PHASE 2 GEOSCIENTIFIC PRELIMINARY ASSESSMENT

GEOLOGICAL MAPPING, TOWNSHIP OF IGNACE AND AREA, ONTARIO

APM-REP-01332-0225 November, 2017

Golder Associates Ltd.

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Golder Associates

Executive Summary

This technical report documents the results of the Phase 2 Detailed Geological Mapping activity conducted in 2015 and 2016 as part of the Phase 2 Geoscientific Preliminary Assessment, to further assess the suitability of the Ignace area to safely host a deep geological repository. This study followed the successful completion of Phase 2 Findings from Initial Field Studies (Golder, 2015), which identified four candidate areas for detailed mapping.

The purpose of the Phase 2 Detailed Geological Mapping is to advance understanding of the bedrock geology of the candidate areas, with an emphasis on observation and analysis of bedrock structure and lithology. Information collected during Phase 2 Detailed Geological Mapping also helps to identify areas of exposed bedrock, assess overburden thickness, and identify surface constraints within the candidate area, which might affect suitability.

Observations were conducted at select locations that were accessed using existing secondary roads, trail networks and waterbodies, as well as some off-trail hiking. The four areas were mapped over a total period of 37 days by three mapping teams using a consistent workflow and standardized digital data collection system. Observations were made at a total of 580 locations in the four candidate areas, including 260 stations in the Revell batholith area, 136 stations in the Basket Lake-Indian Lake West batholith area, and 184 stations in the Indian Lake East batholith area.

A digital data collection protocol was applied, and observations were compiled into a GIS-compatible database. This includes information on bedrock character (lithology, magnetic susceptibility, gamma ray spectrometry, structure, rock strength), fracture character, bedrock exposure and surface constraints. This report details the field observation for the candidate areas.

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APPENDICES

1.0 INTRODUCTION

This technical report presents the results of Phase 2 Detailed Geological Mapping conducted in 2015 and 2016 as part of the Phase 2 Geoscientific Preliminary Assessment, to further assess the suitability of the Ignace area (Figure 1.1) in northwestern Ontario, to safely host a deep geological repository as part of NWMO's Adaptive Phased Management (APM) Site Selection process. Phase 2 Detailed Geological Mapping builds on the results of the Initial Screening (Golder, 2011), Phase 1 Geoscientific Desktop Preliminary Assessment (Golder, 2013), Phase 2 Observation of General Geological Features (OGGF) for Ignace (SRK and Golder, 2015a) and Phase 2 Findings from Initial Field Studies (Golder, 2015).

The Phase 1 desktop geoscientific assessment identified a number of large potentially suitable areas warranting further studies such as high-resolution geophysical surveys and geological mapping. Subsequent high-resolution geophysical surveys and interpretation included airborne magnetic and gravity geophysical surveys (SGL, 2015), and were followed by further lineament interpretation (SRK, 2015) and Observing General Geological Features (SRK and Golder, 2015a). Phase 2 Detailed Geological Mapping in the Ignace area focussed on the four candidate areas that were identified in the Phase 2 Initial Findings report (Golder, 2015a).

The objective of Phase 2 Detailed Geological Mapping is to advance understanding of the bedrock geology of the four candidate areas, with an emphasis on observation and analysis of bedrock structure and lithology, in the context of the results from the Phase 2 Airborne Geophysical Assessment (SGL, 2015) and the Phase 2 Lineament Assessment (SRK, 2015). Information collected during Phase 2 Detailed Geological Mapping also helps identify areas of exposed bedrock, assess overburden thickness, and identify surface constraints affecting accessibility within candidate areas.

The Phase 2 Detailed Geological Mapping activity was completed by Golder Associates Ltd. (Golder) and Paterson, Grant and Watson Ltd. (PGW). The observations were conducted at select locations that were accessed using existing secondary roads, trail networks and waterbodies, as well as some off-trail hiking (Figure 1.2).

1.1 Scope of Work

The Phase 2 Detailed Geological Mapping work was carried out in three stages as follows:

- Stage 1: Pre-mapping planning stage;
- Stage 2: Mapping stage; and
- Stage 3: Synthesis and reporting stage.

During the pre-mapping planning stage, a work plan for the geological mapping was developed for the four candidate areas identified in the Phase 2 Initial Findings report (Golder, 2015a). These include, one area in the northern portion of the Revell batholith, one area in the southeastern portion of the Basket Lake batholith, one area in the adjacent western portion of the Indian Lake batholith, and one area in the eastern portion of the Indian Lake batholith (Figure 1.2). During the geological mapping (Stage 2), geological information was collected in accordance with the work plan defined during Stage 1 (See Section 4 Methodology) and during Stage 3 the observations and information were analysed and compiled, and documented in this report.

The four areas were mapped in the fall of 2015 and spring and summer of 2016 over a total period of approximately 37 mapping days by three teams, each consisting of two geologists and one local guide. Several GIS datasets were used as base maps for planning and undertaking the geological mapping activity, including predictive outcrop mapping generated by NWMO using remote sensing data (see Section 4 Methodology), high-resolution satellite imagery, recently-acquired high-resolution geophysical data (SGL, 2015) and interpreted lineaments (SRK, 2015).

1.2 Qualifications of the Mapping Team

The project team was assembled by Golder Associates Ltd. and included subconsultants from Paterson, Grant & Watson Ltd. and several independent consultants with extensive field mapping and structural geology experience.

Employee-owned since its formation in Toronto in 1960, Golder Associates has grown to more than 7,000 employees in offices located throughout Africa, Asia, Australasia, Europe, North America and South America. Golder has a depth of experience and expertise supporting the nuclear industry including approvals and licensing, radioactive waste management, and investigations and engineering for deep geological repository studies in Canada, the United States, Sweden, Finland, France, Hungary, South Korea, Japan and the United Kingdom.

Paterson, Grant & Watson Limited (PGW) was established in 1973 to provide geophysical consulting services to the mineral, petroleum and engineering sectors. PGW specializes in geophysical survey management, quality control, data processing, modelling and interpretation applied to both hard rock and sedimentary basin environments. PGW has worked extensively throughout the Canadian Shield on interpretation projects, mainly to explore for base metals, precious metals and diamonds. As a result, it is very familiar with the granite-greenstone terrains, and interpreting geophysical data for lithology and structure. PGW has conducted processing and interpretation of geophysical data for a number of communities considered by the NWMO as part of Phase 1 of the Geoscientific Desktop Preliminary Assessments, including the Ignace area.

The investigations and compilation of the data presented in this report were completed by Dr. Iris Lenauer (PGW), Dr. Fred Breaks, Mr. Tim Corkery, Dr. Charles Mitz (Golder), Dr. Greg Stott, and Dr. Alex Man (Golder). The work was completed under the supervision of Mr. George Schneider (Golder). A brief description of their roles and qualifications is provided below.

Dr. Iris Lenauer, Ph.D, P.Geo. (APGO #2473), is a Consultant (Structural Geology) at PGW with over 8 years of experience specializing in regional mapping, structural analysis in various tectonic settings, and fault analysis. She has recently completed a regional structural lineament interpretation of the Phoenix project in the Red Lake Greenstone Belt of the Superior Province, and an interpretation of fault network from aeromagnetic data from the Palmarejo project area in Mexico. While at SRK, she was the lead interpreter for the NWMO Phase 2 Lineament Interpretation for Ignace. Dr. Lenauer was a lead geologist on both the Ignace OGGF and Detailed Geological Mapping programs, and is a lead author of this report.

Dr. Fred Breaks, Ph.D., P.Geo. (APGO #0760) is a Professional Geoscientist in Ontario and Quebec. His geological mapping skills have been developed in over 40 years of field work including projects with a cumulative area of 150,000 km^2 of the Superior and Grenville Provinces. He has extensive experience with petrography, mineralogy, litho- and mineral chemistry of most Archean shield rock types in a wide variety of domain settings. Fred has authored 118 publications while at the OGS and numerous external publications. Fred was a lead geologist in the field for the Detailed Geological Mapping at Ignace.

Mr. Tim Corkery, M.Sc., P.Geol. (APGO #2586) Mr. Corkery is a Professional Geologist with over 40 years of diversified geological experience, providing geological mapping and mineral occurrence services. His work included extensive regional and detailed geological and structural mapping programs that resulted in publications of numerous reports and geological maps. Tim was employed for 38 years by the Manitoba Geological Survey and while there he provided management of multi-organizational (industry-university-Federal and Provincial Government surveys), multi-year regional studies. His projects focused on structural studies in the Archean of Manitoba. Tim was a lead geologist in the field for the Detailed Geological Mapping at Ignace.

Dr. Charles Mitz, Ph.D., P.Geo. (APGO #0277), is a senior engineering geologist at Golder with expertise in fractured rock hydrogeology. He was the lead geologist for the Initial Screening and Phase 1 Geoscientific Assessments for Ignace, and several other communities that have participated in the APM site selection process. Charles was an assistant geologist in the field for the OGGF and Detailed Geological Mapping at Ignace.

Dr. Greg Stott, Ph.D., P.Geo. (APGO #0105) is a consulting geoscientist with more than 30 years of distinguished experience in the crystalline bedrock environment of northern Ontario. For this project, Dr. Stott provided oversight in the field to ensure a consistent approach was being applied by the three mapping teams. During his career with the OGS, Dr. Stott made significant advancements in the understanding of the tectonic evolution of the Superior Province, as well as making numerous important contributions to geochronology, economic geology and structural geology. Dr. Stott has been actively involved in a number of NWMO projects including Phase 1 Assessments of Hornepayne and Wawa, as well as providing technical review for Golder's Phase 1 Assessments of various communities in northern Ontario and Saskatchewan. Dr. Stott also participated in the OGGF mapping.

Dr. Alex Man, P.Eng. (PEO #100228183), is an Associate and senior geotechnical engineer at Golder with a focus on nuclear repository site selection and characterization. He was the task leader for the Phase 1 Geoscientific Assessments for the Creighton, Pinehouse and ERFN communities that have participated in the APM site selection process. Alex was an assistant geologist in the field for the OGGF program and was the Project Manager for the Detailed Geological Mapping at Ignace.

Mr. George Schneider, M.Sc., P.Geo. (APGO #1239) is a Principal and senior geoscientist at Golder with over 25 years of experience in a wide range of geological, geophysical and hydrogeological projects, including nuclear repository site selection and characterization in Canada. He has managed a number of projects over the last several years for NWMO related to APM, including: reviews of geophysical methods for site characterization, the development of a generic approach to initial screenings for the APM site selection process, initial screenings for the APM site selection process, updates to the APM cost estimate and schedule, Phase 1 Geoscientific Desktop preliminary assessments for multiple communities in northern Ontario and Saskatchewan, and Phase 2 OGGF mapping projects in Ignace and Creighton. He is the Project Director, responsible for senior oversight of the Detailed Geological Mapping at Ignace and review of this report.

1.3 Report Organization

This report was prepared by Golder and PGW. A general description of the Ignace area, including location, and physiography is provided in Chapter 2. Chapter 3 summarizes the regional and local geological setting for the Ignace area. The methodology employed to undertake the geological mapping activity is provided in Chapter 4. Results are presented in Chapter 5. Key findings are summarized in Chapter 6, followed by references cited in Chapter 7 and a set of figures. In addition, Appendix A provides supporting tables from the Work Plan.

2.0 LOCAL AREA DESCRIPTION

2.1 Location

The Ignace area is located within the District of Kenora in northwestern Ontario, along the north shore of Lake Agimak, approximately 250 km northwest of Thunder Bay (Figure 1.1). The four candidate areas identified in the Phase 2 Initial Findings report (Golder, 2015a) comprised the main regions of focus during the detailed geological mapping field work described herein. One candidate area is located on the Basket Lake batholith, to the northwest of the Township of Ignace. There are two candidate areas on the Indian Lake batholith, one adjacent to, and northwest of the Township, and the other northeast of the Township of Ignace. The fourth candidate area is on the Revell batholith, to the west of the Township of Ignace (Figure 1.2).

2.2 Physiography

The Ignace area is covered by a discontinuous mantle of unconsolidated glacial deposits underlain by approximately 3 to 2.6 Ga bedrock of the Superior Province of the Canadian Shield. Significant deposition of glaciofluvial outwash moraines, which form northwest-trending linear features and fine-textured glaciolacustrine material has resulted in significant overburden cover across parts of the Ignace area, particularly in the region immediately north of Highway 17. The Revell batholith, to the south of Highway 17, has a comparatively low proportion of overburden cover. The bedrock is generally resistant to weathering and contributes to the rolling rugged topography and numerous lakes that characterize much of the area.

The land surface topography in the Ignace area ranges in elevation from about 350 to 550 metres (m) above sea level, with this amount of relief being expressed over a lateral distance of about 80 km. Bedrock knobs and ridges typically extend above the large lakes in areas underlain by the Basket and Indian Lake batholiths, while the relief is generally more consistent over the Revell batholith. Topography over the greenstone belts is often in the form of long narrow ridges reflecting differential erosion of the layered metavolcanic and metasedimentary rocks. Many of the bedrock knobs and whalebacks in the Basket and Indian Lake batholith areas exhibit a northeast-oriented, ‘drumlinoid’ elongation, suggesting a greater degree of glacial modification of the topography (JDMA, 2013). Glacial striae measured during the OGGF activity with orientations of 018° and 045° indicate recent glacial ice advance from the northeast (SRK and Golder, 2015a).

3.0 SUMMARY OF GEOLOGY

Details of the geology of the Ignace area were described in the Phase 1 Geoscientific Desktop Preliminary Assessment (Golder, 2013). A brief description of the geological setting, bedrock geology, structural history and mapped structures, metamorphism and Quaternary geology is provided in the following subsections, with a focus on the areas identified during Phase 1 as being potentially suitable for further consideration to host a deep geologic repository (Revell, Basket Lake and Indian Lake batholiths), their surrounding bedrock units and important structural features.

3.1 Geological Setting

The Ignace area is located in the central portion of the Archean Wabigoon Subprovince of the Superior Province. The Wabigoon Subprovince is approximately 900 km long and 150 km wide and is bounded by the Winnipeg River Subprovince to the northwest, the English River Subprovince to the northeast, and the Quetico Subprovince to the south (Blackburn et al., 1991). The Wabigoon Subprovince is further subdivided into three lithotectonic terranes:

the granitoid Marmion terrane, the predominantly volcanic Western Wabigoon terrane, and the plutonic Winnipeg River terrane. The Ignace area includes portions of all three terranes. The boundaries between lithotectonic terranes are not sharply defined due to the emplacement of younger plutonic rocks at places along the inferred terrane boundaries (Stone, 2010a).

3.2 Bedrock Geology

The geology of the Ignace area is dominated by large granitic intrusions and associated tonalitic units, including the Indian Lake, Revell, and Basket Lake batholiths, where the four general potentially suitable areas were identified in Phase 1 Geoscientific Desktop Preliminary Assessment (Figure 1.2) (Golder, 2013). These intrusions were emplaced into the older Raleigh Lake, Bending Lake and Phyllis Lake greenstone belts. These bedrock units exhibit evidence of both ductile and brittle deformation and are transected by at least two suites of undeformed diabase dykes. A description of these three granitic batholiths, associated tonalitic units, and surrounding greenstone belts and dykes is provided in the following subsections.

3.2.1 Intrusive Rocks

3.2.1.1 Revell Batholith

The Revell batholith is the oldest granitoid intrusion in the Ignace area, and is found in the southwestern portion of the Ignace area (Figure 1.2). It is roughly rectangular in shape, trends northwest, is approximately 40 km in length, and it covers an area of approximately 455 km^2. Szewczyk and West (1976) interpreted this batholith to be a sheet-like intrusion approximately 1.6 km thick. Recent 2.5D gravity modelling suggests that the thickness of the batholith is on the order of 2 km to 3 km thick through the center of the northern portion of the batholith (SGL, 2015).

Three different intrusive phases were recognized in the Revell batholith (Stone et al., 2011a and b). The oldest phase corresponds to an approximately 2.734 Ga, medium-grained, foliated, mesocratic biotite tonalite (Stone et al., 2010) exposed primarily along the western margin of the batholith and in its southern portion. A younger 2.732 Ga phase (Stone et al., 2010) consisting of coarse-grained mesocratic gneissic hornblende tonalite is also found along the western margin of the batholith. The youngest phase, approximately 2.694 Ga (Buse et al., 2010), consists of mesocratic to leucocratic feldspar megacrystic biotite granodiorite to granite; this phase extends over most of the remaining surface extent of the batholith. A distinctive oval-shaped, K-feldspar megacrystic lithofacies of this younger phase that is approximately 47 km^2 in areal extent is identified on the central-east portion of the batholith based on previous mapping and interpretation of existing geophysical data (Stone et al., 2011a, 2011b; Stone et al., 2007; PGW, 2013; SGL, 2015).

3.2.1.2 Basket Lake Batholith

The Basket Lake batholith is exposed in the northwestern part of the Ignace area. The batholith is approximately 10 to 15 km in width and 35 km in length, with almost half of this batholith extending beyond Little Basket Lake to the northwest (Figure 1.2). Szewczyk and West (1976) estimated the thickness of the northern part of the Basket Lake batholith to be at least 8 km and thinning progressively to 0.5 km to the southeast, forming a tongue-like extension of the main batholith body. Recent 2.5D gravity modelling suggests the thickness of the batholith is approximately 2.5 km to 3 km deep at the southeastern margin, with the depth steadily increasing to the northwest, where its reaches a depth of approximately 4 km (SGL, 2015).

Previous mapping of the eastern portion of the Basket Lake batholith describes the lithology as hornblende-biotite quartz-diorite to tonalite (Sage et al., 1974). The western-northwestern portion of the batholith consists mainly of leucocratic biotite-rich granodiorite, which varies to granite with subordinate tonalite, quartz monzonite, quartz diorite and a mixed hybrid zone locally developed near the contact with the Bending Lake and Raleigh Lake greenstone belts (Berger, 1988). The contact zone contains white tonalite dykes which cross-cut the granite and granodiorite facies of the intrusion, as well as the adjacent metavolcanics. These dykes are interpreted to be a late phase of the Basket Lake batholith (Berger, 1988).

Bedrock of the Basket Lake batholith is commonly foliated, with foliation being weak and mostly defined by alignment of biotite and a fine- to medium-grained character. This suggests that this batholith experienced some degree of ductile deformation (Szewczyk and West, 1976), and that it pre-dates the intrusion of the Indian Lake batholith, as well as the youngest phase of the Revell batholith.

A small swarm of Wabigoon dykes cut across the southern margin of the batholith while two mapped Kenora-Fort Frances dykes occur immediately to the southeast (Figure 1.2).

3.2.1.3 Indian Lake Batholith

The approximately 2.671 Ga Indian Lake batholith (Tomlinson et al., 2004) covers a total surface area of about 1,366 km^2 (Figure 1.2). This batholith has previously been estimated to be a sheet-like intrusion up to 2 km thick (Szewczyk and West, 1976; Everitt, 1999). Recent 2.5D gravity modelling suggests the batholith shallows from a depth of approximately 3 km at its boundary with the tonalite in the northwest, to a depth of approximately 2 km at the eastern margin (SGL, 2015). However, sensitivity analyses that decreased the density of the bedrock unit underlying the batholith suggests that the western portion of the batholith could thin to approximately 0.5 kilometres, and to 0.8 kilometres north of the candidate area in the eastern part of the batholith.

The Indian Lake batholith is composed of light grey-white to pale pink biotite granite, typically medium- to coarse-grained, inequigranular, leucocratic, and is massive to weakly foliated. It usually contains a small percentage of biotite (3-5%) and subequal proportions of quartz, plagioclase and potassium feldspar (Stone et al., 1998). Non-tectonic foliation present in the batholith is defined by the alignment of igneous minerals that delineate concentric patterns in the granite (Stone et al., 1998).

An enclave of biotite-hornblende tonalite to granite, approximately 35 km^2 in area is mapped within the Indian Lake batholith (Figure 1.2), extending from the southern portion of the Township of Ignace southward beyond its boundaries (OGS, 2011). This enclave is generally coarse, granular and mesocratic and, when hornblende granite is present, it is characterized by large potassium feldspar megacrysts that are 1 to 5 cm in size (Stone et al., 1998). It is not known whether this tonalitic body is a separate intrusive body, the product of different phases of magmatic injection, or compositional zoning.

3.2.1.4 Tonalitic Units

The region north of the Ignace area surrounding the Basket Lake and Indian Lake batholiths has been mapped as compositionally heterogeneous tonalitic gneiss and biotite tonalite (Figure 1.2).

The biotite tonalite suite is typically white to grey, medium-grained, and variably massive to foliated. Weakly gneissic biotite tonalite to granodiorite is the principal type of rock within this suite. The biotite tonalite suite grades into the tonalite gneiss suite largely through progressive development of a gneissic texture. Intrusions of the biotite tonalite suite show considerable variation in age, ranging from approximately 2.994 to 2.688 Ga (Stone, 2010a).

The tonalite gneiss suite comprises older gneissic, foliated, migmatized tonalite-granodiorite, intruded by younger granitoid batholiths. The tonalite gneiss suite is layered with individual gneissic layers varying compositionally from leucocratic tonalite and granodiorite through mesocratic tonalite and granodiorite to diorite and amphibolite. They range substantially in age from approximately 3.009 to 2.673 Ga, similar to the variation in age shown by the biotite tonalite suite (Stone, 2010a). The gneiss commonly shows strongly foliated to mylonitic textures and belts of gneiss are spatially associated with zones of high ductile strain such as the margins of large batholiths (Stone, 2010a). Locally, the tonalitic gneiss is gradational in composition to amphibolitic gneiss of volcanic or migmatized sedimentary rock origin, whereas the more felsic phases are gradational to biotite tonalite (Stone, 2010a).

3.2.2 Supracrustal Rocks

The Raleigh Lake, Bending Lake and Phyllis Lake greenstone belts surround the Revell batholith and the area adjacent to the Indian Lake and Basket Lake batholiths (Figure 1.2). These greenstone belts are composed of alternating units of mafic pillowed metavolcanic rocks and intermediate fragmental metavolcanic rocks, both metamorphosed to amphibolite facies.

The northwest-trending Raleigh Lake greenstone belt occurs north of the Revell batholith and extends over a length of 50 km. The Raleigh Lake greenstone belt is dominated by mafic metavolcanic rocks, and contains approximately 30% intermediate to felsic fragmental metavolcanic rocks (Stone, 2010a). The greenstone belt is intruded by oval, smaller felsic to intermediate plutons such as the Raleigh Lake intrusions, which consist of three epizonal granitic stocks hosted in the metavolcanic rocks of the Raleigh Lake greenstone belt (Figure 1.2). These small bodies are compositionally similar to the larger granodioritic to granitic batholiths that dominate the Ignace area.

The northwest-trending Bending Lake Greenstone Belt occurs southwest of the Revell batholith. It is composed of mafic metavolcanic rocks, with subordinate gabbro, intermediate metavolcanic rocks, and clastic metasedimentary rocks (wacke and argillite; Stone, 2010b). The Phyllis Lake greenstone belt, of similar general composition to the other greenstone belt rocks in the Ignace area, occurs as several east-trending slivers to the south of the Indian Lake batholith.

3.2.3 Mafic Dykes

Mafic dykes in the Ignace area include the Kenora-Fort Frances and Wabigoon swarms, emplaced between approximately 2.20 and 1.96 Ga (Osmani, 1991). The Wabigoon dyke swarm constitutes the most prominent dyke generation and extends in a northwest orientation for at least 70 km from Ignace to Lac des Mille Lacs without offsets along any terrane boundaries.

The Kenora-Fort Frances dyke swarm contains hundreds of northwest-trending dykes up to 100 km long and 120 m wide, covering an area of approximately 90,000 km^2 (Osmani, 1991). The Kenora-Fort Frances dykes form clusters in the Melgund Lake area to the northwest of the Revell batholith, and in the Mameigwess Lake area between the Basket and Indian Lake batholiths. The Kenora-Fort Frances dykes are composed of variable amounts of plagioclase, pyroxene, quartz, hornblende, as well as varying degrees of alteration minerals. Southwick and Halls (1987) reported an Rb-Sr age of approximately 2.120 Ga for these dykes.

