotite is associated with alteration of amphibole.

(2%) Pyroxene: Fine-grained subhedral crystals occur in hornblende.

(3%) Opaque minerals: Very fine-grained inclusions in hornblende and biotite. Spatially associated with ferromagnesian minerals.

MG 17 – Quartz monzonite

This sample is a massive, medium-grained, green to pink quartz monzonite. Plagioclase laths overlap, are highly altered to sericite, and contain inclusions of fine-grained muscovite and calcite. Muscovite occurs as very coarse-grained oikocrysts with inclusions of finer-grained plagioclase and biotite laths. Relict pyroxene is rare and is partially replaced by amphibole. Biotite is medium- to fine-grained with moderate chloritization and rare inclusions of apatite.

(40%) Plagioclase: Coarse- to medium-grained subhedral laths. Compositional zoning can be seen in some grains. Sericitization is present in every grain at 50-60%. Simple twins are present. Very fine-grained inclusions of muscovite microlites.

(25%) Muscovite: Coarse-grained, anhedral poikilitic megacrysts with a perthitic texture. Dominant inclusions in plagioclase laths and rarely in fine-grained biotite.

(16%) Quartz: medium- to fine-grained anhedral crystals with undulatory extinction, subgrains and grain boundary migration.

(7%) Biotite: Medium- to fine-grained subhedral laths. Moderate chloritization. Weakly poikilitic with inclusions of pyroxene.

(5%) Orthoclase: Medium-grained anhedral crystals. Well-developed perthitic texture and simple twinning.

(5%) Hornblende: Coarse- to fine-grained subhedral crystals, moderate chloritization and inclusions of relict pyroxene partially replaced by hornblende.

(3%) Pyroxene: Fine-grained subhedral crystals partially replaced by hornblende. May be spatially associated with biotite.

(1%) Opaque minerals: Fine-grained subhedral crystals spatially associated with ferromagnesian minerals.

(1%) Calcite: Associated with carbonate alteration in plagioclase and microcline.

(<1%) Apatite: very fine-grained inclusions in biotite and in the quartz groundmass.