3.3 Structural History and Mapped Structures

Information on the structural history of the Ignace area and surrounding region is limited. This summary was written using information available in the literature for the Wabigoon Subprovince and is largely based on Bethune et al. (2006), Percival et al. (2004), Sanborn-Barrie and Skulski (2006), and Stone (2010a). Five episodes of penetrative strain (D1 to D5) affected the central Wabigoon Subprovince (Percival et al., 2004). Gneissic tonalitic rocks (Tonalite Gneiss Suite) commonly display D1 and D2 fabrics, overprinted by pervasive, regional D3 to D5 fabrics or structures. Table 3.3.1 provides a tabulated summary of the structural history of the Ignace area.

S1 gneissic foliation is folded into tight to isoclinal F2 folds. The geometric and kinematic character of the D1 and D2 deformation is cryptic as a result of structural (D3-D5) and magmatic overprinting (Percival et al., 2004). D1 and D2 deformation fabrics are confined to gneissic rocks in the central Wabigoon Subprovince. The best constraints on the age of the D1-D2 deformations are 2.725 to 2.713 Ga (Percival et al., 2004).

Two episodes of penetrative strain (D3 and D4 of Percival et al. (2004); D1, D2 of Sanborn-Barrie and Skulski (2006)), hereby termed D3 and D4, affected the supracrustal rocks of the central Wabigoon Subprovince. D3 and D4 deformation events are interpreted to have occurred prior to 2.698 Ga (Percival et al., 2004). D3 resulted in the development of F3 northwest-trending folds and an associated S3 axial planar cleavage. These are well exposed in the nearby Savant-Sturgeon Lake greenstone belt to the northeast of the Ignace area; where they have been correlated with a northwest-striking foliation (locally known as F1 and S1) within the Lewis Lake biotite-tonalite (2.735 to 2.730 Ga; Sanborn-Barrie and Skulski, 2006). In the Raleigh Lake and Bending Lake greenstone belts, within the Ignace area, D3 structures dominate as shown in the strong north-west grain observed in the supracrustal rocks. D4 east- to northeast-striking structures locally overprint the northwest-striking S3 foliation. S4 foliation occurs as a moderately- to strongly-developed schistosity characterized by a uniformly steep dip. The S4 foliation is commonly axial planar to 050-070° trending, steeply plunging F4 folds (locally known as F2; Sanborn-Barrie and Skulski (2006)).

Percival et al. (2004) attributed sinistral shear zone development in plutonic and gneissic rocks to a D5 deformation event in the central Wabigoon Subprovince, bracketed between approximately 2.690 Ga (Davis, 1989) and 2.678 Ga (Brown, 2002). These shear zones are associated with significant sinistral strike-slip displacement along the Miniss River fault zone and dextral strike-slip motion along the Sydney-Lake St. Joseph fault zone 150 km north of the Ignace area (Bethune et al., 2006). Regional differential uplift associated with movement along these shear zone systems continued until approximately 2.4 Ga (Hanes and Archibald, 1998) indicating a protracted D5 fault history.

3.3.1 Mapped Structures and Named Faults

There are two mapped faults within the Ignace area. One, the Washeibemaga Lake fault, trends east and is located to the west of the Revell batholith (Figure 1.2). An unnamed fault is located in the northwestern corner of the Ignace area and trends northeast close to Minnitaki Lake and beyond the northwestern margin of the Basket Lake batholith. There are no previously mapped faults within the four areas identified for detailed mapping in Ignace (Figure 1.2).

The northeast-trending Finlayson-Marmion fault is located approximately 30 km southeast of Ignace (outside of the footprint of Figure 1.2), and extends northeast from Steep Rock Lake where it intersects, and is thought to represent a splay of the east-west trending Quetico fault. The Finlayson-Marmion fault cross-cuts the eastern portion of the Indian Lake batholith and is interpreted to represent a D5 shear zone. This fault is characterized by the mylonitization and brittle deformation of granitoid rocks within the Indian Lake batholith (Schwerdtner et al., 1979; Stone, 2010a). To the south, close to the Quetico fault, the Finlayson-Marmion fault broadens to a complex braided zone of fault segments, some of which are auriferous (Stone, 2010a). The latest known movement along the associated Quetico fault, and therefore potentially the D5 Finlayson-Marmion fault, occurred at approximately

1.947 Ga with the development of pseudotachylite (Peterman and Day, 1989). Immediately to the southeast of the Ignace area, a Wabigoon dyke (1.9 Ga; Buchan and Ernst, 2004) cross-cuts the Finlayson-Marmion fault, which indicates that only limited movement could have occurred along the Finlayson-Marmion fault since the intrusion of the Wabigoon dyke swarm.

Table 3.3.1: Summary of the Geological and Structural History of the Ignace Area

Time Period (Ga)	Geological Event
ca. 3.0	Assemblage of the oldest rocks in the Ignace area comprising the Marmion terrane – essentially a micro-continent comprising tonalite basement rocks dominated by the Marmion batholith which occurs immediately south of the Ignace area.
ca. 3.0 to 2.74	Progressive growth of the Marmion terrane through the additions of magmatic and crustal material in continental arcs and through accretion of allocthonous crustal fragments. This growth included the emplacement of the Phyllis Lake gneisses and tonalites approximately 2.955 to 2.989 Ga ago and amalgamation of the Winnipeg River and Marmion terranes by approximately 2.93 to 2.87 Ga (Tomlinson et al., 2004; Percival and Easton, 2007).
ca. 2.745 to 2.711	A major period of volcanism, derived from subduction, occurred in the Winnipeg River-Marmion terrane (Blackburn et al., 1991). The result of this volcanic period is the Raleigh Lake and Bending Lake greenstone belts (Stone, 2010a). Sedimentation within the greenstone belts was largely synvolcanic, although sediment deposition in the Bending Lake area may have continued past the volcanic period (Stone, 2009b; Stone, 2010b). Synvolcanic to post-volcanic plutonism in the Ignace area included minor mafic intrusions (possibly flow centres) of gabbroic composition and the intrusion of tonalitic phases of the Revell batholith, approximately 2.737 to 2.732 Ga ago (Larbi et al., 1998; Buse et al., 2010). D1-D2 (Percival, 2004) ca. 2.71 Collision of the Winnipeg River-Marmion terrane and a northern superterrane (Uchian Orogeny) (Corfu et al., 1995).
ca. 2.70 to 2.67	Collision of the volcanic island arc (Western Wabigoon terrane) against the superterrane (Central Superior Orogeny) (Percival et al., 2006; Stone, 2010a). The central Superior Orogeny was accompanied by widespread regional plutonism. In the Ignace area, this resulted in emplacement of intrusive rocks including the major batholiths of interest. Specific dates include: ca. 2.694 Ga: Crystallization age of the youngest phase of the Revell batholith; ca. 2.685 Ga: Crystallization age of the Indian Lake batholith; and ca. 2.697 to 2.684 Ga: an interval of sanukitoid magmatism (Stone, 2010a), which is expressed in the Ignace area by the emplacement of small plutons, such as the Islet pluton (Stone, 2009a) D3 and D4 (Percival, 2004).
ca. 2.6 to 2.4	Regional faulting and brittle fracturing (Kamineni et al., 1990).
ca. 2.12	Emplacement of the northwest trending Kenora-Fort Frances dyke swarm (Southwick and Halls, 1987).
ca. 1.947	Brittle reactivation of regional-scale faults (Peterman and Day, 1989).
ca. 1.900	Emplacement of the west-northwest trending Wabigoon dyke swarm (Fahrig and West, 1986; Osmani, 1991).
Post-1.14	A complex interval of erosion, brittle fracture, repeated cycles of burial and exhumation, and glaciations, particularly from the latest Miocene to the present.

3.4 Metamorphism

Metamorphism in the Central Wabigoon region occurred in late Neoarchean time, from approximately 2.722 to 2.657 Ga (Stone, 2010a) and peaked at approximately 2.701 Ga (Easton, 2000). The regional metamorphism may be related to the collision of the Western Wabigoon terrane with the Winnipeg River-Marmion terrane at approximately 2.7 Ga (Percival et al., 2006). Metamorphism in the Central Wabigoon region is generally restricted to greenschist facies, and increases locally to middle amphibolite facies in parts of the greenstone belts (Sage et al., 1974; Blackburn et al., 1991; Easton, 2000; Sanborn-Barrie and Skulski, 2006). Very high grade (i.e., granulite facies) and very low grade (e.g., zeolite facies) metamorphism is largely absent in the Central Wabigoon region (Stone, 2010b).

A low to medium metamorphic grade overprint is present in the Ignace area, mainly within the Raleigh Lake and Bending Lake greenstone belts and within marginal zones of the Revell batholith. High metamorphic grade and migmatization occurs locally in the Ignace area in tonalite adjacent to plutons and greenstone belts. Medium metamorphic grade is widespread in the Raleigh Lake greenstone belt, where greenschist facies metamorphism grades into amphibolite facies. Numerous amphibolite and garnetiferous layers and clasts are found in rocks in the Raleigh Lake greenstone belt (Blackburn and Hinz, 1996).

In the Bending Lake greenstone belt, mineral assemblages are indicative of low to medium metamorphic grade. In general, rocks at the margins and in narrow extensions of the greenstone belt exhibit higher metamorphic grade than rocks in the core of the belt, implying a degree of contact metamorphism adjacent to the surrounding intrusive bodies (Stone, 2010a).

3.5 Quaternary Geology

Information on Quaternary geology in the Ignace area is described in detail in the Phase 1 Terrain and Remote Sensing Study for the Ignace area (JDMA, 2013) and has been summarized here.

The Quaternary deposits in the Ignace area accumulated during and after the last glacial maximum, known as the Late Wisconsinan Glaciation, with a significant amount of the material deposited during the progressive retreat of the Laurentide Ice Sheet. Advancement of the Laurentide Ice Sheet from the northeast across the area deposited a veneer of till throughout the areas mapped as bedrock terrain, with thicker accumulations of till mapped as morainal terrain. During the retreat of the Laurentide Ice Sheet, significant deposition of glaciofluvial outwash and glaciolacustrine plains occurred, with two major end moraines (Lac Seul and Hartman moraines) extending through the Ignace area recording the progressive retreat of the ice sheet.

The Hartman moraine is a significant Quaternary landform in the Ignace area that divides the area into distinct zones based on the thickness of Quaternary deposits. Thicker till, glaciofluvial outwash, and deep-water glaciolacustrine deposits occur north of this moraine, whereas surficial deposits are generally thinner to the south. Areas mapped as bedrock terrain to the north of the Hartman moraine represent a spattering of islands within a proglacial lake known as Glacial Lake Agassiz that subsequently contracted into a set of large modern lakes.

Information on the thickness of Quaternary deposits within the Ignace area is described in detail in JDMA (2013). Measured thicknesses are limited to a small number of water well records for rural residential properties, typically along the Trans-Canada highway, and to diamond drill holes concentrated in the greenstone belts. Recorded depths to bedrock in the Ignace area range from 0 to 80 m, with an average depth of about 7 to 10 m. The thickness of the Quaternary deposits southwest of the highway in the periphery of the Township of Ignace is typically less than 5 m. The thickest overburden is inferred to occur along the axes of the Hartman and Lac Seul moraines.

4.0 METHODOLOGY

The following sections provide an overview of the methods implemented in order to fulfill the requirements of the technical scope of work for the Phase 2 Detailed Geological Mapping completed by Golder and PGW for the Ignace area in Ontario. Phase 2 Geological Mapping in the Ignace area focused within and around the four candidate areas for mapping that were identified in the Phase 2 Initial Findings report (Golder, 2015a) (Figure 1.2).

The methods described below include tasks associated with planning, implementation, and reporting of the Phase 2 Detailed Geological Mapping.

4.1 Pre-Mapping Planning

The pre-mapping planning stage of the Phase 2 Detailed Geological Mapping was completed prior to mobilizing to the Ignace area. This stage included the development of a list of available source data (Appendix A, Table A.1) and equipment requirements (Appendix A, Table A.2), for planning and implementing the two components of the Phase 2 Detailed Geological Mapping. This stage also included the development of a summary list of daily field tasks allocated to each mapping team member (Appendix A, Table A.3).

The key geological attributes to be investigated, along with the methods identified to observe and capture the relevant information at each bedrock outcrop location, are presented in Table A.4 in Appendix A. An ArcGIS compatible data collection tool was developed for the iPad using ESRI's Collector application software, which was programmed to implement a variation of the GanFeld data collection protocol. The GanFeld system is an Ontario Geological Survey (OGS) standard system for data collection which was originally provided in an open file format by the Geological Survey of Canada (Shimamura et al., 2008). Entry of geological information into the Collector-GanFeld database follows a simple data collection protocol (Appendix A, Table A.4), which directs the observer to the appropriate digital form within the database system to capture the appropriate information for each geological characteristic being investigated. Additional guidance relevant for geomechanical characterization based on a simple field-based test of rock hardness, is provided in Table A.5 in Appendix A.

4.1.1 Predicted Outcrop Filtering and Defining Daily Traverses

The results from a remote predictive bedrock mapping exercise, provided by the NWMO, show the distribution of predicted bedrock outcrop locations within and around the candidate areas (Figure 1.2). The process that was used to undertake the remote predictive bedrock mapping exercise is included in Appendix B. These predicted outcrops serve as input for the task of defining traverses for the Phase 2 Detailed Geological Mapping, as they represent potential targets for direct investigation of exposed bedrock. The spatial distribution of predicted outcrop locations in relation to their distance to the existing road and trail network, and to the key geological features to be investigated during the Phase 2 Detailed Geological Mapping, was assessed.

The predicted outcrops were individually assessed for proximity to the key geological features, including interpreted lineaments, interpreted geophysical anomalies and mapped geological bedrock units and their contacts. Outcrops that were coincident with, or near to, key geological features, and in close enough proximity that they could reasonably be examined during one day of mapping, were grouped together to form daily traverses.

This assessment defined the daily traverses for the Phase 2 Detailed Geological Mapping. Practical knowledge of any accessibility constraints for each area was incorporated from the previous OGGF mapping (SRK and Golder, 2015), and on a daily basis during the mapping, to refine the Phase 2 Detailed Geological Mapping traverse plan.

Daily traverses were assessed and adjusted to accommodate several considerations, including method(s) of access, weather and overall progress of the mapping.

4.2 Mapping Stage

The Detailed Geological Mapping activity followed the plan in a manner that met the technical requirements identified in the Pre-observation Planning stage. At each outcrop location in the traverse areas, the geological attributes identified in Table A.4 (Appendix A) were investigated according to the allocation of the applicable tasks listed in Table A.3 (Appendix A).

Prior to mobilizing the teams to begin the mapping activity, a reconnaissance fly-over was done to assess the results from the remote predicted outcrop activity. In general, the outcrops observed during the fly-over corresponded well with the predicted outcrops. Only minor modifications to the daily traverse plan were required.

An important additional aspect of the Phase 2 Detailed Geological Mapping was the non-technical workflow that was followed on a daily basis to allow the technical work to be done to meet the required objectives. This included morning safety briefings, equipment calibration checks, data quality assurance checks, and planning for the next mapping day (Appendix A, Table A.3). A telephone conference was held with NWMO every evening during the course of the mapping campaign in order to discuss all aspects of the on-going work.

This simple workflow was adhered to on a daily basis and allowed for communication between the mapping team and NWMO when field conditions resulted in changes to the proposed plans. The daily report documented the completion of the safety briefing, calibration check and data back-up (i.e. the reports served as HSE and QA records).

4.2.1 Proterozoic Mafic Dyke Scanline Fracture Mapping Exercise

Along with compiling observations on Proterozoic mafic dykes that were encountered on daily traverses, one well-exposed example of a Proterozoic mafic dyke was identified as a candidate for a scanline fracture mapping exercise. The emplacement of these Proterozoic mafic dykes, as outlined in Section 3, is understood to post-date the penetrative regional ductile deformation that is characteristic of the Superior Province. However, the relationship between dyke emplacement and the brittle deformation history of the Superior Province is less well constrained. The purpose of the scanline fracture mapping exercise is to assess both the nature and extent (if any) of the damage to the bedrock caused by dyke emplacement and the nature and extent of brittle deformation overprinting the dykes themselves. A summary of the method employed to complete the scanline fracture mapping exercise is described below.

When the suitable (i.e. well-exposed) target dyke is located, a scanline is laid out perpendicular to the strike of the dyke contact. One metre intervals were marked for reference along the strike direction, shifting the line to a parallel location where necessary (e.g. overburden cover). Observations of the type and distribution (spacing) of brittle deformation features (veins, faults, joints) were collected systematically within a 1 to 2 m wide swath parallel to the scanline line perpendicular to strike of dyke contact and extending as far as possible into the adjacent bedrock beyond the dyke contacts. Additional characteristics such as fracture infill, cross-cutting relationships and offsets were noted, if present. A sketch of the scanline was drawn, and photographs taken, to highlight key features (dyke contacts, prominent fractures, shifts in the scanline, overburden cover, etc.). Magnetic susceptibility readings were made at each 1 m interval, with five readings used to obtain an average for each measurement location. Host rock foliation on both sides of the dyke was also recorded, if present. The results from the scanline fracture mapping exercise are included in Section 5.4.2 of this report.

Note also that due to the magnetic properties of the dykes, compass readings were significantly affected when placed close to the ground surface. In order to achieve the most accurate measurements for joints within the dyke, measurements were made approximately 1.5 m above the ground, and measuring the dip with the clinometer.

4.3 Synthesis and Reporting Stage

Following the completion of the mapping stage, the team prepared this stand-alone report describing the results of the Detailed Geological Mapping activity, in alignment with the objective of increasing our conceptual understanding of the key geological attributes for the identified potential areas. This report includes the interpretation and analysis of the field observations in terms of an update on the new state of knowledge that the observations provide, specific to the potentially suitable areas. The table of contents for the report was specified by the NWMO and developed prior to the completion of the mapping stage of the Phase 2 Detailed Geological Mapping activity. This table of contents also provided guidance on the structure of a figure set, and appendices, to be included with this final report.

The reporting stage included a thorough quality assurance check of the field data and the preparation and delivery of electronic data in the form of shapefiles, digital photographs and scanned field notes in zipped folders. Shapefiles were delivered in accordance with the types of information entered into the GanFeld database. These deliverables, which align with the observed key geological attributes as described in Table A.4 (Appendix A), include:

- Station;
- Lithology;
- Structure;
- Linework;
- Samples;
- Magnetic Susceptibility;
- Gamma Ray Spectrometry; and
- Photographs.

The data delivery also included a summary calibration report that includes copies of all calibration reports provided by third-party equipment providers and summary of results from all calibration activities undertaken during the mapping activities.

Metadata accompanying each shapefile and zipped folder, along with the calibration report, was prepared according to metadata guidelines provided by the NWMO. A summary of the detailed mapping observations is presented in Section 5 of this report.

5.0 DETAILED MAPPING FINDINGS

This section presents the detailed field geological observations in the Ignace area based on the work undertaken by Iris Lenauer, Frederick Breaks, and Timothy Corkery assisted by Alex Man, Charles Mitz, Adrian Kowalchuk, Matthew Bowman, Josip Balaban, Andrey Fomenko and Albert Stoffers. The Phase 2 Detailed Geological Mapping activity was conducted over the course of three mapping campaigns: from October 4 to 9, 2015; from June 17 to

July 3, 2016; and from July 26 to August 10, 2016. In total, this encompassed 37 days of field mapping in the Ignace area.

A total of 580 locations were visited for bedrock characterization within and in close proximity to the candidate areas defined for detailed mapping in the Ignace area. The candidate areas cover portions of the Revell, Basket Lake and Indian Lake batholiths (Golder, 2015a) and lie within and in proximity to the withdrawal areas (Figure 1.2).

Descriptions of both non-geological (e.g., accessibility) and geological observations are presented below for each of three areas covered during the Phase 2 Detailed Geological Mapping activity, including the Revell batholith area (Section 5.1), the Basket Lake batholith-Indian Lake West batholith area (Section 5.2) and the Indian Lake East batholith area (Section 5.3). For reporting purposes, data collected in the Basket Lake batholith and the western portion of the Indian Lake batholith are presented together. Each of these sets of geological descriptions includes a summary of detailed observations relating to bedrock exposure and overburden thickness, lithological units encountered, ductile and brittle structure and secondary mineralization/alteration. Section 5.4 provides a summary of the mapping observations related to dykes, both mafic and felsic, observed across the Ignace area. Section 5.4 also presents the results from a scanline fracture mapping exercise undertaken in a traverse across one well-exposed mafic dyke.

5.1 Revell Batholith Area

The Phase 2 Detailed Geological Mapping in the Revell batholith area focussed in the region to the northwest of Highway 622, west of Ignace, Ontario and covers the northwestern half of the withdrawal area (Figure 1.2). As noted in Section 3, the Revell batholith area is roughly rectangular in shape, with a long axis trending northwest and approximately 40 km in length. The batholith covers an area of approximately 455 km^2. The detailed mapping was concentrated in the northern-central portion of the batholith. A total of 260 stations were visited in this area (Figure 5.1.1).

5.1.1 Accessibility and Surface Constraints

The majority of the Revell batholith area is easily accessed via a network of logging and general use roads extending southward from the Trans-Canada Highway and westward from Highway 622 (Figure 5.1.1). These roads are generally in good condition and passable using a 4X4 vehicle (Figure 5.1.2a). In a few cases, overgrown older logging roads and open, clear-cut areas, were traversed by foot. The western and southwestern parts of the Revell batholith area currently have no road network and are thickly forested. They were accessed by a combination of boat, travelling on a small river system (Figure 5.1.2b), and foot traverse.

Topography is generally subdued and small ridges, with up to several metres of vertical relief, are only encountered rarely (Figure 5.1.2c). These small ridges occur mainly in the northwest and west. A broad north-trending valley with an unnamed stream splits the southern part of the Revell batholith area in half (Figure 5.1.2d). This stream is passable by canoe and connected to the river system.

5.1.2 Bedrock Exposure and Overburden Thickness

The Revell batholith area exhibits the lowest degree of overburden cover relative to the other mapping areas in Ignace. A large number of predicted locations of exposed bedrock were identified for this area and the majority were confirmed as such through visual inspection. Out of the 260 total predicted observation locations visited, 256 were positively identified as having exposed bedrock (99%), while four out of 260 (1%) were found to be overburden covered (Figure 5.1.1). The ease of accessibility and high degree of exposed bedrock, except for the western and southwestern parts of the Revell batholith area, resulted in a relatively high density of observation locations compared to other mapping areas in Ignace.

Visual inspection in the field suggests that even more outcrop is present in the area compared to what was predicted, especially considering the thin nature of the overburden over much of the area and recent logging activity (Figure 5.1.2c). Average (estimated) overburden thickness around the edges of exposed bedrock outcrop varies between 0.3 and 1 m.

5.1.3 Lithology and Physical Character

The descriptions below, and Table 5.1.3, provide an overview of the lithological and physical character of the main and minor bedrock lithological units observed in the Revell batholith area, in decreasing order of abundance.

Three main lithological units are observed in the Revell batholith area including: granodiorite, tonalite and granite (Figure 5.1.3a). The character and distribution of three additional minor lithological units (Figure 5.1.3b), including diorite/quartz-diorite, mafic metavolcanic rocks and schist is described in Section 5.1.3.4. Dykes of mafic and intermediate to felsic composition, also observed in the Revell batholith area, are discussed separately in Section 5.4.

Table 5.1.3: Summary of Lithological Units in the Revell Batholith Area

Lithological Unit	# of Occurrences (% of bedrock stations)	Fabric	Magnetic Susceptibility (mean SI)	Gamma Spectrometry (average)	Strength
Granodiorite	142 (55%)	Massive to weakly foliated	$0.31\pm0.885 \times 10^{-3}$	K = 2.1±0.58 % U = 1.56±1.07 ppm Th = 7.05±3.49 ppm	R5
Tonalite	98 (36%)	Massive to weakly foliated	$0.48\pm1.67 \times 10^{-3}$	K = 1.43±0.31 % U = 1.33±1.14 ppm Th = 6.14±2.53 ppm	R5
Granite	46 (18%)	Massive to weakly foliated	$0.365\pm1.22 \times 10^{-3}$	K = 3.2±0.47 % U = 2.67±1.87 ppm Th = 12.20±4.68 ppm	R5
Diorite/ Quartz diorite	9 (4%)	Strongly foliated	$0.454\pm0.14 \times 10^{-3}$	K = 0.91±0.22 % U = 0.83±0.42 ppm Th = 4.60±2.06 ppm	N/A
Mafic metavolcanic rocks	7 (3%)	Massive to strongly foliated	0.55×10^{-3}	K = 0.5 – 2.1 % U = 0 – 1.3 ppm Th = 2.2 – 9.9 ppm	R5
Schist	2 (<1%)	Strongly foliated	$0.11 – 58.7 \times 10^{-3}$	K = 1.8 % U = 0.6 ppm Th = 9.2 ppm	N/A

Note: N/A indicates insufficient data collected due to limited number of occurrences.

5.1.3.1 Granodiorite

Granodiorite is the most common lithology encountered in the Revell batholith area. It is observed at 142 out of 256 bedrock stations (55%) and has a relatively uniform distribution across the entire Revell batholith area (Figure 5.1.3a). It is characterized as the main lithology at 134 out of these 142 locations (94%) and in the majority of these instances it covers greater than 90% of the exposed bedrock. At an additional nine locations out of the 142 (6%), granodiorite is observed in lesser quantity, including as xenoliths covering less than 10% of the outcrop area. These few occurrences are located throughout the southeastern part of the Revell mapping area within granite host rock. A total of 92 representative rock samples of the granodiorite unit were collected from the Revell batholith area.

Granodiorite is in gradational contact with the tonalite (described below), and the transition between the two is defined by slight variations in potassium content, manifested by the increased presence of potassium feldspar in the granodiorite. No distinct intrusive contact relationships between these two rock types are observed and they appear to represent compositional variations within a coherent intrusive complex. The granodiorite is intruded by granite (described below) and their contacts are consistently sharp and intact with no evidence of fault reactivation.

The granodiorite is predominantly white to light grey, pink or beige on fresh surfaces and light grey, white, brown or pink on weathered surfaces (Figure 5.1.4a). The granodiorite matrix is most commonly medium-grained (1–5 mm), with some local fine-grained (0.5–1 mm) and coarse-grained (5–10 mm) variations. Main matrix mineral phases within the granodiorite are quartz, plagioclase, alkali feldspar and biotite (Figure 5.1.4b). Phenocrysts, predominantly K-feldspar, were observed in almost half of the locations where granodiorite was identified as the main lithological unit. Phenocryst size ranges from medium-grained to very coarse grained (10–50 mm). Magnetite, hornblende and muscovite are the main accessory minerals.

The granodiorite is usually massive with a variable equigranular to inequigranular, occasionally porphyritic, texture. Locally, the granodiorite exhibits a weak foliation defined by aligned quartz, biotite and/or plagioclase phenocrysts. This planar fabric becomes well developed in close proximity to observed ductile shear zones. Based on 141 field estimates of intact rock strength, the granodiorite is consistently classified as very strong with a rock hardness of R5, equivalent to fracturing after many hard blows with a hammer.

The granodiorite has a uniformly low magnetic susceptibility (mean = 0.31±0.885 x10^{-3} SI, N=141). Susceptibility values range between 0.01 and 7.06 x10^{-3} SI with 50% of the readings between 0.07 and 0.17 x10^{-3} SI (Figure 5.1.4c). The higher magnetic susceptibility values recorded for the granodiorite are attributed to the local presence of accessory magnetite.

The gamma ray spectrometry readings (Figure 5.1.4d) for the granodiorite, including 143 sets of measurements, show the following characteristics:

- Total count is on average 55.2±17.0 cps and ranges between 11.2 and 107.9 cps.
- Potassium content is on average 2.1±0.58% and ranges between 0.3 and 4.0%.
- Uranium content is on average 1.56±1.07 ppm and ranges between lower than the detection limit and 6.4 ppm.
- Thorium content is on average 7.05±3.49 ppm and ranges between 1.5 and 19.8 ppm.

5.1.3.2 Tonalite

Tonalite is the second most common lithological unit, observed at 98 out of 256 bedrock stations (36%) in the Revell batholith area. Tonalite generally occurs across the southern as well as the northwestern and northeastern portions of the Revell batholith area (Figure 5.1.3a). A portion of the central part of the Revell batholith area has no tonalite occurrences. Where observed as the main lithological unit, in 91 out of 98 instances (93%) tonalite generally covers greater than 90% of the exposed bedrock outcrop. On seven occasions (7%) the tonalite is observed as a minor lithological unit comprising less than 30% of the outcrop area as xenoliths within granodiorite or granite. These minor occurrences are found throughout the southeastern part of the Revell mapping area. A total of 69 representative rock samples of the tonalite unit were collected from the Revell batholith area.

As stated above, the tonalite transitions gradationally into granodiorite and no distinct contact relationships between these two rock types are typically observed. The granodiorite and tonalite appear to represent a coherent intrusive complex. The contact between tonalite and granite, by contrast, is generally sharp and intact with no evidence of fault reactivation.

The tonalite is predominantly white to light grey or grey on fresh surfaces and most commonly light grey to grey or beige on weathered surfaces (Figure 5.1.5a). The tonalite matrix is most commonly medium-grained (1–5 mm), with some local variation to fine-grained (0.5–1 mm) and coarse-grained (5–10 mm). Main mineral phases within the tonalite matrix include quartz, plagioclase, biotite and hornblende (Figure 5.1.5b). Hornblende, in particular, was observed in clusters of locations throughout the southeastern portion of the Revell batholith area. Phenocrysts, predominantly plagioclase, were observed in about one third of the locations where tonalite was the main lithological unit. Phenocryst size commonly ranged from medium to coarse-grained (10–50 mm). Magnetite is the main accessory mineral. Hornblende was also observed as an accessory mineral phase within the tonalite unit in the southeastern portion of the Revell batholith area.

The tonalite is observed as either massive or weakly foliated in texture. In both cases plagioclase phenocrysts are common. Where foliated, the long axes of the phenocrysts and aligned quartz define the planar structure. The foliation may be an igneous flow fabric or tectonic in origin. Based on 97 field estimates of intact rock strength, the tonalite is consistently classified as very strong with a rock hardness of R5, equivalent to fracturing after many hard blows with a hammer.

The tonalite has a uniformly low magnetic susceptibility (mean = 0.48±1.67 x10^{-3} SI, N=94). Susceptibility values range between 0.04 and 9.63 x10^{-3} SI, with 50% of the readings between 0.10 and 0.27 x10^{-3} SI (Figure 5.1.5c). The higher magnetic susceptibility values recorded for the tonalite are attributed to the local presence of accessory magnetite.

The gamma ray spectrometry readings (Figure 5.1.5d) for the tonalite, including 90 sets of measurements, show the following characteristics:

- Total count is on average 42.5±11.5 cps and ranges between 21.7 and 88.1 cps.
- Potassium content is on average 1.43±0.31% and ranges between 0.6 and 2.4%.
- Uranium content is on average 1.33±1.14 ppm and ranges between below the detection limit and 9.2 ppm.
- Thorium content is on average 6.14±2.53 ppm and ranges between 2.2 and 19.1 ppm.

5.1.3.3 Granite

Granite was observed at 46 out of 256 bedrock stations (18%) in the Revell batholith area. Granite is primarily observed throughout the southeastern portion of the Revell batholith area, with isolated occurrences in the northwest (Figure 5.1.3a). In 35 of the 46 occurrences (76%), granite covers greater than 90% of the exposed bedrock. On 11 other occasions, it is observed as a minor lithological unit comprising less than 50% of the outcrop area, including as dykes within both the granodiorite and tonalite. A total of 15 representative rock samples of the granite unit were collected from the Revell batholith area.

The granite intrudes into the adjacent granodiorite and tonalite units. Where observed, the intrusive granite contact is sharp and intact without evidence of fault reactivation. A decrease in grainsize within the granite along its contact with the surrounding bedrock suggests that the granodiorite and tonalite were cooler than the granite when it intruded.

The granite is predominantly pink to off white or light grey on fresh surfaces and most commonly light grey to beige or pink on weathered surfaces (Figure 5.1.6a). The granite matrix varies between fine-grained (0.5–1 mm) and medium-grained (1–5 mm). Main mineral phases within the granite are quartz, plagioclase, alkali feldspar and biotite (Figure 5.1.6b). Phenocrysts, predominantly plagioclase, K-feldspar or quartz, were observed in about one third of the locations where granite was the main lithological unit. Phenocryst size commonly ranged from medium to coarse-grained (10–50 mm). Magnetite is the main accessory mineral phase.

The granite is predominantly massive in texture, but locally exhibits a weak foliation defined by aligned biotite. Based on 33 field estimates of intact rock strength, the granite is consistently classified as very strong with a rock hardness of R5, equivalent to fracturing after many hard blows with a hammer.

The granite has a variable and generally low magnetic susceptibility (mean = 0.365±1.22 x10^{-3} SI, N=34). Susceptibility values range between 0.001 and 7.04 x10^{-3} SI, with 50% of the readings between 0.05 and 0.11 x10^{-3} SI (Figure 5.1.6c). The higher magnetic susceptibility values recorded for the granite may be attributed to the local presence of accessory magnetite.

The gamma ray spectrometry readings (Figure 5.1.6d) for the granite, including 36 sets of measurements, show the following characteristics:

- Average total count of 91.2±24.6 cps and ranging between 51 and 163.1 cps.
- Potassium content is on average 3.2±0.47% and ranges between 2.1 and 4.1%.
- Uranium content is on average 2.67±1.87 ppm and ranges between below the detection limit and 6.9 ppm.
- Thorium content is on average 12.20±4.68 ppm and ranges between 4.5 and 22 ppm.

5.1.3.4 Minor Lithological Units

Minor lithological units identified in the Revell batholith area include: diorite to quartz diorite, metamafic rocks, and schist (Figure 5.1.3b; Table 5.1.3). These rock types were primarily observed as rafts or xenoliths within one of the main lithological units described above. Only general descriptions are included for these minor lithological units due primarily to the limited number of observations and occurrences of each within the Revell batholith area.

Diorite to Quartz Diorite

Diorite to quartz diorite was observed at nine out of 256 bedrock stations (4%) (Figure 5.1.3b). These occurrences are primarily within the east-southeastern part of the Revell batholith area, proximal to the adjacent greenstone belt. The diorite occurs as both a distinct unit and as metre-scale xenoliths within granodiorite and tonalite, in both cases exhibiting a sharp and intact contact with the surrounding bedrock, with no evidence of fault reactivation. One representative rock sample each of the diorite and quartz diorite were collected from the Revell batholith area.

The diorite to quartz diorite is grey to dark grey on fresh surfaces and dark to light grey where weathered (Figure 5.1.7a). It occurs as both massive bedrock and strongly foliated in texture. It is equigranular and fine- to medium-grained (1–5 mm) (Figure 5.1.7b). Plagioclase, hornblende, biotite and quartz represent the main mineralogical components, along with minor pyrite (Figure 5.1.7b). No rock hardness measurements were made on this lithological unit.

The diorite to quartz diorite has a variable and generally low magnetic susceptibility (average = 0.454±0.14 x10^{-3} SI, N=6). Susceptibility values range between 0.25 and 0.71 x10^{-3} SI.

The gamma ray spectrometry readings for the diorite to quartz diorite, including seven sets of measurements, show the following characteristics:

- Average total count of 29.03±10.4 cps and ranging between 15.6 and 47.2 cps.
- Potassium content is on average 0.91±0.22% and ranges between 0.6 and 1.3%.
- Uranium content is on average 0.83±0.42ppm and ranges between 0.4 and 1.7 ppm.
- Thorium content is on average 4.60±2.06 ppm and ranges between 2.2 and 7.6 ppm.

Metamafic Rocks

Seven occurrences out of 256 bedrock stations (4%) of massive to foliated mafic rock, collectively referred to as metamafic rocks, are distributed throughout the eastern half of the Revell batholith area. These mafic rocks include gabbro (two instances), amphibolite gneiss (two instances) and undifferentiated mafic volcanic rocks (three instances). The metamafic rocks occur primarily as metre-scale xenoliths representing less than 10% of any outcrop by area, hosted by granodiorite or tonalite. In one instance a 5 by 35 m wide massive gabbro xenolith occupies more than 90% of the outcrop. Two representative samples of the metamafic rocks, one of a gabbro and one of an amphibolite gneiss, were collected from the Revell batholith area.

Contacts between the xenoliths and the host granitoid units are sharp and intact, with no evidence of fault reactivation. Two occurrences in the extreme southeastern corner of the Revell batholith area occupy the entire outcrop and no relationship with the surrounding granitoid rocks is evident. Granitic veins cross-cut some of the mafic meta-igneous rock occurrences exhibiting sharp and intact contacts.

The metamafic rock occurrences are black, grey or brown when fresh and when weathered (Figure 5.1.7d). The occurrences are equigranular or inequigranular, exhibiting varying average grain sizes ranging from very fine (0.1–0.5 mm) to coarse-grained (5-10 mm) (Figure 5.1.7d). Plagioclase, biotite and hornblende represent the main recognizable mineralogical components. Plagioclase occurs locally as phenocrysts suggesting that some of these occurrences may be feldspar-porphyritic volcanic flows (Figure 5.1.7e), while other examples have the character of pillow basalts (Figure 5.1.7f).

Metamafic rocks exhibit a massive to strongly foliated appearance in outcrop. Based on three field estimates of intact rock strength, the metamafic rocks are consistently classified as very strong with a rock hardness of R5, equivalent to fracturing after many hard blows with a hammer.

Five measurements of magnetic susceptibility of the metamafic rocks are 0.30, 0.35, 0.4, 0.73 and 0.95×10^{-3} SI, reflecting a moderate to low magnetic susceptibility. The six gamma ray spectrometry readings for the gabbro show that the total count ranges between 15.1 and 49.1 cps, potassium content ranges between 0.5 and 2.1%, uranium content ranges between below the detection limit and 1.30 ppm, and thorium content ranges between 2.20 and 9.90 ppm.

Schist

Two occurrences of schist out of 256 bedrock stations (<1%) were observed at the northeastern margin of the Revell batholith area near to the contact with the adjacent greenstone belt (Figure 5.1.3b). None of the main lithological units described above is present at this bedrock observation location so no contact relationships with the large granitoid bodies are documented. Minor mafic meta-igneous xenoliths were observed within the schist (Figure 5.1.7c).

The schist is dark grey in colour on fresh surfaces and brown to beige when weathered. A total of two representative rock samples of the schist were collected from the Revell batholith area.

The schist is fine (0.5–1 mm) to medium-grained (1–5 mm) and strongly foliated. An internal, well-developed, foliation strikes west-northwest and dips moderately to steeply to the northeast, towards the contact with the adjacent greenstone belt. Plagioclase, biotite, quartz and magnetite represent its main mineralogical components.

Three measurements of magnetic susceptibility of the schist are 0.11, 0.31 and 58.70×10^{-3} SI, reflecting a highly variable magnetic susceptibility. The one gamma ray spectrometry reading for the schist has a total count of 51.6 cps, potassium content of 1.8%, uranium content of 0.6 ppm, and thorium content of 9.20 ppm.

5.1.4 Structure

Structures observed in the Revell batholith area, including features associated with both ductile to brittle deformation processes, are described below. Secondary mineralization, in the form of fracture infilling minerals and alteration phases, is also discussed.

5.1.4.1 Ductile Structure

Ductile structural features observed in the Revell batholith area comprise various types of penetrative planar fabrics, mainly igneous flow foliation and tectonic foliation, and localized ductile and brittle-ductile shear zones. These structural features are described in detail below. Linear structures associated with these ductile planar structures are also described below, where applicable.

Orientation information is summarized in Table 5.1.4.1 for the ductile structures described below. This information is based on the analysis of the data-specific rose diagrams. A degree of confidence is provided for each orientation peak identified based on the frequency of that orientation within the dataset.

Table 5.1.4.1: Summary of Ductile Structures in the Revell Batholith Area

Structure Type	Orientation Family	Peak (degrees)	Range (degrees)	Frequency (%)	Confidence
All Foliation	E	090	080-100	16.9	High
	ESE	105	100-120	13	High
	ENE	075	055-080	9.8	Medium-High
	NE	045	035-055	7.7	Medium
	SE	130	120-140	6.6	Medium-Low
Igneous Flow Foliation	E	090	080-100	22	High
	ENE	070	055-080	16.6	Medium-High
	NE	045	035-055	14.3	Medium-High
	ESE	107	103-120	7.4	Medium-Low
Tectonic Foliation	E	090	080-098	15.8	High
	ESE	105	098-120	14.7	High
	SE	130	120-140	8.4	Medium
	ENE	076	070-080	8.6	Medium-Low
	ENE	060	052-070	7.1	Low
	NE	043	033-052	6.2	Low
Shear Zones	SSE	165	148-177	11.5	Medium
	N	005	357-015	10	Medium
	NE	057	045-075	9.9	Medium-Low
	ESE	120	090-130	8.2	Medium-Low
	NE	040	030-045	7	Low
	NNE	020	015-030	7	Low
Ductile Shear Zones	N	007	355-015	13.6	Medium
	ENE	060	048-075	11.1	Medium
	ESE	120	110-130	10.7	Medium
	NNE	018	015-025	8.7	Medium-Low
	SSE	165	158-175	8.3	Medium-Low
	NNE	032	025-036	7.9	Low
	NE	040	036-048	7.9	Low
Brittle-Ductile Shear Zones	SSE	166	150-190	14.6	Medium-High
	ENE	057	044-067	9.7	Medium
	SE	140	130-150	9.3	Medium
	ESE	118	110-128	6.3	Low
	NE	038	025-044	6.3	Low

Foliation

The two main types of foliation recognized in the Revell batholith area are igneous flow foliation and tectonic foliation (Figure 5.1.8, Figures 5.1.9a and 5.1.9b). Overall, 157 measurements of foliation orientation were made at the 256 bedrock stations in the Revell batholith area. A total of 146 of these foliation measurements also include dip information (Figure 5.1.9a). The combined foliation dataset is dominated by one broad orientation ranging between 080° and 120 that includes peaks at 090° and 105° (Figure 5.1.9b). This east trending foliation population dominantly dips at greater than 60° towards the north or south. Three additional statistically significant peaks are oriented at 045°, 075° and 130°, also generally with relatively steep dips.

There were 31 igneous flow foliation measurements made in the Revell batholith area, and 28 of these measurements contained both strike and dip information. Igneous flow foliation is defined primarily by aligned feldspar phenocrysts (Figure 5.1.12a). This primary rock fabric is generally weakly developed in the north and west portions of the Revell mapping area, and moderately well developed in the northeast (Figure 5.1.8). Igneous flow foliation exhibits a dominant peak orientation at 090°, along with northeast (045°) and east-northeast (070°) trending peaks, and a less prominent east-southeast (107°) trending peak (Figure 5.1.9c). Overall, the igneous flow foliation tends to parallel the curved northwestern boundary of the Revell batholith, with minor variations (Figure 5.1.8).

There were 120 tectonic foliation measurements made in the Revell batholith area, 116 of these measurements contained both strike and dip information. Tectonic foliation is most commonly defined by aligned biotite, as well as aligned quartz eyes (Figure 5.1.12b). Weakly to moderately developed tectonic foliation represents the most common planar fabric type in the Revell mapping area. Locally, this foliation is strongly developed. Tectonic foliation strikes predominantly east (090°) to east-southeast (105°) within a broad range between 080° and 120° (Figure 5.1.9d). Minor northeast (043°, 060°, and 076°) and southeast (130°) peaks are also evident, though less prominent. Tectonic foliation generally dips relatively steeply at greater than 60° (Figure 5.1.8). The southeastern portion of the Revell mapping area also contains some occurrences of shallow to moderate dipping tectonic foliation. Northeast striking tectonic foliation appears to occur in several corridors in the northeastern portions of the mapping area (Figure 5.1.8). Tectonic foliation orientation can also be quite variable locally, and it is observed to wrap around xenoliths, as well as rotated within xenoliths. No lineations were observed in association with the tectonic foliation.

Additional, less common foliation types observed in the Revell batholith area include one observation each of gneissic layering and fracture cleavage (Figure 5.1.8). Gneissic layering is measured within a tonalite gneiss xenolith (Figure 5.1.12c) at one location. Weak but penetrative fracture cleavage was recognized at one location within mafic xenoliths on the eastern margin of the Revell mapping area. Massive (unfoliated) bedrock, indicated by bedrock stations with no foliation measurements, is locally common in portions of the mapped western and southern parts of the batholith.

Shear Zones

A total of 73 shear zones were measured throughout the Revell batholith area, 35 of which are characterized as ductile shear zones and 38 of which are described as brittle-ductile shear zones (Figures 5.1.10 and 5.1.11). The shear zones were observed most commonly in the eastern, northeastern and southeastern parts of the Revell batholith area. Shear zones are notably rarer in the western and northwestern part of the Revell batholith area. Clusters of shear zones occur south and west of the southeastern terminus of two parallel segments of the Proterozoic Wabigoon dyke swarm that transect the northern portion of the Revell batholith area.

The total shear zone population shows two main broad orientations (Figure 5.1.11a and Figure 5.1.11b), including a northerly one that ranges between 328° and 015°, with peaks at 345° and 005°, and another northeast-trend that ranges between 030° and 075° with peaks at 040° and 057°. One other peak orientation is evident at 120°, as well as a minor peak at 20°. Shear zones predominantly dip greater than 60°, but show some variability, especially for east- and west-dipping shear zones (Figure 5.1.10).

The ductile shear zones observed in the Revell batholith area are characterized by a strong to intense planar fabric with no evidence of associated fracturing. Where a tectonic foliation is well developed, this fabric is rotated in the shear zone (Figure 5.1.12d). Ductile shear zones range in width from under 1 centimetre to several decimetres (Figure 5.1.12e). In 13 instances (37%), they are associated with sheared quartz veins or localized near the margin of undeformed quartz veins (Figures 5.1.12d and e). Ductile shear zones are also localized along the margins of felsic dykes. Four shear zones in the central portion of the Revell batholith area are described as protomylonitic, with rotated feldspar phenocrysts and a grain size reduction in the matrix of the shear zone core. A strong foliation fabric is developed in the core of the shear zone, the orientation of which is oblique to the shear zone margin. One shear zone, located at the southwestern margin of the Revell batholith area, marked by a shallow dip and a strong linear fabric (Figure 5.1.12f), is also associated with an occurrence of pseudotachylite several centimetres thick, indicating possible local brittle-ductile reactivation.

Ductile shear zones exhibit three main peak orientations: a northerly one at 007° ranging between 355 and 015°, a second east-northeast orientation at 060° ranging between 048° and 075°, and a third east-southeast at 120° ranging between 110° and 130° (Figure 5.1.11c). Other minor peaks occur at 018°, 165°, 032°, and 040° (Figure 5.1.11c). Ductile shear zones vary in dip, ranging from 22° to 90° (Figure 5.1.10).

Shear sense is determined for 27 of the 35 mapped ductile shear zones based on offset of quartz veins, tension gashes, and rotation of foliation. Offset of markers is on the order of several centimetres to decimetres. Horizontal dextral shear sense was observed at 12 ductile shear zones, sinistral shear sense was observed at 12 ductile shear zones and three ductile shear zones display vertical reverse shear sense. Dextral and sinistral ductile shear zones occur in a broad range of strike orientations (Figure 5.1.11e). Multiple steeply dipping shear zones were observed striking northeast or northwest (Figure 5.1.11e). There is some coincidence in orientation between shear zones that exhibit sinistral versus dextral offset, however, no evidence of reactivation was observed on any of the shear zones. At one location at the southern margin of the Revell batholith area, a southwest-striking sinistral quartz-filled ductile shear zone is cross-cut by a north-striking dextral ductile shear zone (Figure 5.1.12d). Reverse shear zones dip at a low angle (Figure 5.1.11e and Figure 5.1.12f). Lineations observed on two ductile shear zones that exhibit dextral or sinistral horizontal offset plunge subhorizontally to downdip and the two lineations on reverse ductile shear zones are inclined, suggesting an oblique movement direction (Figure 5.1.11e).

In the Revell batholith area, brittle-ductile shear zones are characterized by both localized ductile fabric development and brittle fracturing. The width of these shear zones ranges mostly between 1-10 cm, but are occasionally associated with a zone of fault splays up to 1 m wide. Brittle-ductile shear zones are occasionally associated with quartz infill (5/38, 13%), hematite (2/38, 5%) and muscovite (2/38, 5%) on shear planes (Figure 5.1.12e). These structures are occasionally found to localize at the margins of undeformed quartz veins and aplite dykes.

Brittle-ductile shear zones exhibit three main peak orientations: one south-southeast at 166° ranging between 150° and 190°, a second east-northeast at 057° ranging between 044° and 067°, and a third southeast at 140° ranging between 130° and 150° (Figure 5.1.11d). Other minor peaks occur at 118° and 038° (Figure 5.1.11d). Brittle-ductile shear zones vary in dip, ranging from 44° to 90° (Figure 5.1.10).

Shear sense is determined for 30 of the 38 mapped brittle-ductile shear zones based on offset of quartz and pegmatite veins, s-c fabric, and rotation of foliation. Offset of markers is on the order of several centimetres to decimetres. Horizontal dextral shear sense was observed at 18 brittle-ductile shear zones and sinistral shear sense was observed at 12 brittle-ductile shear zones. Dextral and sinistral ductile shear zones occur in a broad range of strike orientations (Figure 5.1.11f). Multiple steeply dipping shear zones were observed striking northeast or north-northwest (Figure 5.1.11f). Two lineations observed on brittle-ductile shear zones subhorizontally to downdip (Figure 5.1.11f).

5.1.4.2 Brittle Structure

Fractures, including joints, veins and faults are the predominant brittle structures observed throughout the Revell batholith area. A total of 927 fracture measurements were made across the 256 bedrock stations in the Revell batholith area, including 795 joints, 57 faults and 75 veins. The characteristics of each of these fracture types are described below. The secondary mineral infillings and linear structures that accompany some veins and faults are also described in this section.

Orientation information is summarized in Table 5.1.4.2a for the brittle structures described below. This information is based on the analysis of the data-specific rose diagrams. A degree of confidence is provided for each orientation peak identified based on the frequency of that orientation within the dataset.

Table 5.1.4.2a: Summary of Brittle Structures in the Revell Batholith Area

Structure Type	Orientation Family	Peak (degrees)	Range (degrees)	Frequency (%)	Confidence
Joints - All	NE	45	034-082	8	High
	NNE-NE	029	015-034	7.3	Medium-High
	SE	130	100-165	7.2	Medium-High
	N	000	345-015	5.6	Low
Joints - Shallow	SE	133	123-145	9.9	Medium-Low
	SSE	155	147-165	9	Medium- Low
	E	095	077-114	8.6	Medium- Low
	ENE	065	043-077	8.1	Medium- Low
	S	175	165-181	7.9	Medium- Low
	NE	035	015-044	5.8	Low
Joints - Moderate	NNE	027	006-036	11	High
	NE	045	036-060	11	High
	SE	134	124-158	6.5	Low
	ENE	065	060-086	6.5	Low
	ESE	118	105-124	5.6	Low
Joints – Steep	NE	040	015-083	7.6	Medium-High
	SE	127	100-135	7.4	Medium-High
	SE	140	135-172	7.3	Medium-High
	N	003	353-015	6	Medium
Faults - All	NNE	025	015-035	9.1	Medium-Low
	SSE	152	136-160	8.6	Medium- Low

Structure Type	Orientation Family	Peak (degrees)	Range (degrees)	Frequency (%)	Confidence
	N	005	358-015	8.3	Medium- Low
	NE	050	040-058	8.2	Medium- Low
	ESE	115	110-125	8.2	Medium- Low
	ESE	102	090-110	8	Low
	SSE	166	160-178	7	Low
	ENE	060	058-075	5.7	Low
Faults – Dextral	SSE	152	132-168	16.9	Medium
	NE	050	037-070	10.1	Medium-Low
	ESE	120	108-134	9.9	Medium-Low
	ESE	100	090-108	8.6	Medium-Low
	NNE	028	020-035	7.2	Low
	NNE	010	003-020	7.1	Low
Faults – Sinistral	S	172	155-180	13.2	Medium-Low
	NE	062	056-070	13	Medium-Low
	SSE	142	115-160	11.4	Medium-Low
	NNE	022	014-034	11	Medium-Low
	N	005	000-014	10.6	Medium-Low
	E	088	080-100	6.1	Low
Veins	E	100	090-106	10.5	Medium-Low
	ESE	110	106-122	9.7	Medium-Low
	NE	038	026-060	9.4	Medium-Low
	SE	140	122-162	8.4	Medium-Low
	NNE	020	012-026	6	Low
	ENE	076	060-086	5.8	Low
	N	006	354-012	5.7	Low
Secondary Mineral Infill - All	E	098	086-115	8.7	Medium
	NE	040	028-066	7.9	Medium-Low
	SE	128	115-134	7.4	Medium-Low
	SE	142	134-150	7.3	Medium-Low
	N	008	355-015	7.3	Medium-Low
	SSE	165	150-175	7.2	Medium-Low
	NNE	020	015-028	6.2	Low

Joints

There are 795 joint measurements recorded in the Revell batholith area (Figure 5.1.13, Figure 5.1.14a). Joints are a common structural feature at almost all bedrock observation locations and are distributed across the entire area. It is common for more than one orientation of joints to be present at any single location. The majority of these measurements were made in granodiorite (438/795, 55%) and tonalite (259/795, 33%), which is distributed across the Revell batholith area. Out of the 795 measurements, 66 were made in the third main lithology granite (8%). The remaining 32 measurements were made in the minor lithologies within the Revell batholith area. The analysis of the joint data, presented below, suggests that four main joint sets can be identified for the Revell batholith area, including one shallowly dipping set and three steeply dipping sets, trending north-south, northeast, and northwest.

The combined joint population is shown on an equal area lower hemisphere stereonet plot and a rose diagram (Figure 5.1.14a and Figure 5.1.14b). The rose diagram shows that the combined joint population is dominated by two, broad, major sets oriented northeast and southeast. One includes internal peaks at 029° and 045° and ranges between 015° and 082°. Another has one peak at 130° and ranges between 100° and 165°. One additional, less significant, orientation peaks is evident at 0° (ranging between 345° and 015°). Most of the joints in these four sets dip greater than 65° though all sets also include features that range down to subhorizontal. The equal area lower hemisphere stereonet plot highlights the fifth, shallow-dipping (<25°), joint set in the Revell batholith area by the central cluster of poles.

Separating the joints into their three general dip magnitude bins (shallow, <25°; moderate, 25° to 65°; steep, >65°) and re-plotting the rose diagrams individually provides a better means of defining the number of recognizable joint sets. The shallowly dipping to subhorizontal joint set (<25° in dip magnitude) was observed in 43 instances (5%) (Figure 5.1.14c). The shallowly dipping joints exhibit several sharp orientation peaks of relatively equal frequency at 065°, 095°, 133° 155° and 175°. One statistically less significant peak is also evident at 035°.

A total of 156 joints (20%) were observed to dip at a moderate magnitude between 25 and 65 degrees (Figure 5.1.14d). The moderately dipping joints exhibit two significant orientation peaks at 027° and 045°, ranging from 006° to 060°. Less significant orientation peaks occur at 134° (ranging between 124° and 158°), 065° (ranging between 060° and 086°), and 118° (ranging between 105° and 124°).

A total of 596 joints (75%) were measured with a dip magnitude greater than 65° (Figure 5.1.14e). similar to the total joint data set, the combined steeply dipping joint population is dominated by two, broad, major sets. One exhibits a peak at 040° and ranges between 015° and 083°. Another has two internal peaks at 127° and 140° and ranges between 100° and 172°. One additional, less prominent, orientation peak is evident at 003° (ranging between 353° and 015°).

Joint spacing was assessed by assigning joint sets at the outcrop scale into one of eight spacing bins as noted in the table below. An additional category of ‘unknown’ was assigned when joint spacing could not be properly measured, for example due to small outcrop size. The results from this assessment are shown in a histogram (Figure 5.1.14f) and in Table 5.1.4.2b below. Table 5.1.4.2b also separates the joint spacing information by the same dip subsets described above. Rose diagrams, along with orientation peaks, for joints of each spacing class are shown in Figures 5.1.14g to 5.1.14n.

Looking at the distribution of spacing for the entire joint dataset, the majority of observed joints exhibit spacing between 100-500 cm (305/795; 38%). Considering the 196 instances of joints that exhibit 30-100 cm spacing, and the 305 instances of joints that exhibit 100-500 cm spacing, more than 50% of all joint spacings measured in the Revell batholith area range from 30-500 cm (501/795; 63%). One joint was identified with spacing at less than 1 cm, and 52 joints (7%) exhibited spacing of 10 cm or less. Joint spacing of 500 cm or greater was observed in 66 (8%) instances.

All spacing bins exhibit a similar variability in joint peak orientation to that of the total joint set. The northeast and northwest orientation peaks are well evident in the 10-30 cm, 30-100 cm, 100-500 cm, and 500-1000 cm joint spacing classes (Figure 5.1.14i, j, k, l), as well as the 1-3 cm joint spacing class (Figure 5.1.14g). The 10-30 cm joint spacing class also exhibits a north-trending orientation peak (Figure 5.1.14i), which is a minor peak in the combined joint orientation data (Figure 5.1.14b). The 3-10 cm joint spacing class exhibits major orientation peaks south-southeast at 155° and east-southeast at 114° (Figure 5.1.14h). Joints spaced >1000 cm show orientation peaks northeast at 038° and east-northeast at 058° (Figure 5.1.14m). The orientation of joints with unknown spacing is highly variable (Figure 5.1.14n).

Table 5.1.4.2b: Revell Batholith Area - Joint Spacing

	All Joints		Steep Dip		Moderate Dip		Shallow Dip	
Spacing Bins (cm)	# of joints	% of joints	# of joints	% of all joints	# of joints	% of all joints	# of joints	% of all joints
<1	1	0.13	1	0.13	0	0.00	0	0.00
1–3	16	2.01	13	1.64	3	0.38	0	0.00
3–10	41	5.16	38	4.78	1	0.13	2	0.25
10–30	76	9.56	60	7.55	13	1.64	3	0.38
30–100	196	24.65	143	17.99	41	5.16	12	1.51
100–500	305	38.36	227	28.55	61	7.67	17	2.14
500–1000	47	5.91	37	4.65	9	1.13	1	0.13
>1000	37	4.65	29	3.65	4	0.50	4	0.50
Unknown	76	9.56	48	6.04	24	3.02	4	0.50
Total # Joints	795		596		156		43	

The results are also presented for shallow, moderate and steep joint dip subsets (Table 5.4.1.2b), with stated percentages calculated using the total number of 795 joints. The majority of shallowly dipping joints (29/43; 67%) fall into the 30–500 cm range in spacing, with few examples exhibiting tighter spacing. Joint spacing for shallowly dipping joints greater than 500 cm are rare due to the scarcity of vertical exposure that would allow the assessment of such wide joint spacing. The majority of moderately dipping joints (61/156; 39%) exhibit spacing of 100-500 cm. The steeply dipping joints also predominantly exhibit spacing of 100-500 cm, occurring in 227/596 (38%) instances.

Overall, the majority of joints observed throughout the Revell batholith area are subvertical. A subhorizontal set is observed locally, where vertical relief is present, and is commonly spaced 100-500 cm apart (Figure 5.1.15a). While most joints are spaced between 30 and 500 cm, several locations in the southeast and the northwest of the Revell batholith area show joint spacing greater than 500 cm (Figure 5.1.15b). Joint spacing under 30 cm (Figure 5.1.15c) occurs locally throughout the Revell batholith area. Multiple, tightly-spaced, joint orientations are a common at single bedrock observation locations (Figure 5.1.15d).

Faults

Fifty-seven faults were observed in the Revell batholith area, most of which (52/57; 91%) were observed in the eastern and northern portions of the mapping area (Figure 5.1.16). Very few faults (5/57) were observed in the central and southwestern Revell batholith area. Of the 57 fault observations made, 21 are located within granodiorite and 24 within tonalite. The remaining 12 faults occur within granite, quartz diorite, and diorite.

Poles to the fault planes and the corresponding fault rose diagrams are shown on Figure 5.1.17. All faults dip relatively steeply with very few occurrences of dip magnitude <65° (Figure 5.1.17a). The combined fault population exhibits several orientation peaks of relatively equal frequency at 005°, 025°, 050° (with a less significant shoulder peak at 060°), 102° and 115° (Figure 5.1.17b). The latter two may represent one broad fault orientation with a total range between 090° and 125°. One additional broad fault orientation ranges between 136° and 178° with internal peaks at 152° and 166°.

Damage zones of faults range from thin, single slip surfaces, to zones several metres wide comprising tightly spaced joints parallel to the fault plane (Figure 5.1.18a). Some of the thinnest, single-surface, faults overprint pre-existing ductile shear zones (Figure 5.1.18b). Almost half of the observed faults (22/57, 38%) are less than 3 cm in width. Out of the 57 faults, eight were described with a width of greater than 3 cm, which accounts for a damage zone around the fault core. Larger faults, with damage zones between 10 and 500 cm wide, include tight joint spacing. Some faults include minor amounts of brecciation. Overall, field observations suggest that the damage to bedrock, primarily in the form of tighter joint spacing or increased number of evident joint orientation families, is generally limited to approximately 5-10 m beyond fault core zones.

Out of the 57 faults observed in the Revell batholith area, 21 exhibit dextral horizontal offset and 18 exhibit sinistral horizontal offset. One occurrence each of reverse, normal and oblique slip faults, and an additional 15 faults of unknown slip sense, are also present. Slip sense on faults are inferred from the geometry of curviplanar splaying fractures, steps on slickensides, and offset of “marker structures”, such as aplite dykes or quartz veins (Figure 5.1.18e). Where observed, displacement of markers ranges from several centimetres to decimetres. At two locations, a sinistral south-striking fault was observed as cross-cut by west-striking fault of unknown slip sense.

The dextral fault population is dominated by one main orientation peak at 152°, which ranges between 132° and 168°, and several additional less prominent peaks at 010°, 028°, 050°, 100° and 120° (Figure 5.1.17c). The sinistral fault population exhibits several orientation peaks, including, 352° (172)° and 005°, which together fall within a broad range between 335° and 014°, and 022°, 062°, 088° and 142° (Figure 5.1.17d). At some locations both dextral and sinistral faults are observed (Figure 5.1.16a).

Faults are locally coated with epidote (Figure 5.1.18b), hematite (Figure 5.1.18c), quartz (Figure 5.1.18d), chlorite or breccia. The presence of these secondary minerals emphasizes the presence of slickenline lineations. Slickenlines are observed on individual, isolated, fault planes and in fault zones characterized by multiple parallel surfaces (Figure 5.1.18a). They are consistently subhorizontal to moderately plunging suggesting primarily or partly strike-slip fault movement (Figure 5.1.17e and 5.1.18d). Secondary minerals associated with fault zones are summarized in Section 5.1.4.3 below.

Veins

There are 75 observations of veins in the Revell batholith area (Figure 5.1.19), 74 of which were recorded with both strike and dip information. Vein occurrences cluster in the southeast and north of the mapping area. Both shear-related and extension veins were identified, along with several instances where a genetic association for vein emplacement was not clear (Figure 5.1.19).

The vein population is dominated by two adjacent, broad, orientation sets. One ranges between 090° and 122° with internal peaks at 100° and 110°. The other ranges between 122° and 162° with one internal peak at 140°. Another dominant vein orientation peak is evident at 038° and three statistically less relevant minor peaks are evident at 006°, 020° and 076° (Figure 5.1.20b). Veins are mostly steeply dipping, with only few occurrences of veins dipping less than 65° (Figure 5.1.20a).

In 54 instances (72%), the observed vein was interpreted as extensional in nature (Figure 5.2.20c). These veins are narrow, ranging mostly between 1-3 cm in width (39/75; 52%). Eighteen veins greater than 3 cm in width were recorded and six veins were less than 1 cm in width. The shear veins range from 1-30 cm in width.

The majority of the veins (50/75; 67%) were quartz filled. The vein mineral infilling was identified as pegmatite, aplite or granite in another 19 instances. These granitic veins are further described in Section 5.4.2 with respect to their distribution, lithological association and structure. The remaining six vein occurrences were filled with feldspar or the infill was not determined. Quartz veins were consistently observed to cross-cut the aplite veins (Figure 5.1.20c). Quartz filled veins occur as series of parallel veins or as networks of mutually cross-cutting veins (Figure 5.1.20d).

5.1.4.3 Secondary Minerals and Alteration

Evidence of secondary mineral infilling within, and alteration in the wall rock adjacent to, fractures was documented during mapping of the Revell batholith area (Figure 5.1.21). The most common secondary minerals observed across all fracture types (795 joints + 57 faults + 75 veins; N = 927) in the Revell batholith area include quartz (112 occurrences; 12%), hematite (17 occurrences; < 2%), epidote and feldspar (nine occurrences each; < 1%) (Table 5.1.4.3a). Lesser bleaching (six occurrences), breccia (four occurrences), chlorite (three occurrences), biotite and pyrite (two occurrences each), represent the remaining secondary mineral types and are collectively referred to as ‘other’ in Table 5.1.4.3a and on Figure 5.1.21. Note that in some instances more than one infilling mineral was identified within a single fracture.

Quartz infilling occurs throughout the entire southeast portion of the Revell batholith area (Figure 5.1.21). Hematite infilling occurs throughout the Revell batholith area. Epidote occurs as a fracture infill in the southwest and along the northwestern boundary of the Revell batholith area. Chlorite and hematite appear as a common mineral pairing along eastern margin of Revell batholith area, where lithological complexity increases in proximity to the greenstone belt. Quartz-filled fractures were observed to cross-cut, and therefore post-date, felsic dykes (Figure 5.1.20c).

Table 5.1.4.3a: Revell Batholith Area Joints, Faults and Veins (Combined) - Secondary Mineral Infills and Alteration

Mineral Phase/ Alteration	All Occurrences	% of total
Quartz	112	12.12
Hematite	17	1.84
Epidote	9	0.97
Feldspar	9	0.97
Other	17	1.84
None	760	82.25
Total # of Fractures	**927**	**100**

The orientations of all filled fractures in the Revell batholith area is compiled in Figure 5.1.22. The majority of filled fractures are steeply dipping, with only few dipping less than 65°. The combined filled fracture population is dominated by two main orientation peaks at 098° and 040°, both of which are broad peaks ranging between from 086° to 115°, and from 028 to 066°, respectively. Less prominent peaks at 128°, ranging from 115° to 134° and a broad peak ranging from 134° to 175° with internal peaks at 142° and 165°. An additional less prominent broad peak ranges from 355° to 028° with internal peaks at 008° and 020°.

The orientation peaks for the fracture population infilled by quartz, shown in Figure 5.1.22c, is dominated by two main peaks oriented east at 098° and northeast at 040°, both of which are broad peaks ranging between from 086° to 115°, and from 028 to 066°, respectively. Less prominent peaks are oriented southeast at 128°, ranging from 115° to 134° and a broad peak ranging from 134° to 175° with internal peaks at 142° and 165°. An additional less prominent broad peak oriented north to north-northeast ranges from 355° to 028° with internal peaks at 008° and 020°. For hematite filled fractures (Figure 5.1.22d) dominant orientation peaks are southeast to south-southeast (130°, 150° and 162°) and north (010°). One additional statistically less relevant peak is evident at 027°. For epidote (figure 5.1.22e), the dominant orientation peak is northeast at 053°. For feldspar (figure 5.1.22f), the dominant orientation peak is east at 098°.

Table 5.1.4.3b provides an overview of the types and number of joints with secondary mineral infilling and alteration in the Revell batholith area. The majority of observed joints (721/795; 90%) are unfilled. The predominant infill mineral is quartz with 51 occurrences (6%), followed by hematite which occurs as infill in 12 joints (1.5%). Four joints displayed a several cm wide bleached halo on either side of the joint (Figure 5.1.23d). Irregular quartz inclusions observed in the bleached halos distinguish these zones from the unbleached granodiorite/tonalite host rock and suggest this particular feature is associated with silicification. Lesser amounts of alkali feldspar, epidote, biotite, pyrite, and chlorite were also observed, each equalling less than 1% of the total number of joints. In two instances a breccia fill was identified. Mineral infill is most common in joints with a steep dip. No infill was recorded on shallowly dipping joints.

Table 5.1.4.3b: Revell Batholith Area Joints - Secondary Mineral Infills and Alteration

Mineral Phase / Alteration	All Occurrences	% of total	Steep Dip	Moderate Dip	Shallow Dip
Quartz	51	6.42	44	7	0
Hematite	12	1.51	11	1	0
Epidote	4	0.50	4	0	0
Feldspar	6	0.75	4	2	0
Bleaching	4	0.50	4	0	0
Breccia	2	0.25	2	0	0
Biotite	2	0.25	1	1	0
Pyrite	2	0.25	2	0	0
Chlorite	1	0.12	1	0	0
None	721	89.57	530	148	43
Total # of Joints	**795**	**100**	**596**	**156**	**43**

Evidence of secondary mineral infilling and alteration associated with faults was also documented during mapping. Table 5.1.4.3c below provides an overview of the types and number of fault infill occurrences encountered in the Revell batholith area, noting that the majority of observed faults (34/60; 58%) were unfilled. Quartz fill occurs in 11 (19%) instances, and hematite and epidote in five instances (8.5%), including one instance where both are observed together. Two faults (3%) are recorded as infill with chlorite and two faults are associated with breccia. Epidote occurs as fault infill in the southwest and along the northwestern boundary of the Revell batholith area. Chlorite, epidote and hematite are observed mostly as pervasive coatings on and around northeast- and north-striking fault surfaces (Figures 5.1.23a and b).

Table 5.1.4.3c: Revell Batholith Area Faults - Secondary Mineral Infills and Alteration

Mineral Phase/ Alteration	All Occurrences	% of total
Quartz	11	19.30
Hematite	5	8.77
Epidote	5	8.77
Breccia	2	3.51
Chlorite	2	3.51
None	34	59.65
Total # of Faults	**57**	**100**

Evidence of secondary mineral infilling and alteration adjacent to veins was also documented during mapping. Table 5.1.4.3d below provides an overview of the types and number of vein infill occurrences encountered in the Revell batholith area. The most common infill in veins is quartz, occurring in 50 out of 75 (67%) instances (Figures 5.1.20c, 5.1.20d and 5.1.23c). Four veins (5%) are infilled with feldspar and nineteen (19.99%) of the observed veins are described as joints with pegmatite, aplitic, or granitic fill, or as dykes up to 50 cm width. The structures filled with granitic material are further discussed along with felsic dykes (Section 5.4.2). The remaining five veins (6.67%) have an unknown infilling mineral.

Table 5.1.4.3d: Revell Batholith Area Veins - Secondary Mineral Infills and Alteration

Mineral Phase/ Alteration	All Occurrences	% of total
Quartz	50	66.67
Feldspar	4	5.33
Other	19	19.99
Unknown Fill	5	6.67
Total # of veins	**75**	**100**

5.2 Basket Lake-Indian Lake West Batholith Area

The Phase 2 Detailed Geological Mapping area in Basket Lake-Indian Lake West batholith encompasses the southeastern portion of the Basket Lake batholith withdrawal area, the region between this withdrawal area and the Indian Lake West batholith withdrawal area, and the southernmost portion of the Indian Lake West batholith withdrawal area. This area is generally located to the north, and to a smaller extent to the south, of the Trans-Canada Highway, to the west and northwest of Ignace, Ontario. Given the large extent of this mapping area relative to the other two mapping areas in Ignace, and the preference to maintain a consistent scale of map presentation between areas, the Basket Lake-Indian Lake West batholith area is shown on two figures, 5.2.1a and 5.2.1b (all other mapped datasets are also shown as a/b figure sets) for the northern and southern portions of the Basket Lake-Indian Lake West batholith area, respectively. A total of 136 stations were visited throughout this area.

5.2.1 Accessibility and Surface Constraints

The Basket Lake-Indian Lake West batholith area is accessed via a network of logging and general use roads extending northwards from the Trans-Canada Highway, west of Ignace (Figures 5.2.1a and 5.2.1b). The northeastern part of the Basket Lake-Indian Lake West batholith area is accessed via a separate network of logging and general use roads extending west of Highway 599 north of Ignace. These roads are generally in good condition and accessible using a 4X4 vehicle (Figure 5.2.2a). In few cases, overgrown older logging roads and open clear-cut areas were traversed by foot.

Topography in the south of the Basket Lake-Indian Lake West batholith area is generally subdued and small ridges, with up to several metres of vertical relief, are only encountered rarely. Moderately high ridges with greater than 10 m vertical extent occur in the central portion of the Basket Lake-Indian Lake West batholith area (Figure 5.2.2b), but these minor topographic variations do not limit accessibility.

5.2.2 Bedrock Exposure and Overburden Thickness

The Basket Lake-Indian Lake West batholith area is covered by two west-northwest trending end moraines (Hartman and Lac Seul) that cover the southern portions of the area in varying, but often appreciable, thickness of overburden. Out of the 136 total stations visited in the Basket Lake-Indian Lake West batholith area, 108 were positively identified as exposed bedrock (79%), while 28 (21%) were found to be overburden covered. Average (estimated) overburden thickness around the edges of exposed bedrock outcrop areas varied between 0.3 and 1 m. Estimated overburden thickness at overburden stations was mostly between 1-3 m, or greater than 3 m.

Areas of bedrock exposure are more frequent in the northern portion of the Basket Lake-Indian Lake West batholith area, mostly over the Basket Lake batholith (see predicted outcrops in Figure 5.2.1a). In this area opportunities to characterize the bedrock occur where it is exposed along elongate ridges (Figure 5.2.2b) and there is abundant sand and gravel between these exposures (Figure 5.2.1a, Figure 5.2.2d). In flat areas, bedrock is commonly exposed as glacially smoothed pavement outcrops (Figure 5.2.2c). The southern part of the Basket Lake-Indian Lake West batholith area coincides with the location of the Hartman moraine and is covered very broadly in overburden with only a few scattered locations accessible for observation of exposed bedrock (Figure 5.2.1b).

5.2.3 Lithology and Physical Character

The descriptions below and in Table 5.2.3 provide an overview of the lithological and physical character of the main and minor bedrock lithology types observed in the Basket Lake-Indian Lake West batholith area, in decreasing order of their abundance.

Two main lithological units are observed in the Basket Lake-Indian Lake West batholith area including: granite and gneiss (which includes tonalite gneiss and unsubdivided gneiss) (Figures 5.2.3a and 5.2.3b). The character and distribution of minor lithological units (Figures 5.2.4a and 5.2.4b), including mafic metavolcanic rocks, granodiorite and schist are described in Section 5.2.3.3. Dykes of mafic and intermediate to felsic composition, also observed in the Basket Lake-Indian Lake West batholith area, are discussed separately in Section 5.4.

Table 5.2.3: Summary of Lithological Units in the Basket Lake-Indian Lake West Batholith Area.

Lithological Unit	# of Occurrences (% of bedrock stations)	Fabric	Magnetic Susceptibility (mean SI)	Gamma Spectrometry (average)	Strength
Granite	108 (100%)	Massive to weakly foliated	$2.25 \pm 2.05 \times 10^{-3}$	K = 3.69±0.55% U = 7.95±5.24 ppm Th = 27.5±11.7 ppm	R5
(Tonalite) Gneiss	31 (29%)	Foliated to gneissic	$2.48 \pm 2.33 \times 10^{-3}$	K = 1.61±0.77% U = 3.19±2.10 ppm Th = 10.00±6.82 ppm	R5
Mafic metavolcanic rocks	6 (6%)	Gneissic	$0.470 – 10.00 \times 10^{-3}$	K = 1.2 – 2.6 % U = 0.6 – 4.50 ppm Th = 6.0 – 27.7 ppm	N/A
Granodiorite	4 (4%)	Massive to weakly foliated	$0.120 – 7.80 \times 10^{-3}$	K = 1.4 – 2.2 % U = 1.89 – 4.00 ppm Th = 4.30 – 11.1 ppm	N/A
Schist	2 (2%)	Foliated	0.210×10^{-3}	K = 1.61 % U = 7.40 ppm Th = 15.90 ppm	N/A

5.2.3.1 Granite

Granite is by far the predominant lithology and is uniformly distributed across the entire Basket Lake-Indian Lake West batholith area. It is observed at all 108 bedrock stations. The granite is characterized as the main lithology at 102 (94%) out of 108 bedrock stations (Figures 5.2.3a and 5.2.3b), where it usually represents greater than 90% of the outcrop area; locally, in the six remaining instances (6%), granite occurs as a minor lithology covering less than 30% of the outcrop area. In places, most pervasively in the western portion of the Basket Lake-Indian Lake West batholith area, the granite hosts varying amounts of potassic pegmatite veins or dykes, as well as pegmatite pods and segregations with gradational contacts to the granite. A total of 106 representative rock samples of the granite unit were collected from the Basket Lake-Indian Lake West batholith area.

The granite is pink when fresh and pink to grey, off white or beige when weathered (Figure 5.2.5a). Most commonly the granite is medium-grained (1-5 mm); locally it is also either fine-grained or extremely coarse-grained. Main matrix mineral phases within the granite are quartz, alkali feldspar, plagioclase and biotite (Figure 5.2.5b). Phenocrysts, predominantly plagioclase and K-feldspar, were observed at 39 of the 102 locations where granite was identified as the main lithological unit. Phenocryst size ranges from medium-grained to very coarse-grained (10–50 mm). Accessory mineral phases include magnetite and lesser hematite or titanite.

The granite is predominantly characterized as massive with a variable equigranular or inequigranular texture. In some instances, a primary layering is evident, defined by variation in grain size and mineral composition (e.g. variable biotite and quartz content). The igneous layering occurs on the decimetre scale and is highly variable in orientation. In 28 occurrences, biotite alignment defines a weak tectonic foliation within the granite.

Based on 107 field estimates of intact rock strength, the granite is consistently classified as very strong with a rock hardness of R5 equivalent to fracturing after many hard blows with a hammer.

The granite has a relatively high magnetic susceptibility (mean = 2.25±2.05 x10^{-3} SI, N=116). Susceptibility values range between 0.03 and 15 x10^{-3} SI with 50% of the readings between 0.72 and 3.35 x10^{-3} SI (Figure 5.2.5c). The higher magnetic susceptibility values recorded for the granite is attributed to the local presence of accessory magnetite.

The gamma ray spectrometry readings (Figure 5.2.5d) for the granite, including 123 sets of measurements, show the following characteristics:

- Total count is on average 165.5±48.5 cps and ranges between 58.8 and 288.5 cps.
- Potassium content is on average 3.69±0.55% and ranges between 2.4 and 5.1%.
- Uranium content is on average 7.95±5.24 ppm and ranges between 0.7 and 23.4 ppm.
- Thorium content is on average 27.5±11.7 ppm and ranges between 4.1 and 58.7 ppm.

5.2.3.2 (Tonalite) Gneiss

Gneiss (encompassing tonalite gneiss, and unsubdivided gneiss) is observed at a total of 31 bedrock observation locations (29%), primarily in the northern and northeastern portions of the Basket Lake-Indian Lake West batholith area (Figures 5.2.3a and 5.2.3b). At five out of 108 bedrock stations (5%) it occurs as the main lithology constituting over 60% of the outcrop area. At the remaining 26 bedrock stations (24%), gneiss is observed as a minor lithological unit comprising less than 30% of the outcrop area or as distinct xenoliths within granite. Gneiss xenoliths range in size from 20 cm to greater than 1 m in diameter. Internally these xenoliths are well foliated to gneissose and exhibit intact contacts with the surrounding granite bedrock. There is no indication of brittle reactivation along these contacts. A total of 22 representative rock samples of the gneiss were collected from the Basket Lake-Indian Lake West batholith area.

The gneiss is primarily white to dark grey when fresh and light or dark grey when weathered (Figure 5.2.6a). The tonalite gneiss matrix is generally medium-grained (1-5 mm) and either equigranular or inequigranular in occurrence, and few coarse-grained examples are also observed (Figure 5.2.6b). Main mineral phases within the tonalite gneiss are biotite, plagioclase and quartz.

The gneiss is observed as foliated or gneissose in texture. Foliation is defined by the alignment of planar biotite minerals or gneissose banding. Out of a total of 28 field estimates of intact rock strength the tonalite gneiss is classified as very strong with a rock hardness of R5 in all occurrences, equivalent to fracturing after many hard blows with a hammer.

The gneiss has a moderately high magnetic susceptibility (mean = 2.48±2.33 x10^{-3} SI, N=32). Susceptibility values range between 0.13 and 17 x10^{-3} SI with 50% of the readings between 0.57 and 4.1 x10^{-3} SI (Figure 5.2.6c). The higher magnetic susceptibility values recorded for the tonalite gneiss is attributed to the local presence of accessory magnetite.

The gamma ray spectrometry readings (Figure 5.2.6d) for the gneiss, including 28 sets of measurements, show the following characteristics:

- Average total count of 65.41±33.1 cps and ranging between 33.6 and 168.7 cps.
- Potassium content is on average 1.61±0.77% and ranges between 0.8 and 3.9%.
- Uranium content is on average 3.19±2.10 ppm and ranges between 0.5 and 7.2 ppm.
- Thorium content is on average 10.00±6.82 ppm and ranges between 3.9 and 33.9 ppm.

5.2.3.3 Minor Lithological Units

Minor lithological units identified in the Basket Lake-Indian Lake West batholith area include: mafic metavolcanic rocks, granodiorite, and schist (Figures 5.2.4a and 5.2.4b). These rock types were observed as xenoliths, primarily within the granite. Only general descriptions are included for these minor lithological units due primarily to the limited number of observations and occurrences of each within the Basket Lake-Indian Lake West batholith area.

Mafic metavolcanic rocks

Mafic metavolcanic rocks occur at six bedrock observation locations (6%) in the Basket Lake-Indian Lake West batholith area, where they consistently represent less than 30% of the exposed outcrop by area (Figures 5.2.4a and 5.2.4b). Mafic metavolcanic rocks occur as xenoliths up to 2 m in diameter that exhibit intact and sharp contacts with surrounding granite host rock. There is no indication of brittle reactivation along any of the observed contacts. The occurrences of mafic metavolcanic rocks are restricted to the northern and central part of the Basket Lake-Indian Lake West batholith area. A total of three representative samples of mafic metavolcanic rocks were collected from the Basket Lake-Indian Lake West batholith area.

The mafic metavolcanic rocks are light to dark grey in colour when fresh and dark grey when weathered (Figure 5.2.7a). They exhibit a medium-grained (1-5 mm) and equigranular to inequigranular matrix. Amphibole, biotite, alkali feldspar, quartz and plagioclase are the primary mineralogical components of the mafic metavolcanic rocks. The internal gneissic fabric of the xenoliths is sharply truncated against the surrounding granite.

Four measurements of magnetic susceptibility of the mafic metavolcanic rocks are 0.470, 0.500, 2.100, and 10.00 x10^{-3} SI, reflecting their moderately high but variable magnetic susceptibility. The five gamma ray spectrometry readings for the mafic metavolcanic rocks show that the total count ranges between 48.9 and 111.7 cps, potassium content ranges between 1.2 and 2.6%, uranium content ranges between 0.60 and 4.50 ppm, and thorium content ranges between 6.00 and 27.7 ppm.

Granodiorite

Granodiorite occurs as a minor unit at four bedrock observation locations (4%) in the Basket Lake-Indian Lake West batholith area (Figure 5.2.4a and 5.2.4b). It represents less than 30% of the outcrop area in three of these instances and over 60% of the outcrop area in the other one. The occurrences of granodiorite are observed mainly in the northern part of the Basket Lake-Indian Lake West batholith area. A total of three representative rock samples of the granodiorite unit were collected from the Basket Lake-Indian Lake West batholith area.

The granodiorite predominantly occurs as massive or foliated xenoliths in gradational contact with the surrounding granite. In some instances, the granodiorite is intruded by coarse granitic pegmatite veins (Figure 5.2.7b). The granodiorite contacts with the surrounding granite are consistently intact and there is no evidence of any brittle reactivation along them. The granodiorite is light to dark grey in colour on both fresh and weathered surfaces. It exhibits a medium-grained (1-5 mm) and equigranular to inequigranular matrix. Quartz, alkali feldspar, plagioclase and biotite are the primary mineralogical components of the granodiorite.

Three measurements of magnetic susceptibility of the granodiorite are 5.100, 7.800 and 0.120x10^{-3} SI, reflecting the moderately high but variable magnetic susceptibility. The three gamma ray spectrometry readings for the granodiorite show that the total count ranges between 45.5 and 69.6 cps, potassium content ranges between 1.4 and 2.2%, uranium content ranges between 1.89 and 4.00 ppm, and thorium content ranges between 4.30 and 11.1 ppm.

Schist

Schist occurs at two bedrock observation locations (2%) in the Basket Lake-Indian Lake West batholith area. In both instances it represents less than 30% of the outcrop area (Figure 5.2.4a and 5.2.4b). The occurrences of schist are located in the central Basket Lake Basket Lake-Indian Lake West batholith area. Schist is interpreted to occur as xenoliths within the granite, however heavy lichen cover did not allow for examination of the contacts. No representative rock samples of the schist were collected from the Basket Lake-Indian Lake West batholith area.

The schist is dark grey when fresh and when weathered. It exhibits a medium-grained (1-5 mm) and equigranular matrix. Biotite is one of the primary mineralogical components of the schist and defines the strong internal foliation within the xenoliths. One measurement of magnetic susceptibility of the schist is 0.210x10^{-3} SI, reflecting a low magnetic susceptibility. The one gamma ray spectrometry reading for the schist has a total count of 104.5 cps, potassium content of 1.6%, uranium content of 7.40 ppm, and thorium content of 15.90 ppm.

5.2.4 Structure

Structures in the Basket Lake-Indian Lake West batholith area, including features associated with both ductile to brittle deformation processes, are described below. Secondary mineralization, in form of fracture infilling mineral phases and alteration phases, are also discussed.

5.2.4.1 Ductile Structure

Ductile structural features observed in the Basket Lake-Indian Lake batholith area comprise various types of penetrative planar fabrics, including several types of foliation (igneous flow foliation, tectonic foliation), and localized ductile and brittle-ductile shear zones. These structural features are described in detail below. Linear structures associated with these ductile planar structures are also described below, where applicable.

Orientation information is summarized in Table 5.2.4.1 for the ductile structures described below. This information is based on the analysis of the data-specific rose diagrams. A degree of confidence is provided for each orientation peak identified based on the frequency of that orientation within the dataset. Note that due to the low number of observations (N=6) the statistical analysis of shear zone orientations is limited.

Table 5.2.4.1: Summary of Ductile Structures in the Basket Lake-Indian Lake West Batholith Area

Structure Type	Orientation Family	Peak (degrees)	Range (degrees)	Frequency (%)	Confidence
Foliation - All	E	087	075-100	20.9	High
	ENE	060	050-075	10.3	Medium
	ESE	112	100-122	9.5	Medium-Low
	SSE	157	152-170	7.5	Low
	SSE	146	140-152	7.3	Low
	SE	130	122-140	6.6	Low
Igneous Flow Foliation	ENE	060	055-065	64.7	High
	E	088	084-092	16.5	Medium
	ENE	154	150-158	16	Medium
Tectonic Foliation	E	088	075-100	21.5	High
	ESE	113	100-124	10.7	Medium
	SE	147	140-153	7.6	Low
	SSE	161	153-170	7.6	Low
	ENE	067	050-075	6.4	Low
Shear Zones - All	NNE	012	008-016	16.9	Medium
	ENE	060	056-064	16.9	Medium
	E	100	096-104	16.9	Medium
	ESE	115	111-119	16.9	Medium
	SSE	158	154-162	16.9	Medium
	S	170	166-174	16.9	Medium

Foliation

A total of 69 foliation measurements were made at the 108 bedrock stations of the Basket Lake-Indian Lake West batholith area (Figures 5.2.8a and 5.2.8b). Sixty-six of these foliation measurements contain both strike and dip information (Figure 5.2.9). The two main types of foliation recognized are igneous flow foliation and tectonic foliation. Gneissic layering was measured at one bedrock station. The combined foliation dataset is dominated by one main peak orientation to the east at 087°, which includes structures that mostly dip steeply (>70°) to the north or south. Several additional orientation peaks are evident at 060°, 112°, 130°, 146° and 157°. The majority of these foliation planes dip steeply (Figures 5.2.9a and 5.2.9b).

Of the 66 foliation measurements, six are igneous flow foliations. Observations of igneous flow fabric in the Basket Lake-Indian Lake West batholith area are sparse and occur mainly in the southeast of the Indian Lake West batholith area (Figure 5.2.8b). Igneous flow foliation is generally weakly developed, and is defined primarily by aligned feldspar phenocrysts (Figure 5.2.12a) or biotite schlieren. Igneous flow foliation exhibits one dominant strike direction to the east-northeast at 060°, with minor east and south-southeast trending peaks at 088° and 154°, respectively (Figure 5.2.9c). The igneous flow foliation is predominantly steeply dipping (Figure 5.2.9a).

A tectonic foliation is the most common planar fabric type observed in the Basket Lake-Indian Lake West batholith area, with 59 measurements of strike and dip recorded (Figure 5.2.9d). This foliation occurs both in granite and in tonalite gneiss. Within the granite, it is most commonly defined by aligned biotite and is weakly to moderately developed (Figure 5.2.12b). In tonalite gneiss, the tectonic foliation is very well developed and includes a subset of fabric characterized as a gneissic layering (Figure 5.2.12c). The tectonic foliation population strikes predominantly east-west (088°) and is mostly steeply dipping. Minor orientation peaks strike east-northeast (067°), east-southeast (113°) and south-southeast (147° and 161°) (Figure 5.2.9d).

Corridors of north-northwest striking tectonic foliation occur locally in the central Basket Lake-Indian Lake West batholith area (Figure 5.2.8a). Tectonic foliation orientation in tonalite gneiss xenoliths is highly variable and suggests that these inclusions may be rotated within the granite host rock. Mineral lineation associated with the planar tectonic foliation is rare. Two mineral lineations were measured in the Basket Lake-Indian Lake West batholith area. One plunges shallowly to the northeast (043/16) and the other moderately to the west (260/60).

Massive (unfoliated) bedrock, indicated by bedrock stations with no foliation measurements, occurs locally throughout the Basket Lake-Indian Lake West batholith area (green dot locations on Figures 5.2.8a and 5.2.8b).

Shear Zones

Shear zones are rare in the Basket Lake-Indian Lake West batholith area (Figures 5.2.10a and 5.2.10b). A total of six shear zones were measured throughout the Basket Lake-Indian Lake West batholith area, three of which are characterized as ductile shear zones and three of which are described as brittle-ductile shear zones. The ductile shear zones, identified in the granite are narrow, generally 1-3 cm in width (Figure 5.2.12d). Brittle-ductile shear zones are locally associated with curviplanar fault splays extending outwards from the ductile shear zone core. No mineral infill or alteration phase is observed with the ductile or brittle-ductile shear zones or its surrounding wall rock. No linear fabric is observed in association with the shear zones.

The combined shear zone population shows that each of the six shear zones has a distinct orientation (Figure 5.2.11a and 5.2.11b). Two shear zones strike roughly east to east-southeast, with peaks at 100° and 115°. Two shear zones strike south-southeast to south with peaks at 158° and 170°. The other two shear zone orientations are north-northeast, with a peak at 012°, and east-northeast, with a peak at 060°.

Of the three ductile shear zone observations, one is a sinistral shear zone in the west of the mapping area (Figure 5.2.10a) and two are shear zones with unknown slip in the southeast of the mapping area (Figure 5.2.10b). The sinistral ductile shear zone strikes north-northeast and is vertical (Figure 5.2.11c). The two ductile shear zones with unknown slip strike west-northwest and are inclined and vertical, respectively (Figure 5.2.11c). These two ductile shear zones occur in the southern portion of the Indian Lake West batholith area and sub-parallel to the well-developed fabric in the adjacent greenstone belt to the south (Figure 5.2.10b).

Of the three brittle-ductile shear zones, one is a shear zone with unknown slip in the west of the mapping area (Figure 5.2.10a) and two are located in the central mapping area (Figure 5.2.10a), one of which is dextral, and one is sinistral, and strike north-northwest to north (Figure 5.2.11d). The third brittle-ductile shear zone has an unknown slip and strike east-northeast (Figure 5.2.11d).

5.2.4.2 Brittle Structure

Brittle structures observed throughout the Basket Lake-Indian Lake West batholith area include joints, veins and faults. A total of 374 fracture measurements were made across the 108 bedrock stations in the Basket Lake-Indian Lake West batholith area. These include 297 joints, 36 faults and 41 veins. The characteristics of each of these fracture types, observed in the Basket Lake-Indian Lake West batholith area, are described below. The secondary mineral infillings and linear structure that accompany some veins and faults are also described in this section.

Orientation information is summarized in Table 5.2.4.2a for the brittle structures described below. This information is based on the analysis of the data-specific rose diagrams. A degree of confidence is provided for each orientation peak identified based on the frequency of that orientation within the dataset.

Table 5.2.4.2a: Summary of Brittle Structures in the Basket Lake – Indian Lake West Batholith Area

Structure Type	Orientation Family	Peak (degrees)	Range (degrees)	Frequency (%)	Confidence
Joints - All	S	173	160-185	8.6	Medium-Low
	NNE	013	005-029	8	Medium-Low
	NE	038	025-043	7.8	Low
	NE	048	043-059	7.8	Low
	E	084	075-115	5.9	Low
	ENE	064	059-075	5.8	Low
	SSE	155	133-158	5.8	Low
Joints – Shallow	NE	034	024-040	9.7	Medium-Low
	NE	055	048-076	9.7	Medium-Low
	NNE	015	005-024	8.8	Medium-Low
	E	085	076-104	8.7	Medium-Low
	NE	045	040-048	8.6	Medium-Low
	SSE	155	145-163	7.5	Low
	S	173	163-180	7.5	Low
	ENE	070	065-076	7.1	Low
Joints – Moderate	NNE	013	000-028	14.8	Medium
	SSE	168	160-174	12.1	Medium-Low
	NE	056	041-072	9.3	Medium-Low
	E	094	084-102	7.3	Low
	NE	035	028-041	6.3	Low
	ENE	075	072-084	6.2	Low
Joints - Steep	S	178	159-188	9.6	Medium-Low
	NE	040	024-058	8.2	Medium-Low
	NNE	012	008-024	6.9	Low
	SSE	152	135-159	6.4	Low

Structure Type	Orientation Family	Peak (degrees)	Range (degrees)	Frequency (%)	Confidence
	SE	125	115-135	6.3	Low
Faults - All	N	005	357-027	16.9	High
	SSE	167	153-177	15	Medium-High
	SE	130	121-137	7.9	Low
	NE	035	027-046	7	Low
	SSE	148	137-153	6.3	Low
Faults – Dextral	N	005	357-025	20.3	High
	SSE	165	155-177	18.6	Medium-High
	SE	127	120-136	7.9	Low
	SSE	149	146-155	7.7	Low
	NE	035	025-046	6	Low
Faults – Sinistral	E	100	093-107	20.9	High
	NE	035	030-040	11.1	Low
	ENE	065	060-070	11.1	Low
	ESE	113	107-118	11.1	Low
	SE	130	125-135	11.1	Low
	SE	142	135-148	11.1	Low
	SSE	158	154-163	11.1	Low
	S	170	163-175	11.1	Low
Veins – All	E	083	065-090	12.3	Medium-Low
	NE	038	018-065	9.9	Low
	ESE	108	100-114	9.8	Low
	N	000	350-018	9.4	Low
	SSE	157	148-170	7.2	Low
	SE	130	126-138	6.9	Low
	SE	144	138-148	6.2	Low
Secondary Minerals	SSE	160	152-170	20.1	Medium-High
	N	00	002-024	18.2	Medium-High
	S	178	170-182	15.3	Medium-High
	E	093	084-102	8.1	Medium
	ENE	079	075-084	6.8	Low
	NE	045	041-049	6.7	Low

Joints

A total of 297 joint measurements are recorded in the Basket Lake-Indian Lake West batholith area (Figures 5.2.13a and 5.2.13b), 295 of which include both strike and dip orientation. Joint measurements are distributed across the entire Basket Lake-Indian Lake West batholith area consistent with the observation that joints are a common structural feature at almost all observation locations. The majority of these measurements (283/297, 95%) were made in granite bedrock which is distributed across the entire Basket Lake-Indian Lake West batholith area. Five measurements were made in tonalite gneiss, five in mafic dykes, and four in granodiorite. The analysis of the joint data, presented below, suggests that four main joint sets can be identified for the Basket Lake-Indian Lake West batholith area, including one shallowly dipping set and three steeply dipping sets, trending north, northeast, and east.

The combined joint population is shown on an equal area lower hemisphere stereonet plot and a rose diagram (Figures 5.2.14a and 5.2.14b). The rose diagram shows that the combined joint population is dominated by two, broad, major sets. One trends roughly north-south and includes a main central peak at 173° and two smaller peaks at 155° and 013°, with a total range between 325° and 029°. The majority of joints in this north-striking joint set dip greater than 65° to the east or west. The other is oriented northeast and includes two main peaks at 038° and 048°, and a smaller peak at 064°, with a total range between 029° and 075°. The majority of joints in this northeast-striking joint set dip greater than 65° to the southeast or northwest. A third, but less prominent, steeply dipping joint set exhibits a peak orientation to the east at 084°. The equal area lower hemisphere stereonet plot highlights the fourth, shallowly-dipping (<25°), joint set in the Basket Lake-Indian Lake West batholith area by the central cluster of poles (Figure 5.2.14a).

Separating the joints into their three general dip magnitude bins (shallow, <25°; moderate, 25-65°; steep, >65°) and re-plotting the rose diagrams individually provides a means of further evaluating joint orientation. The shallowly dipping to subhorizontal joint set (<25°) was observed in 51 instances (17%) (Figure 5.2.14c). The shallowly dipping joints exhibit one, broad, northeast-trending set with orientation peaks at 034°, 045°, 055° and 070° within a range between 024° and 076°. Additional minor peaks at 015°, 085°, 155° and 173° highlight the variability in orientation for shallowly dipping joints.

Thirty-six joints (12%) were observed to dip at a moderate magnitude between 25° and 65° (Figure 5.2.14d). The moderately dipping joints exhibit two main narrow peaks striking north-northeast at 013°, ranging between 000° and 028°, and south-southeast at 168°, within a range between 160° and 174°. Additional minor peaks occur within a range between 028° and 102°, with peaks at 056°, 094°, 035° and 075°.

A total of 208 joints (78%) fall into the steeply dipping bin with dip magnitude greater than 65° (Figure 5.2.14e). The steeply dipping joint population exhibits two main joint sets, including one striking roughly north-south with a range between 159° and 204° and with internal peaks at 178° and 012°. The other strikes northeast and exhibits an orientation peak at 040° and ranges between 024° and 058°. Sharp, but minor, orientation peaks are also evident at 125° and 152°.

Joint spacing was assessed by assigning joint sets at the outcrop scale into one of eight spacing bins. An additional category of ‘unknown’ was assigned when joint spacing could not be properly measured, for example due to small outcrop size. The results from this assessment are included shown in a histogram (Figure 5.2.14f) and in Table 5.2.4.2b. Table 5.2.4.2b also separates the joint spacing information by the same dip subsets described above. The orientations of joints for each spacing class are shown in Figure 5.2.14g to Figure 5.2.14n.

Table 5.2.4.2b: Basket Lake–Indian Lake West Batholith Area - Joint Spacing

	All Joints		Steep Dip		Moderate Dip		Shallow Dip	
Spacing Bins (cm)	# of joints	% of joints	# of joints	% of all joints	# of joints	% of all joints	# of joints	% of all joints
<1	1	0.3	1	0.3	0	0.00	0	0.00
1–3	2	0.7	1	0.3	0	0.00	1	0.3
3–10	21	7.1	18	6.1	2	0.7	1	0.3
10–30	39	13.2	30	10.1	2	0.7	7	2.4
30–100	62	21	33	11.2	6	2.0	23	7.8
100–500	89	30.1	62	21.0	15	5.1	12	4.1
500–1000	24	8.1	20	6.8	4	1.4	0	0.00
>1000	11	3.7	11	3.7	0	0.00	0	0.00
Unknown	46	15.6	32	10.8	7	2.4	7	2.4
Total # Joints	295		208		36		51	

Looking at the distribution of spacing for the entire joint dataset, the majority of observed joints exhibit spacing of between 100-500 cm (89; 30%). Including the 62 instances of joints that exhibit 30-100 cm spacing indicates that more than 50% of all joint spacings range between 30 and 500 cm (151/295; 51%). One joint was identified with spacing at less than 1 cm, and only 24 joints (8%) exhibited spacing of 10 cm or less. Joint spacing of 500 cm or greater was observed in 35 (12%) instances.

All spacing bins exhibit a similar variability in joint peak orientation to that of the total joint set. Both the northeast and north orientation peaks, which are the dominant orientations from the total joint set, are well evident in the 30-100 and 100-500 cm joint spacing class (Figure 5.2.14j and 5.2.14k). The north-striking peak is dominant in the 10-30 cm as well as the 500-1000 cm joint spacing class (Figure 5.2.14i and 5.2.14l). The 1 -3 cm joint spacing class exhibits a northwest-trending orientation peak (Figure 5.2.14h), which is less prominent in the combined joint data. Joints spaced 500-1000 cm and >1000 cm show an additional orientation peak trending east-northeast (Figure 5.2.14l and 5.2.14m). The orientation of joints with unknown spacing is variable (Figure 5.2.14n).

The results are also presented for shallow, moderate and steep joint dip subsets (Table 5.2.4.2b), with stated percentages calculated using the total number of joints (295). The majority of shallowly dipping joints (35; 12%) fall into the 30 to 500 cm range in spacing, with few examples exhibiting tighter spacing. Joint spacing for shallowly dipping joints greater than 500 cm are rare due to the scarcity of vertical exposure that would allow the assessment of such wide joint spacing. The majority of moderately dipping joints (21; 7%) exhibit a spacing of 100-500 cm. The steeply dipping joints predominantly exhibit spacing of 100-500 cm, occurring in 62 (21%) instances. Steeply dipping joints also exhibit the majority of very broad spacing, i.e. greater than 500 cm, including 11% of all occurrences.

Overall, the majority of joints observed throughout the Basket Lake-Indian Lake West batholith area are subvertical. A subhorizontal set is observed locally, where vertical relief is present, and is commonly spaced 30-100 cm (Figure 5.2.15a). While most joints are spaced between 30 and 500 cm, several locations in the central and eastern Basket Lake-Indian Lake West batholith area exhibit joint spacing greater than 500 cm (Figure

5.2.15b). Joint spacing under 30 cm (Figure 5.2.15c) occurs locally throughout the Basket Lake-Indian Lake West batholith area, sometimes with multiple, tightly-spaced, joint orientations at a single location (Figure 5.2.15d).

Faults

Thirty-six faults were observed in the Basket Lake-Indian Lake West batholith area, most of which were observed in the northern and central part of the Basket Lake-Indian Lake West area (Figures 5.2.16a and 5.2.16b), with few faults also observed in the southern portion of the area. All fault occurrences were mapped within the granite host rock in the area. The total fault population is dominated by two main orientation peaks trending north-south at 167° and 005° that together define a broad range between 153° and 207° (Figure 5.2.17b). Additional minor peaks are evident at 035°, 130° and 148°. The majority of all faults observed, regardless of orientation, dip steeply (Figure 5.2.17a).

Faults are generally narrow fault planes, millimetre- to centimetre-scale wide, locally with metre-scale damage zones (Figures 5.2.18a to 5.2.18c). Larger fault widths, between 10 and 500 cm, include damage zones characterized by tighter joint spacing. Field observations suggest that the damage to bedrock, primarily in the form of tighter joint spacing or increased number of evident joint orientation families, is generally limited to approximately 15-20 m beyond fault core zones.

Out of the 36 faults observed, 25 (69%) exhibit dextral horizontal offset and nine faults (25%) exhibit sinistral horizontal offset. Slip sense on faults is inferred from offset markers such as quartz and pegmatite veins (Figure 5.2.18b) and curviplanar splays and steps on slickensides (Figure 5.2.18d). Where observed, displacement of markers ranges from 25 to 100 cm. For the other two faults (6%) no offset direction could be determined.

The dextral fault population exhibits a similar pattern as the total fault population with two main orientation peaks trending north-northwest to north at 345° and 005° with a range between 335° and 025° (Figure 5.2.17c). Additional minor peaks are evident at 035°, 127° and 149°. The sinistral fault population exhibits several orientation peaks, including one main orientation trending east-west at 100° and minor peaks at 035°, 065°, 113°,130°, 142°, 158°, and 170°, each representing a single fault (Figure 5.2.17d).

Subhorizontally plunging slickenline lineations were observed on subvertical fault surfaces, including north-striking dextral faults and west-striking sinistral faults (Figure 5.2.17e). At some locations both dextral north-northwest and sinistral east-striking faults are observed (Figure 5.2.16a). These observations suggest that faults are primarily strike-slip in character and that some of the fault structures may have formed as a conjugate set under broadly northeast-southwest oriented horizontal shortening.

Faults are locally coated with chlorite, hematite, quartz, epidote or infilled with minor breccia (Figure 5.2.18a). Secondary minerals associated with fault zones are summarized in Section 5.2.4.3 below.

Veins

There were 41 observations of veins made in the Basket Lake-Indian Lake West batholith area. Vein occurrences cluster in the southeast and northeast of Basket Lake, and northwest and east of Mameigwess Lake (Figures 5.2.19a and 5.2.19b). Strike and dip information was measured for all 41 vein occurrences (Figure 5.2.20a). The total vein population exhibits a wide spread of orientations, with one slightly dominant peak trending east at 083°, and additional peaks at 000°, 038°, 108°, 130°, 144° and 157°. The latter two, combined, define a range between 138° and 170° (Figure 5.2.20b). Veins are primarily steeply dipping, with only few moderately to shallowly dipping occurrences (Figure 5.2.20a).

In 39 instances the observed vein is interpreted as extensional in nature (Figure 5.2.20c). These veins range mostly between one and 30 cm in width in 35 instances, while the other four extensional veins measure greater than 30 cm in width. Extensional veins are in some cases observed to terminate by thinning at their tips (Figure 5.2.20c). One, less than three cm wide, shear-related vein was observed. In one other instance, no genetic association was determined for the observed vein. Vein contacts with the surrounding bedrock are consistently intact and exhibit no evidence of brittle reactivation.

The most common vein infilling material observed is pegmatite, in 38 out of 41 instances (Figure 5.2.20d). In one of these instances magnetite and garnet were also identified as accessory minerals within the pegmatite. Multiple pegmatite vein orientations were commonly observed to occur at a single outcrop (Figures 5.2.19a and 5.2.19b). The pegmatite veins exhibit mutually cross-cutting relationships, without any systematic pattern. Veins with pegmatite fill are described in further detail with regard to their distribution, lithological association and structure in Section 5.4.2. Additional secondary minerals observed within veins include one instance of quartz infill and two instances where the infilling material was unidentifiable. Secondary minerals associated with all fracture types, including the 3 non-pegmatite filled veins, are described below in Section 5.2.4.3.

5.2.4.3 Secondary Minerals and Alteration

Evidence of secondary mineral infilling within, and alteration in the wall rock adjacent to, fractures was documented during mapping of the Basket Lake-Indian Lake West batholith area (Figures 5.2.21a and 5.2.21b). The most common secondary minerals observed across all fracture types combined (297 joints + 36 faults + 3 veins; N = 336) include quartz (five occurrences; 1.5%) and hematite (four occurrences; 1%) (Table 5.2.4.3a). In addition, two occurrences each of breccia and epidote, and one occurrence each of magnetite, feldspar, chlorite and bleaching, were observed. These five infill types are collectively referred to as ‘other’ in Table 5.2.4.3a and on Figures 5.2.21a, 5.2.21b and 5.2.22. A total of 322 fractures (96%) were observed to be unfilled in the Basket Lake-Indian Lake West batholith area. Note that in some instances more than one infilling mineral was identified within a single fracture. Quartz was observed in association with epidote in one instance, and chlorite and epidote were each observed in association with hematite in one instance (Figure 5.2.23a). In one instance, a bleached margin was identified around a fracture and is attributed to silicification.

The combined population of joints, faults, and veins that exhibit secondary mineral infill and wall rock alteration show that the filled structures are consistently steeply dipping and predominantly trend northerly (Figures 5.2.22a and 5.2.22b). The combined population is dominated by one, broad, roughly north-trending orientation that ranges between 332° and 024°, with internal peaks at 340°, 358° and 010°. Additional minor peaks are evident at 045°, 079° and 093° (Figure 5.2.22b).

Table 5.2.4.3a: Basket Lake-Indian Lake West Batholith Area Joints, Faults and Veins (Combined) - Secondary Mineral Infills and Alteration

Mineral Phase/ Alteration	All Occurrences	% of total
Quartz	5	1.34
Hematite	4	1.07
Other	9	2.12
None	322	86.1
Total # of fractures	**374**	

Table 5.2.4.3b below provides an overview of the types and number of joints with associated secondary minerals or wall rock alteration in the Basket Lake-Indian Lake West area. Almost all of the recorded joints (291/297; 98%) are identified as being unfilled. A small number (2; 0.7%) are filled by quartz. Hematite and feldspar infill each occur at a single joint (0.3%). Bleaching was identified around one joint (0.3%). The bleaching is interpreted as an effect of silicification of the wall rock around the joint. Note that hematite as a secondary mineral also occurs as hematite staining of quartz crystals, tinting the overall rock mass darker orange-red. Mineral infill is observed only in joints with a steep dip.

Table 5.2.4.3b: Basket Lake-Indian Lake West Batholith Area Joints - Secondary Mineral Infills and Alteration

Mineral Phase/ Alteration	All Occurrences	% of total	Steep Dip	Moderate Dip	Shallow Dip
Quartz	2	0.67	2	0	0
Hematite	1	0.34	1	0	0
Bleaching	1	0.34	1	0	0
Feldspar	1	0.34	1	0	0
None	291	97.98	203	36	51
Total # of joints	297	100	208	36	51

Table 5.2.4.3c below provides an overview of the types and number of faults with associated secondary minerals or wall rock alteration in the Basket Lake-Indian Lake West area. The majority of the observed faults (29/36; 81%) are unfilled. Hematite is the most common infill mineral of faults in the Basket Lake-Indian Lake West area with three occurrences (8%) (Figure 5.2.23b). Quartz and epidote infill each occurs in two (6%) instances. Two faults (6%) are associated with breccia. One fault (3%) has a chlorite coating on the slip surface.

Table 5.2.4.3c: Basket Lake-Indian Lake West Batholith Area Faults - Secondary Mineral Infills and Alteration

Mineral Phase/ Alteration	All Occurrences	% of total
Hematite	3	8.33
Quartz	2	5.56
Epidote	2	5.56
Breccia	2	5.56
Chlorite	1	2.78
None	29	80.5
Total # of faults	**36**	

Evidence of secondary mineral infilling and wall rock alteration associated with veins was also documented during the mapping. Table 5.2.4.3d below provides an overview of the types and number of vein infill occurrences encountered in the Basket Lake-Indian Lake West batholith area. Of the three observed veins, one is infilled with quartz and two veins have unknown infill. Note that the majority of the veins (38/41, 92.7%) are joints with pegmatite fill. These granitic-filled veins are discussed later in the report in Section 5.4.2 on felsic dykes.

Table 5.2.4.3d: Basket Lake-Indian Lake West Batholith Area Veins - Secondary Mineral Infills and Alteration

Mineral Phase/ Alteration	All Occurrences	% of total
Quartz	1	2.40
Other	38	92.7
Unknown	2	4.80
Total # of veins	**41**	

5.3 Indian Lake East Batholith Area

The Phase 2 Detailed Geological Mapping area in the Indian Lake East batholith encompasses the entire Indian Lake East batholith withdrawal area and extends slightly beyond the withdrawal area boundaries to the northwest and southeast. A total of 182 stations were visited in the Indian Lake East batholith area (Figure 5.3.1).

5.3.1 Accessibility and Surface Constraints

The Indian Lake East batholith area is easily accessed via a network of logging and general use roads extending eastward and westward from Highway 599 to the northeast of Ignace. The easternmost part of the Indian Lake East batholith area is accessed via a system of logging roads to the east of Ignace that extend northwards from the Trans-Canada Highway. These roads in the Indian Lake East batholith area are generally in good condition and accessible using a 4X4 vehicle (Figure 5.3.2a). In few cases, overgrown older logging roads and clear cut areas were traversed by foot.

The shorelines of Cecil Lake (Figure 5.3.2b) and Ken Lake, as well as the river system to the north of Ken Lake, were used to access mapping traverses by boat.

Topography is generally subdued with small ridges of up to several metres in vertical relief occasionally encountered (Figure 5.3.2c). Notable exceptions include the area to the southwest of Cecil Lake, as well as a north-trending topographic ridge that defines the eastern shore of Cecil Lake. The eastern shoreline of the river system north of Ken Lake also displays several metres of vertical topographic relief.

5.3.2 Bedrock Exposure and Overburden Thickness

The Indian Lake East batholith area is covered by an irregular blanket of overburden. A large number of predicted locations of exposed bedrock were identified for this area; however, a high proportion of these were found upon visual inspection to be overburden covered (Figure 5.3.1). Out of the 184 total stations visited, 108 were positively identified as exposed bedrock (59%), while 76 were found to be overburden covered (41%).

Average (estimated) overburden thickness around the edges of exposed bedrock outcrop varies between 0.3 and 1 m. Bedrock outcrops are often coated in several centimetres to decimetres of moss and lichen (Figure 5.3.2c). A large, low-lying area southeast of Cecil Lake is largely overburden covered, with overburden thickness generally greater than 1 m, and virtually no predicted outcrops. Traverses through this area confirmed the predicted lack of exposed bedrock. Large areas west of Highway 599 are flat-lying and covered in sand (Figure 5.3.2d).

5.3.3 Lithology and Physical Character

The descriptions below, and Table 5.3.3, provide an overview of the lithological and physical character of the main and minor bedrock lithology types observed in the Indian Lake East batholith area, in decreasing order of abundance.

Two main lithological units are observed in the Indian Lake East batholith area including: granite and tonalite gneiss (Figure 5.3.3). The character and distribution of minor lithological units (Figure 5.3.4), including mafic metavolcanic rocks and granodiorite are described in Section 5.3.3.4. Dykes of mafic and intermediate to felsic composition, also observed in the Indian Lake East batholith area, and are discussed separately in Section 5.4.

Table 5.3.3: Summary of Lithological Units in the Indian Lake East Batholith Area.

Lithological Unit	# of Occurrences (% of bedrock stations)	Fabric	Magnetic Susceptibility (mean SI)	Gamma Spectrometry (average)	Strength
Granite	106 (98%)	Massive to moderately foliated	$2.91\pm2.60 \times10^{-3}$	K = 3.85±0.66 % U = 7.38±5.56 ppm Th = 36.67±11.9 ppm	R5/R6
Tonalite Gneiss	9 (8%)	Foliated to gneissic	$11.2\pm12.26 \times10^{-3}$	K = 2.42±1.29 % U = 4.31±1.85 ppm Th = 21.01±13.5 ppm	R5
Mafic metavolcanic rocks	12 (11%)	Strongly foliated to gneissic	$8.3\pm10.44 \times10^{-3}$	K = 2.03±1.16 % U = 2.93±1.69 ppm Th = 11.48±6.50 ppm	N/A
Granodiorite	2 (2%)	Massive to weakly foliated	$0.28 – 5.10 \times10^{-3}$	K = 1.2 – 2.7 % U = 0.90 – 22.0 ppm Th = 10.4 – 26.0 ppm	N/A

5.3.3.1 Granite

Granite is by far the predominant lithology and is uniformly distributed across the entire Indian Lake East batholith area (Figure 5.3.3), occurring at 106/108 (98%) bedrock observation locations. Granite is identified as the main lithology in 103/106 (97%) occurrences where it usually represents more than 90% of the outcrop area. These main occurrences are distributed throughout the entire central part of the Indian Lake East batholith area. In the remaining three instances, granite occurs as a minor lithology covering less than 30% of the outcrop area. These minor occurrences are distributed along both the southwestern and northeastern margins of the Indian Lake East batholith area. Locally, along the northeastern margin of the Indian Lake East batholith area, granite also occurs as veins and dykes intruding into gneissic tonalite. The contacts between the granite, including where it occurs as veins and surrounding bedrock units, are primarily intact and exhibit no evidence of brittle deformation. However, in one instance, it is noted that hematite staining is identified within and around a joint observed at the contact between the granite and a tonalite gneiss xenolith. A total of 107 representative rock samples of the granite unit were collected from the Indian Lake East batholith area.

The granite unit usually exhibits a pink colour when fresh and a pink to light grey, off white or beige colour when weathered (Figure 5.3.5a). Most commonly the granite is medium-grained (1-5 mm) and inequigranular in texture. Locally, examples of fine-grained, coarse-grained and extremely coarse-grained granite are observed; medium-grained to very coarse-grained alkali feldspar phenocrysts are common. Main matrix mineral phases within the granite are quartz, plagioclase, alkali feldspar and biotite (Figure 5.3.5b). Magnetite is the most common accessary mineral, along with lesser epidote.

The granite is predominantly characterized as massive. A primary igneous layering is identified in seven instances by gradational contacts between fine and medium-grained portions of the granite. These layers are several centimetres to a metre in thickness and of variable orientation. In 30 locations the granite exhibits a weak to moderately well-developed foliation. Out of a total of 96 field estimates of intact rock strength, the granite exhibited a very strong (R5) character in 73 instances (76%) and an extremely strong (R6) character in 23 instances (24%).

The granite has a moderately high magnetic susceptibility (mean = 2.91±2.60 x10^{-3} SI, N=146) ranging between 0.09 and 14.7 x10-3 SI, with 50% of the readings between 0.89 and 4.4 x10^{-3} SI (Figure 5.3.5c). The higher magnetic susceptibility values recorded for the granite is attributed to the local presence of accessory magnetite. The gamma ray spectrometry readings (Figure 5.3.5d) for the granite, including 118 sets of measurements, show the following characteristics:

- Total count is on average 189.3±52.5 cps and ranges between 70.4 and 510.3 cps.
- Potassium content is on average 3.85±0.66% and ranges between 1.9 and 6.8%.
- Uranium content is on average 7.38±5.56 ppm and ranges between 0.7 and 51.1 ppm.
- Thorium content is on average 36.67±11.90 ppm and ranges between 1.0 and 63.8 ppm.

5.3.3.2 Tonalite Gneiss

Tonalite gneiss (encompassing tonalite gneiss, granite gneiss and unsubdivided gneiss) is observed at nine bedrock observation locations (9/108; 8%), primarily across the northern and southern margins of the Indian Lake East batholith area to the north and south of the granite (Figure 5.3.3). Tonalite gneiss constitutes over 60% of the outcrop area in four of these locations. At five additional locations, tonalite gneiss comprises less than 30% of the outcrop area, commonly as metre-scale xenoliths within the granite. The contacts between the tonalite gneiss and surrounding granite, where observed, are primarily sharp and intact and exhibit no evidence of brittle deformation. However, as noted above, hematite staining is identified within and around one joint observed at the contact between the granite and a tonalite gneiss xenolith. A total of five representative rock samples of the tonalite gneiss were collected from the Indian Lake East batholith area.

The tonalite gneiss is dark grey to grey or pink when fresh and usually is light or dark grey when weathered (Figure 5.3.6a). The tonalite gneiss is generally medium-grained (1-5 mm) but its grainsize does vary slightly. Biotite, plagioclase and quartz are the primary mineralogical components of the tonalite gneiss (Figure 5.3.6b). Alkali feldspar occurs rarely as an accessory mineral phase. The gneiss is foliated to gneissic in texture. Foliation is defined by the alignment of planar biotite minerals or gneissic banding. All six field estimates of rock hardness for the tonalite gneiss yielded a very strong (R5) character.

The tonalite gneiss has a relatively high magnetic susceptibility (mean = 11.2±12.26 x10^{-3} SI, N=8) and ranging between 0.28 and 38.8 x10^{-3} SI with 50% of the readings between 4.2 and 14.7 x10^{-3} SI (Figure 5.3.6c). The higher magnetic susceptibility values recorded for the tonalite is attributed to the local presence of accessory magnetite. One anomalously high magnetic susceptibility measurement, from a tonalite gneiss occurrence in the northeastern corner of the Indian Lake East batholith area, was taken in close proximity to a fault with epidote infilling and hematite alteration in the surrounding wall rock.

The gamma ray spectrometry readings (Figure 5.3.6d) for the tonalite gneiss, including eight sets of measurements, show the following characteristics:

- Total count is on average 111.4±55.6 cps and ranges between 51.4and 237 cps.
- Potassium content is on average 2.42±1.29% and ranges between 1.2 and 4.7%.
- Uranium content is on average 4.31±1.85 ppm and ranges between 2.3 and 7.9 ppm.
- Thorium content is on average 21.01±13.52 ppm and ranges between 8.4 and 52.9 ppm.

5.3.3.3 Minor Lithological Units

Additional minor lithological units identified in the Indian Lake East batholith area include mafic metavolcanic rocks and granodiorite (Figure 5.3.4 and Figure 5.3.7a and 5.3.7b). These rock types were primarily observed as xenoliths within one of the main lithological units described above. Only general descriptions are included for these minor lithological units due to their limited occurrence within the Indian Lake East batholith area.

Mafic metavolcanic rocks

Mafic metavolcanic rocks are identified at 12 bedrock observation locations (11%) in the Indian Lake East batholith area (Figure 5.3.6). The mafic metavolcanic rock unit includes two mafic sub-types, including amphibolite gneiss which was noted in 11 instances and a mafic volcanic unit in one instance (Figure 5.3.7c). The amphibolite gneiss occurrences of the mafic metavolcanic rock unit occur as metre-scale xenoliths occupying less than 30% an outcrop area. These occurrences are distributed primarily along the northeastern and southwestern margins of the Indian Lake East batholith area, in the vicinity of the contact between the granite and the tonalite gneiss. The mafic volcanic sub-unit occurs as an eight by ten metre wide xenolith with highly altered epidotized pillow cores. This one occurrence is observed in the northwest corner of the Indian Lake East batholith area. The mafic metavolcanic rock xenoliths exhibit sharp and intact contacts with the surrounding granite bedrock. There is no evidence for brittle deformation localized along these contacts. A total of seven representative rock samples of the mafic metavolcanic rock unit (only the amphibolite gneiss component) were collected from the Indian Lake East batholith area.

The mafic metavolcanic rocks are black to dark grey when fresh and when weathered (Figure 5.3.7a). They exhibit a fine- to medium-grained and variable equigranular to inequigranular matrix. Plagioclase, biotite, hornblende and quartz represent the main mineralogical components of both mafic metavolcanic rocks sub-units. These minerals define the strongly foliated to gneissic internal fabric that is characteristic of the amphibolite gneiss sub-unit.

The mafic metavolcanic rocks have a relatively high magnetic susceptibility (mean = 8.3±10.44 x10^{-3} SI, N=10) and ranging between 0.34 and 34.9 x10^{-3} SI. The one anomalously high magnetic susceptibility measurement is from mafic metavolcanic rock occurrence north of Cecil Lake. The gamma ray spectrometry readings for the mafic metavolcanic rocks, including 9 sets of measurements, show the following characteristics:

- Total count is on average 73.27±36.1 cps and ranges between 27.3 and 660.3 cps.

- Potassium content is on average 2.03±1.16% and ranges between 0.9 and 4.4%.
- Uranium content is on average 2.93±1.69 ppm and ranges between 0.7 and 4.7 ppm.
- Thorium content is on average 11.48±6.50 ppm and ranges between 3.3 and 23.7 ppm.

Granodiorite

Granodiorite occurs at two bedrock observation locations (2%), primarily along the northeastern margin of the mapped portion of the Indian Lake East batholith area. Where it does occur, it represents 60% or more of the outcrop, however the limited number of occurrences classifies it as a minor lithological unit. The granodiorite is cross-cut by granite dykes at one station. A total of three representative rock samples of the granodiorite were collected from the Indian Lake East batholith area.

The granodiorite is light grey to pink or beige on both fresh and weathered surfaces (Figure 5.3.7b). The granodiorite matrix is consistently medium-grained (1-5 mm) and locally includes very coarse-grained quartz phenocrysts. Both equigranular and inequigranular examples are observed. Quartz, alkali feldspar, plagioclase and biotite are the primary mineralogical components of the granodiorite. The granodiorite predominantly exhibits a massive character.

Four measurements of magnetic susceptibility of the granodiorite are 0.28, 0.68, 2.20 and 5.10×10^{-3} SI, reflecting its moderate magnetic susceptibility. The five gamma ray spectrometry readings for the granodiorite yielded a total count response that ranged between 50.5 and 215.4 cps, potassium content between 1.2 and 2.7%, uranium content between 0.90 and 22.00 ppm, and thorium content between 10.4 and 26.0 ppm.

5.3.3.4 Summary of Lithology

Granite is by far the predominant main lithology and is uniformly distributed across the entire Indian Lake East batholith area. Tonalite gneiss is common only along the northeastern and southwestern margins of the mapped area. The tonalite gneiss varies in its type of occurrence from being the main component at bedrock observation locations to occurrences as metre-scale xenoliths within the surrounding granite host rock. Minor metre-scale mafic metavolcanic rock xenoliths occur predominantly along the northeastern and southwestern margins of the Indian Lake East batholith area in the vicinity of the contact between the granite and the tonalite gneiss.

The Indian Lake East batholith area surrounding Cecil Lake was previously mapped as massive granodiorite to granite at a reconnaissance scale, and as quartz diorite to quartz monzonite in the 1:126 000 scale map (Sage et al., 1974). The detailed mapping confirmed the lithologies identified in reconnaissance-scale mapping, as the area was found to be comprised primarily of granite, with minor granodiorite and increasing pegmatite segregations, gneissic enclaves, and dykes towards the north and south margins.

5.3.4 Structure

Structures in the Indian Lake East batholith area, including features associated with both ductile and brittle deformation processes, are described below. Secondary mineralization, in the form of fracture infilling mineral phases and wall rock alteration, are also discussed below.

5.3.4.1 Ductile Structure

Ductile structural features observed in the Indian Lake East batholith area comprise various types of penetrative planar fabrics, including igneous flow foliation and tectonic foliation, as well as localized ductile and brittle-ductile shear zones. These structural features are described in detail below. Linear structures associated with these ductile planar structures are also described below, where applicable.

Orientation information is summarized in Table 5.3.4.1 for the ductile structures described below. This information is based on the analysis of the data-specific rose diagrams. A degree of confidence is provided for each orientation peak identified based on the frequency of that orientation within the dataset.

Table 5.3.4.1: Summary of Ductile Structures in the Indian Lake East Batholith Area

Structure Type	Orientation Family	Peak (degrees)	Range (degrees)	Frequency (%)	Confidence
Foliation - All	E	080	064-092	18.4	High
	NE	056	048-064	12.6	Medium-high
	ESE	103	092-124	9	Medium
Igneous Flow foliation	ENE	078	062-093	18.5	High
	ESE	110	093-125	11.5	Medium
	ENE	057	048-062	11.5	Medium
Shear Zones – All	NE	045	036-057	34.5	High
	SE	145	140-150	15.4	Medium
	E	083	075-095	12.2	Medium
	ENE	064	057-075	9.2	Low
	NNE	020	017-023	8.7	Low

Foliation

The two main types of foliation recognized in the Indian Lake East batholith area are igneous flow foliation and tectonic foliation (Figure 5.3.8). Overall, 87 foliation measurements were recorded in the Indian Lake East batholith area, 81 of which are recorded with both strike and dip information (Figure 5.3.9a and 5.3.9b). A total of 44 of these are igneous flow foliation (Figure 5.3.9c), 41 of which contain both strike and dip information, and 39 are tectonic foliation, 35 of which contain both strike and dip information. Subordinately, gneissic layering is observed at five locations within tonalite gneiss xenoliths (Figure 5.3.9a).

The combined foliation population is dominated by one main orientation peak trending east at 080°, with adjacent peaks at 056° and 103° (Figure 5.3.9b). Together these data define a broad range in foliation orientation between 048° and 124°. The majority of the foliation planes dip steeply to moderately towards the north or south. A broad, south-striking and west plunging, girdle pattern defined by the distribution of poles to foliation may suggest open folding about an easterly plunging axis (Figure 5.3.9a).

Igneous flow foliation is the most common planar fabric type observed throughout the Indian Lake East batholith area. It is generally weakly to moderately developed, defined primarily by aligned feldspar phenocrysts, and occurs throughout the granite (Figure 5.3.12a). The igneous flow foliation population exhibits one main, broad, orientation peak trending east-northeast at 078°, with one less prominent peak on its shoulder at 057°, and ranging between 048° and 093°. A second orientation peak is evident trending east-southeast at 110° (Figure 5.3.9c). Dip varies mostly between 60° and 90°, although several shallowly dipping occurrences are also documented (Figure 5.3.9a). Igneous flow foliation is not observed to be associated with mineral lineation.

Tectonic foliation occurs throughout the Indian Lake East batholith area (Figure 5.3.8). It is weakly to moderately developed in the granite, and strongly developed in tonalite gneiss and mafic metavolcanic rock xenoliths (Figure 5.3.12b). The tectonic foliation population exhibits dominant orientation peaks trending northeast and east at 054° and 083°, and lesser peaks at 026°, 100° and 162° (Figure 5.3.9d). Tectonic foliation is mostly steeply dipping (Figure 5.3.9a). Mineral lineation associated with the planar tectonic foliation is rare. Two mineral lineations were measured in the Indian Lake East batholith area. One plunges subhorizontally towards the south-southeast (155/03) and the other plunges steeply to the north-northeast (028/78).

Additional, less common, foliation types observed in the Indian Lake East batholith area include four instances of gneissic layering observed in tonalite gneiss xenoliths. The gneissic layering is highly variable in orientation (Figure 5.3.8) suggesting rotation of the hosting xenoliths. In places, gneissic layering is also folded within the xenoliths.

Massive (unfoliated) bedrock, indicated by bedrock stations with no foliation measurements, occurs in the central western in portion of the Indian Lake East batholith area (Figure 5.3.8).

Shear Zones

A total of 11 shear zones were measured throughout the Indian Lake East area, 10 of which are characterized as ductile shear zones and one as a brittle-ductile shear zone. The majority of shear zone observations are documented in the western portion of the mapping area, clustering near Highway 599 and south of Cecil Lake (Figure 5.3.10). The ductile shear zones are all identified in the granite. The single brittle-ductile shear zone is found within a mafic metavolcanic rock xenolith.

The combined ductile and brittle-ductile shear zone population is dominated by one orientation peak trending northeast at 045°, with several less prominent orientation peaks at 020°, 064°, 083° and 145° (Figures 5.3.11a and 5.3.11b). All observed shear zones are steeply dipping (Figure 5.3.11a).

Two of the ductile shear zones are dextral, steeply dipping and east-northeast striking (Figure 5.3.11c). These two shear zones are located in the west and southwest of the Indian Lake East batholith area (Figure 5.3.10). The majority of the ductile shear zones display unknown slip direction (Figure 5.3.11c). The ductile shear zones are generally between 1 and 50 cm in width (Figure 5.3.12d and 5.3.12e). Chlorite and hematite mineral infill are associated with two of the 11 shear zones (Figure 5.3.12d). Several of the shear zones are also overprinted by tightly spaced joints. No linear fabric is associated with the observed shear zones.

One brittle-ductile sinistral shear zone is located in the southwest of the Indian Lake East batholith area (Figure 5.3.10). The brittle-ductile shear zone strikes southeast and dips moderately (Figure 5.3.11d). Markers on either side of the 25 cm wide zone of highest strain indicate approximately 40 cm of sinistral offset.

5.3.4.2 Brittle Structure

Fractures, including joints, veins and faults are the predominant brittle structures observed throughout the Indian Lake East batholith area. A total of 281 fracture measurements were made across the 108 bedrock stations in the mapped area. These include 263 joints, nine veins and nine faults. The characteristics of each of these fracture types are described below. The secondary mineral infillings and linear structure that accompany some veins and faults are also described in this section.

Orientation information is summarized in Table 5.3.4.2a for the brittle structures described below. This information is based on the analysis of the data-specific rose diagrams. A degree of confidence is provided for each orientation peak identified based on the frequency of that orientation within the dataset.

Table 5.3.4.2a: Summary of Brittle Structures in the Indian Lake East Batholith Area

Structure Type	Orientation Family	Peak (degrees)	Range (degrees)	Frequency (%)	Confidence
Joints – All	NE	043	033-045	8.7	Medium-Low
	NE	047047	045-062	8.6	Medium-Low
	SSE	152	140-160	7.6	Low
	NNE	027	018-033	7.1	Low
	N	007	356-018	6.8	Low
	E	090090	078-115	6.3	Low
	SSE	167	160-175	6	Low
	ENE	070	062-078	5.6	Low
Joints - Shallow	ENE	060	049-077	12.8	Medium-Low
	NE	043	034-049	11.4	Medium-Low
	N	005	355-020	10.6	Medium-Low
	NNE	028	020-034	8.3	Low
	SE	142	136-148	6.9	Low
	E	087	077-107	6.7	Low
Joints - Moderate	NE	040/	023-046	13.4	Medium
	NNE	013	000-023	12.7	Medium
	NE	052	046-063	9.3	Medium-Low
	ENE	072	063-086	9.1	Medium-Low
	E	099	086-117	6.2	Low
	SSE	169	162-174	5.9	Low
Joints – Steep	NE	048048	035-060	–9.5	Medium-Low
	SSE	152	140-162	9.2	Medium-Low
	NNE	025	015-035	7.1	Low
	SSE	164	162-176	6.7	Low
	E	088088	078-100	6.6	Low
Faults - All	ESE	110	102-114	22.7	Medium
	E	098	090-102	16.8	Medium-Low
	ENE	074074	070-084	13.5	Low
	SE	140	135-145	13.5	Low
	N	006	002-008	10.6	Low
Veins – All	ENE	060	055-075	23.5	Medium
	SE	145	140-150	16.8	Medium-
	N	000	356-004	12.4	Low
	E	098	094-102	12.4	Low

	ESE	112	108-116	12.4	Low
Secondary Minerals - All	N	008008	357-018	11	Medium-Low
	SE	142142	119-153	10.7	Medium-Low
	S	170	164-178	9.2	Low
	NE	047	025-053	9.1	Low
	ENE	060	053-073	9.1	Low
	E	097	091-103	7	Low

Joints

A total of 263 joint measurements are recorded for the Indian Lake East batholith area (Figures 5.3.13 and 5.3.14). Joint measurements are distributed across the entire mapped area consistent with the observation that joints are a common structural feature at almost all bedrock observation locations. The majority of these measurements (244/263; 93%) are from within the granite. The remaining joints (19/263; 7%) are distributed between the tonalite gneiss, mafic metavolcanic rocks and granodiorite. The analysis of the joint data, presented below, suggests that four main joint sets can be identified for the Indian Lake East batholith area, including one shallowly dipping set and three steeply dipping sets, trending northeast, south-southeast, and east.

The combined joint population is shown on an equal area lower hemisphere stereonet plot and rose plot (Figures 5.3.14a and 5.3.14b). The rose diagram for the combined joint population includes two broad sets. One trends broadly north-northeast to northeast and ranges between 018° and 062°, with internal orientation peaks at 027°, 043° and 047°. Another trends south-southeast and ranges between 140° and 175°, with internal peaks at 152° and 167°. Additional less prominent peaks in the combined joint population are evident at 007°, 070° and 090°. The majority of all joints dip either steeply or shallowly.

The rose diagram for the entire joint population does not distinguish the steeply dipping joint sets as clearly as the stereonet, because of the inclusion of the strikes for the shallowly and moderately dipping joints in the composite rose plot (Figure 5.3.14b). Separating out the joint data by their dip magnitude (shallow, <25°; moderate, 25°-65°; steep, >65°) and re-plotting the rose diagrams individually provides a means of further evaluating joint orientation sets. The shallowly dipping joint set was measured in 45 instances (17%) (Figure 5.3.14c). The shallowly dipping joint set exhibits a broad orientation peak that ranges between 020° and 077°, with internal peaks at 028°, 043° and 060°. Additional peaks are also evident at 005°, 087° and 142°.

Forty joints (15%) were observed to dip at a moderate magnitude between 25° and 65°. The moderately dipping joint sets exhibits two main orientation peaks trending north-northeast and northeast at 013° and 040°, ranging between 000° and 046°. Additional minor peaks are also evident at 072°, 052°, 099°, and 169°.

A total of 178 joints (64%) fall into the steeply dipping bin with dip magnitude greater than 65° (Figure 5.3.14e). The steeply dipping joint population exhibits two broad orientation peaks. One trends north-northeast to northeast and ranges between 015° and 060°, with internal peaks at 025° and 048°. The other broad peak trend south-southeast and ranges between 140° and 176°, with internal peaks at 152° and 164°. One additional, less prominent, peak is evident trending east at 088°.

Joint spacing was assessed by assigning joint sets at the outcrop scale into one of eight spacing bins (Table 5.3.4.2). An additional option of 'unknown' was assigned when joint spacing could not be properly measured, for example due to small outcrop size. The results from this assessment are included shown in a histogram (Figures

5.3.14f) and in Table 5.3.4.2b. Table 5.3.4.2b also separates the joint spacing information by the same dip subsets described above. The orientations of joints for each spacing class are shown in Figures 5.3.14g to 5.3.14n.

Table 5.3.4.2b: Indian Lake East Batholith Area - Joint Spacing

	All Joints		Steep Dip		Moderate Dip		Shallow Dip	
Spacing Bins (cm)	# of joints	% of joints	# of joints	% of all joints	# of joints	% of all joints	# of joints	% of all joints
<1	0	0.0	0	0.0	0	0.0	0	0.0
1–3	1	0.4	1	0.4	0	0.0	0	0.0
3–10	9	3.4	7	2.7	0	0.0	2	0.8
10–30	28	10.6	21	8.0	2	0.8	5	1.9
30–100	48	18.3	26	9.9	7	2.7	15	5.7
100–500	100	38.0	61	23.2	19	7.2	20	7.6
500–1000	26	9.9	21	8.0	5	1.9	0	0.0
>1000	23	8.7	18	6.8	3	1.1	2	0.8
Unknown	28	10.6	23	8.7	4	1.5	1	0.4
Total # Joints	263		178		40		45	

Looking at the distribution of spacing for the entire joint dataset, the majority of observed joints exhibit spacing of between 100 and 500 cm (100; 37%). Including the 51 instances of joints that exhibit 30-100 cm spacing indicates that more than 50% of all joint spacings range between 30 and 500 cm (151/270; 56%). No joints were identified with spacing at less than 1 cm, and only 10 joints (4%) exhibited spacing of 10 cm or less. Joint spacing of 500 cm or greater was observed in 49 (19%) instances.

All spacing bins exhibit a similar variability in joint peak orientation to that of the total joint set. The northeast-trending orientation peaks are well evident in the 30 – 100 cm, 100 – 500 cm, and unknown joint spacing classes (Figures 5.1.14j, 5.3.14k, and 5.3.14n). The southeast-trending orientation peaks show as dominant peaks in the 3-10 cm, 10-30 cm, as well as the 30-100 cm joint spacing classes (Figures 5.3.14h, 5.3.14I, and 5.3.14j). A north- to north-northeast trending peak is evident in the 100-500 cm, 500-1000 cm, and >1000 cm joint spacing classes (Figures 5.3.14k, 5.3.14l, and 5.3.14m).

The results are also presented for shallow, moderate and steep joint dip subsets (Table 5.3.4.2b), with stated percentages calculated using the total number of 263 joints. The majority of shallowly dipping joints (35; 13%) fall into the 30–500 cm range in spacing, with few examples exhibiting tighter or broader spacing. The majority of moderately dipping joints (19; 7%) exhibit spacing of between 100 and 500 cm. The steeply dipping joints predominantly exhibit spacing of 100-500 cm, occurring in 61 instances (23%). Steeply dipping joints also exhibit the majority of very broad spacing, i.e. greater than 500 cm, including 15% of all occurrences.

Overall, the majority of joints observed throughout the Indian Lake East batholith area are subvertical in orientation. A subhorizontal set is observed locally, where vertical relief is present, and is commonly spaced 100-500 cm apart (Figure 5.3.15a). While most joints are spaced between 30 and 500 cm, several locations in the southern portion of the mapped area show spacings between steeply dipping joints at greater than 500 cm (Figure 5.3.15b). Joint spacing under 30 cm (Figure 5.3.15c) occurs locally throughout Indian Lake East batholith area, especially in the southwest and northeast corners. It is also worth noting that it is common for more than one joint orientation to occur at a single station (Figure 5.3.15d).

Faults

Nine faults were observed in the Indian Lake East batholith area, including three instances at locations along the central portion of the western shoreline of Cecil Lake and two instances near the central portion of the eastern shoreline of Cecil Lake, one on the northern shoreline of Cecil Lake, two on the river system north of Ken Lake, and one in the western portion of the Indian Lake East area (Figure 5.3.16). All nine fault occurrences were mapped within the granite.

Fault zones are characterized by metre-scale wide concentrations of tightly spaced individual fault surfaces that range from less than 1 to 3 cm in width (Figure 5.3.18a). There was often little indication of any broader damage to the surrounding host rock than the discrete fault planes observed and closely spaced jointing (Figure 5.3.18b). In addition, there was no slickenline development identified for any of these fault structures. Overall there is no visible damage to the bedrock beyond about 15 to 20 m from the center of any observed fault zone.

Poles to the fault planes and the corresponding rose diagram of fault strikes are shown in Figures 5.3.17a and 5.3.17b. The combined fault population exhibits one dominant east-trending orientation peak that ranges between 090° and 114°, with internal peaks at 098° and 110°. Adjacent but distinct peaks are evident trending east-northeast at 074° and southeast at140°. One additional north-trending peak is evident at 006° (Figure 5.3.17b).

Eight faults striking mostly east-southeast are interpreted, based on visual observation of offset markers, as dextral faults. For one northwest-southeast striking fault, no offset direction could be determined.

Faults are locally coated with quartz, feldspar or carbonate. Secondary minerals associated with fault zones are summarized in Section 5.3.4.3 below.

Veins

There are nine observations of veins in the Indian Lake East batholith area (Figure 5.3.19). Five of the vein occurrences are distributed along the northern lithological boundary between the granite and the adjacent tonalite, and the other four are distributed through the middle of the mapped area, within the granite. One vein occurrence is at the same outcrop as an observed fault, along the western shoreline of Cecil Lake.

Vein orientations are highly variable. Note that in one instance no dip could be determined and so only eight of the vein occurrences are plotted in Figure 5.3.20. The combined vein population is dominated by two orientation peaks, one trending east-northeast at 060° and one trending southeast at 145° (Figure 5.3.20b). Additional less prominent peaks are evident at 000°, 078°, 098° and 112°, each representing a single vein. Veins are mostly steeply dipping (Figure 5.3.20a).

In four instances, the observed vein was interpreted as extensional in nature (Figure 5.3.20c). These veins ranged between 1 and 10 cm in width. In two instances veins were interpreted as being shear-related (Figure 5.3.20d). These veins ranged between 3 and 30 cm in width. In the remaining three instances, no genetic association to the vein emplacement was determined. These veins ranged between 1 and 10 cm in width.

The vein mineral infilling was identified as quartz in two instances, including both shear veins and one extensional vein, while one vein was filled with feldspar and four other veins were filled with pegmatite. These veins with pegmatite fill are described in further detail with regard to their distribution, lithological association and structure, in Section 5.4.2. The additional two veins had unidentifiable mineral infillings.

5.3.4.3 Secondary Minerals and Alteration

Evidence of secondary mineral infilling within, and alteration in the wall rock adjacent to, fractures was documented during mapping of the Indian Lake East batholith area (Figure 5.3.21). The most common secondary minerals observed across all fracture types (263 joints + 9 faults + 9 veins; N = 281) in the Indian Lake East batholith area include hematite (7 occurrences; 3%) and quartz (6 occurrences; 2%) (Table 5.3.4.3a). Six fractures also exhibit a cm-width bleached alteration halo in the wall rock on either side of the fracture. Two occurrences of feldspar (> 1%) and one occurrence each of epidote, chlorite, breccia, biotite and carbonate, represent the remaining secondary mineral types identified. These lesser occurrences are referred to as ‘other’ in Table 5.3.4.3a and on Figure 5.3.21. Note that in some instances more than one infilling mineral was identified within a single fracture.

Table 5.3.4.3a: Indian Lake East Batholith Area Joints, Faults and Veins (Combined) - Secondary Mineral Infills and Alteration

Mineral Phase/ Alteration	All	%
Hematite	7	2.49
Quartz	6	2.14
Bleaching	6	2.14
Other	7	2.49
None	254	90.39
Total # of fractures	**281**	

The combined population of fractures with secondary mineral infill and wall rock alteration show that most of the associated structures are steeply dipping and that several distinct fracture orientations are evident (Figures 5.3.22a and 5.3.22b). Broad peaks include one trending north that ranges between 344° and 018°, with internal peaks at 350° (170°) and 008°, one trending northeast that ranges between 028° and 073°, with internal peaks at 047° and 060°, and one trending southeast that ranges between 119° and 153°, with one internal peak at 142°. One less prominent orientation peak is evident trending east at 097°.

Table 5.3.4.3b below provides an overview of the types and number of joint infill occurrences encountered in the Indian Lake East batholith area. The overwhelming majority of joints observed in the Indian Lake East batholith area were unfilled (246/264; 93%). A small number (7; 3%) were infilled by hematite. Six joints (2%) were associated with a several cm wide bleached halo (Figure 5.3.23c). The bleaching is interpreted as an effect of silicification of the wall rock around the joint. Additional minor infilling types identified include one instance each of quartz, epidote, biotite, and breccia, each representing 0.4% of the total number of joint observations. Separating the data by the dip magnitude bins shows that the majority of occurrences of secondary mineralization of any kind is associated with steeply dipping joints. The one breccia occurrence is associated with a shallowly dipping joint and one moderately dipping joint exhibited bleaching alteration of the adjacent wall rock.

Hematite mineral infill occurs most commonly on the northern part of the Indian Lake East batholith area (Figure 5.3.21). In one instance, it is noted that hematization is localized at the contact between a gneiss xenolith and the granite host rock (Figure 5.3.23a). Quartz infill is recorded dominantly in the western portion of the Indian Lake

East batholith area (Figure 5.3.21), while epidote infill on joints is documented in the northeastern part of the mapped area (Figure 5.3.21 and Figure 5.3.23b).

Table 5.3.4.3b: Indian Lake East Batholith Area Joints - Secondary Mineral Infills and Alteration

Mineral Phase/ Alteration	All	%	Steep Dip	Moderate Dip	Shallow Dip
Hematite	7	2.66	7	0	0
Bleaching	6	2.28	5	1	0
Quartz	1	0.38	1	0	0
Epidote	1	0.38	1	0	0
Breccia	1	0.38	0	0	1
Biotite	1	0.38	1	0	0
Chlorite	1	0.38	1	0	0
None	246	93.54	163	39	44
Total # of Joints	**263**		**179**	**40**	**45**

Table 5.3.4.3c below provides an overview of the types and number of fault infill occurrences encountered in the Indian Lake East batholith area. Six out of nine observed faults (67%) are unfilled. Quartz fill occurs in three (33%) and both feldspar and carbonate are present, along with quartz, in one instance each (11%, respectively).

Table 5.3.4.3c: Indian Lake East Batholith Area Faults - Secondary Mineral Infills and Alteration

Mineral Phase/ Alteration	All	%
Quartz	3	33.33
Feldspar	1	11.11
Carbonate	1	11.11
None	6	66.67
Total # of Faults	**9**	

Table 5.3.4.3d below provides an overview of the types and number of vein infill occurrences encountered in the Indian Lake East batholith area. Of the five measured veins, two (40%) are infilled with quartz and two have an unidentified mineral infill. One vein (20%) is infilled with feldspar. Note that four veins are also locally described as joints with pegmatite or aplitic fill, which predates the emplacement of the secondary minerals documented here. The structures filled with granitic material are discussed later in the report in the section on felsic dykes (Section 5.4.2).

Table 5.3.4.3d: Indian Lake East Batholith Area Veins - Secondary Mineral Infills and Alteration

Mineral Phase/ Alteration	All	%
Quartz	2	22.22
Feldspar	1	11.11
Other	4	44.44
Unknown infill	2	22.22

Mineral Phase/ Alteration	All	%
Total # of veins	9	100

5.4 Dykes in the Ignace Area

This section summarizes the observations made regarding mafic and felsic dyke occurrences documented during the detailed mapping activity in the Ignace area. Mafic dykes in the Ignace area are described in Section 5.4.1 below, including discussion of the results from a detailed scanline fracture mapping exercise undertaken across one well-exposed mafic dyke in the Revell batholith area (Section 5.4.2). Felsic dykes in the Ignace area are described in Section 5.4.3.

5.4.1 Mafic Dykes

Mafic dykes were identified at a total of 17 bedrock observation locations in the Ignace area, including 14 locations in the Revell batholith area and three locations in the Basket Lake – Indian Lake West batholith area (Figure 5.4.1). In several instances, mafic dykes were observed at multiple locations along the same dyke segment. Mafic dykes occupy anywhere between less than 10% to up to 60% of the outcrop by area at any single bedrock observation location. Fifteen representative mafic dyke rock samples were collected from the Ignace area, including 13 from the Revell batholith area and two from the Basket Lake-Indian Lake West batholith area.

The mafic dykes are black to dark grey when fresh and brown to black when weathered (Figures 5.4.2a, 5.4.2b, and 5.4.2c). They are massive in texture and generally vary from very fine- to medium-grained. There is a common transition from very fine grainsize at ubiquitous chilled margins adjacent to the bedrock host transitioning to increasingly coarser grainsize towards the center of the dyke. The coarsest grains were consistently observed at the greatest distance from the bedrock contact (i.e., towards the middle of the dyke). The primary mineral phases observed within the mafic dykes include pyroxene, plagioclase, amphibole, magnetite with minor occurrences of pyrrhotite and biotite (Figure 5.4.2d). Overall, they exhibit the character typical of a diabase dyke.

The mafic dykes consistently exhibit a sharp and mm- to cm-width chilled margin with the surrounding bedrock host (Figure 5.4.2d). Most observed dyke-host contacts were intact and exhibited no evidence of brittle reactivation along the contact. However, as described below, the dyke chosen for the scanline fracture mapping exercise did exhibit an increased density of jointing along one of its contacts with the surrounding bedrock.

A total of 16 field estimates of intact rock strength were undertaken on the mafic dykes identified in the Ignace area. The results include three instances of a strong (R4) character, nine instances of a very strong (R5) character and four instances of an extremely strong (R6) character.

Mafic dykes observed in the Ignace area range from less than 10 cm to approximately 30 m in width. In some cases, the reported width is a minimum estimate, if only one, or neither, contact is exposed. The main mafic dyke segments observed in the Revell batholith area are usually on the order of 5 m wide or greater. The mafic dyke segments observed in the Basket Lake batholith – Indian Lake West batholith area were attributed with a minimum width of 1 m, as the contacts were poorly exposed. Small mafic dyke apophyses, up to 50 cm wide and oriented at high angles to the main dyke trend, are commonly observed in close proximity to the main dyke segments, in both areas.

Twelve of the mafic dyke observations are coincident with, or very close to, dyke segments that were previously identified in the lineament analysis. In the five other observation locations, mafic dykes were not previously identified in the lineament analysis. These latter five occurrences of mafic dykes were noted primarily in the southern central part of the Revell batholith area (Figure 5.4.1). Their widths, based on field observation, were 1.5 m or less in all but one case, where a width of 11 m was measured.

Mafic dyke orientations in the Ignace area were determined from 11 field observations of dyke-bedrock contacts. The total population of mafic dyke contacts is shown in Figures 5.4.2g and 5.4.2h. One dominant orientation peak is evident trending east-southeast at 110°, with additional lesser orientation peaks at 035°, 045°, 070°, 090°, 128° and 155°. Dyke terminations, and smaller dykes between overlapping dyke segments, are commonly close to east-west striking, oblique to the main west-northwest dyke trend. Dyke contacts are consistently steeply dipping (Figure 5.4.2a).

The majority of the mafic dykes have a very high magnetic susceptibility of 21.22±15.06 x10^{-3} SI (N=16) showing a very wide range between 0.59 and 49.40 x10^{-3} SI, with 50% of the readings between 8.74 and 32.10 x10^{-3} SI (Figure 5.4.2e). The magnetic character appears to be principally attributable to the presence of magnetite.

The gamma ray spectrometry readings (Figure 5.4.2f) for the mafic dykes, including 16 sets of measurements, show the following characteristics:

- Total count is on average 46.06±25.18 cps and ranges between 17.80 and 121.40 cps.
- Potassium content is on average 1.36±0.37% and ranges between 0.8 and 2.3%.
- Uranium content is on average 1.35±1.47 ppm and ranges between 0.0 and 5.0 ppm.
- Thorium content is on average 7.84±5.19 ppm and ranges between 1.2 and 49.4 ppm.

5.4.1.1 Mafic Dyke Structure

The mafic dykes observed in the Ignace area and described above exhibit no evidence of ductile deformation and only limited evidence of brittle deformation. The only brittle deformation features observed in association with the mafic dykes are joints.

A total of 15 joints were measured within mafic dykes during the main portion of the detailed mapping activity in the Ignace area. Note that many more joints were measured during the separate scanline fracture mapping exercise, discussed in Section 5.4.2. However, the scale of that investigation was much finer than the main mapping activity. Observations made during the scanline fracture mapping activity are consistent with the observations reported in this section.

Joint spacing in mafic dykes and the adjacent host bedrock are variable and range from 0.03 to 5 m within the dyke. The majority of joint spacings are in the range of 0.03 to 0.1 m within the dykes. Throughout the Revell and Basket Lake-Indian Lake West batholith area, the most common joint spacing class is 1 to 5 m (Figure 5.1.14f), indicating that joint spacing is generally tighter within mafic dykes.

Most of the joint orientiation measurements (80%, 12/15) were steep. Two joints are moderately inclined and one is shallowly dipping (Figure 5.4.2g). The peak orientation of joints within dykes trends southeast at 148° (Figure 5.4.2i and 5.4.2j), ranging between 136° and 168°, and thus oblique to the mostly east-southeast trending dyke orientations with a peak at 110° (Figure 5.4.2h). A second orientation peak of joints within dyke trends north at

006°, ranging from 358° to 012°, at a high angle to the main dyke orientation. Lesser peaks are at 095°, 045°, 063°, 075°, and 120°.

5.4.2 Mafic Dyke Transect

A detailed scanline fracture mapping exercise was performed along a single, northeast-trending, transect across one mafic dyke in the northern Revell area. The selected location (Station 16FB3134; Figure 5.1.1) provided good exposure of the dyke, including its southwestern contact with the tonalite host bedrock. Almost continuous bedrock exposure was available for examination over a total scanline length of 50 m (Figure 5.4.3a). The main purposes of the fracture mapping exercise were to attempt to increase the general understanding the character of the fractures in the vicinity of mafic dykes and to investigate the character of the dyke-host bedrock contact zone.

The scanline crosses an 18 m wide west-northwest trending wide mafic dyke that is typical of the mafic dykes observed in the Ignace area (Figure 5.4.3a). The profile is oriented NE-SW and is orthogonal to the dyke contact. The southern contact between the mafic dyke and the tonalite is well exposed and is oriented 307/89. The northern contact is obscured by overburden. The section between 20 and 21 m south of the scanline center is covered by vegetation and sections between 23 and 26 m south of the scanline center are exposed on a smaller surface area than the rest of the scanline.

Across the scanline, 100 joint measurements were recorded (Figure 5.4.3b). Of these, 23 were measured in the tonalite north of the dyke, 36 within the dyke itself and 41 in the tonalite south of the dyke. No ductile structures or faults were identified in the mapped scanline area.

Joints are mostly steep, with a small number of shallowly dipping joint sets measured in each of the three scanline segments (Figure 5.4.3b). In the tonalite northeast of the mafic dyke, two main, broad, joint orientation peaks are evident at 028° and 125°. These orientations are nearly perpendicular and parallel to the general mafic dyke orientation, respectively (see also Figure 5.4.4f). Within the mafic dyke, three main orientation peaks are evident at 023°, 102° and 140°. One less prominent peak is also evident at 156°. Again, these trends are approximately perpendicular and parallel to the general mafic dyke orientation. In the tonalite southwest of the mafic dyke, the main orientation peaks for measured joints are 003° and 133°. Additional minor peaks are evident at 043°, 084° and 131°. While the dyke-parallel joint trend is still prominent, there appears to be more variability in trend of joints oriented at a high angle to the dyke-bedrock contact at this end of the profile.

The frequency of joints measured along the scanline is variable (Figure 5.4.3c). The central portion, and northeastern half, of the mafic dyke exhibit less than 10 fractures per 1 m interval (Figure 5.4.4a). There are also very few to no observed joints at several intervals along the southwestern end of the scanline in the tonalite (between 13-15 m, 20-21 m, and 25-31 m; Figure 5.4.4d) and across much of the northeastern end of the scanline, also in the tonalite. Between these low joint density regions, distinct intervals of increased joint frequency in the tonalite are observed at 15 m and 18 m northeast of the scanline center, and between 16-19 m and 22-24 m south of the scanline center (see also Figure 5.4.4c). The fracture frequency profile also highlights that the southwestern contact between the dyke and the tonalite is marked by the occurrence of at least 20 joints per 1 m interval between 3 and 10 m south of the scanline center (Figure 5.4.4b).

No infill, wall rock alteration, or offset is observed on any of the measured joints. Cross-cutting evidence is documented by the termination of joints of one orientation on joints of another orientation. For example, northwest-striking joints limit the extent of northeast-striking joints (Figure 5.4.4e).

A series of magnetic susceptibility measurements taken along the scanline shows that the susceptibility values of the dyke are two to three orders of magnitude higher than the tonalite host rock (Figure 5.4.3d). Magnetic susceptibility values for the tonalite range from 0.05 to 0.64 $x10^{-3}$ SI and are mostly around 0.09 $x10^{-3}$ SI. These values are consistent with what is expected for tonalite in the Revell batholith area (e.g. Figure 5.1.5c). Susceptibility values for the dyke range from 13 to 63 $x10^{-3}$ SI and are mostly around 50 $x10^{-3}$ SI. Magnetic susceptibility values within the dyke decrease within 4 m of its contact to the tonalite, in the same location as the highest fracture frequency. This decrease may be due to the observed decrease in grain size near the dyke margin or an unidentified alteration or breakdown of magnetic minerals. There is generally little variability in the magnetic susceptibility of the tonalite, except for one measurement that is an order of magnitude higher than other values for the tonalite. This higher value was measure at the contact to the dyke.

In summary, the detailed mapping transect across the mafic dyke was useful in characterizing lithology and structures of the mafic dyke-tonalite contact zone. The dyke and tonalite host rock exhibited an abundance of joints, with one of the main joint orientations parallel to the dyke contact, and a second dominant joint set orthogonal to the dyke contact. Most joints were steeply dipping. The frequency of fractures showed large variability both in the dyke itself and in the tonalite host rock. An approximately 7 m wide zone of increased joint frequency characterizes the southwestern dyke contact, while very few joints occur in the several metres near the northern dyke contact. The magnetic susceptibility of the mafic dyke is three orders of magnitude higher than the surrounding tonalite host rock. Within the dyke, the magnetic susceptibility appears to decrease within 4 m of the contact with the host rock.

5.4.3 Felsic Dykes

Felsic dykes are documented at 45 bedrock observation locations throughout the Ignace area. The majority are found in the northern and eastern parts of the Revell batholith area, with several clusters of occurrences throughout the Basket Lake batholith – Indian Lake West batholith area, and few additional occurrences in the Indian Lake East batholith area (Figure 5.4.5). This section provides a brief overview of the geological characteristics of these felsic dyke occurrences.

Felsic dykes represent a very small component of the bedrock in the Ignace area. In these documented occurrences, felsic veins primarily occupy less than 10% of the outcrop by area, though in few instances they cover up to 30%. They range in width between 1 cm and 5 m, with the majority of the occurrences measuring between 3 and 30 cm in width. They are observed to transect the bedrock either as single, linear dykes or clustered networks of dykes with multiple, mutually cross-cutting orientations. Often these dykes are observed to be hosted by fractures that are parallel to unfilled joints. A consistent relationship observed throughout the Ignace area, though primarily in the Revell batholith area specifically, is that the felsic dykes are cross-cut by quartz-filled shear zones and fractures.

The felsic dykes are primarily beige, grey, white or pink when fresh and when weathered (Figures 5.4.6c and 5.4.6d). Variations in grainsize are evident between occurrences. Felsic dykes are characterized as aplitic when finer-grained, with grainsize varying between 0.1 to 5 mm, and pegmatitic when coarse-grained, with grainsize up to 50 mm. Most felsic dykes are equigranular, although in few cases coarse-grained K-feldspar phenocrysts up to 50 mm were observed within a finer-grained matrix. The main matrix minerals include plagioclase, quartz, K-feldspar and biotite. Local two-mica granite pegmatite is observed which additionally contains garnet, magnetite and sericite (Figure 5.4.6f). Both massive and foliated examples of felsic dykes are observed.

Where there is a clear grainsize or colour difference between the felsic dyke and the surrounding bedrock, the contact is sharp. In some instances, negligible colour or grainsize differences highlight a gradational contact. In all instances the observed contacts between felsic dykes and the surrounding bedrock are intact. There is no evidence of brittle deformation localized along these contacts. However, shear zones are observed to be localized along felsic dyke contacts, and both shear zones and fractures are observed to cut felsic dykes at high angles to their contacts.

The majority of the felsic dykes are steeply-dipping (Figure 5.4.6a). The total felsic dyke population exhibits a dominant, broad, east-southeast- to southeast-trending orientation peak that ranges between 105° and 137° and exhibits internal peaks at 115° and 130°, which is roughly parallel to the main orientation of mafic dykes. Two other prominent peaks are evident trending north at 010° and east-northeast at 077°. Less prominent peaks are also evident at 056°, 098° and 164° (Figure 5.4.6b). These felsic dyke orientations cover the same general range as steeply-dipping joints in the Revell batholith area.

Out of a total of 20 rock hardness measurements, felsic dykes were very strong (R5) in 18 instances (90%) and extremely strong (R6) in the other two instances (10%). Nine felsic dyke samples were collected.

6.0 SUMMARY OF FINDINGS

This report presents the results of the Phase 2 Detailed Geological Mapping conducted in the Ignace area in 2015 and 2016. Observations were made at outcrops within areas previously identified on the Basket Lake, Indian Lake and Revell batholiths. The detailed mapping was conducted using a consistent approach to confirm and field verify the presence and nature of key geological features of these batholiths, including bedrock lithology and structural character, fracture character and spacing, and bedrock exposure and surface constraints.

The following sections summarize the key findings of the results presented in Section 5, and discusses how the new information builds upon the historical geological understanding of the area (Section 3).

6.1 Revell Batholith Area

The majority of the Revell batholith area is easily accessed via a network of logging and general use roads which are generally in good condition and passable using a 4X4 vehicle. The western and southwestern parts of the Revell batholith area currently have no road network and were accessed by boat and foot. Topography is generally subdued and small ridges, with up to several metres of vertical relief, are only encountered rarely.

The Revell batholith area exhibits the lowest degree of overburden cover relative to the other mapping areas in Ignace. This is reflected in the high density of bedrock observation locations relative to the other area. Visual inspection suggests that even more outcrop is present in the area compared to what was initially predicted. Average (estimated) overburden thickness around the edges of exposed bedrock outcrop varies between 0.3 and 1 m. These observations are consistent with our previous understanding of the Quaternary geology of the Revell batholith area (JDMA, 2013).

6.1.1 Lithology

Six lithological units are identified in the Revell batholith area including granodiorite, tonalite, granite, diorite/quartz diorite, metamafic rocks and schist (Table 5.1.3 in Section 5.1), plus mafic and felsic dykes. The entire Revell batholith area is underlain by a massive to weakly foliated granodiorite-tonalite complex, which was later intruded by a medium-grained granite. The granite occurs as greater than outcrop scale intrusive bodies and as thinner dykes within the granodiorite-tonalite igneous complex. These relative age relationships were observed on a consistent basis. The granite is primarily concentrated in the eastern to southeastern portions of the Revell batholith area, with lesser isolated occurrences in the west-northwest portion. All three of these main bedrock lithological units exhibit consistently low magnetic susceptibilities. Less common lithological units, including metamafic rocks, schist and diorite/quartz diorite, comprise only a small amount of the bedrock and occur throughout the southeastern portion of the Revell batholith area, primarily in close proximity to the adjacent greenstone belt. These units often appear as xenoliths within the granodiorite-tonalite complex, suggesting that they are the oldest components of the bedrock in the Revell batholith area.

Stone et al. (2011), mapping at 1:20 000 scale, described three intrusive phases that comprise the Revell batholith: an older tonalite phase, a younger granodiorite-granite phase, and youngest feldspar megacrystic-granite phase. In general, that interpretation aligns with the field observations made during detailed mapping, with the exception that the oldest phase is now understood to be a granodiorite-tonalite complex that is intruded by a younger granite. The use of a gamma ray spectrometer during the detailed mapping activity proved to be highly useful in making these distinctions. Stone et al. (2011) noted an increase in lithological heterogeneity in proximity to the greenstone belt to the northeast of the Revell batholith area. The observed distribution of metamafic rocks and schist within the Revell batholith area, made during the detailed mapping activity, is consistent with this previous work. The present study also identified very minor amounts of these rocks further from the greenstone belt contact. Overall, the detailed mapping work is generally consistent with previous mapping while providing an updated understanding of the lithological character of the Revell batholith area.

Mafic dyke segments were observed in several locations across the Revell batholith area, including but not limited to areas where mafic dykes of the Wabigoon dyke swarm were previously mapped. All of the mafic dykes observed during Detailed Geological Mapping in the Revell batholith area are similar in character and they are interpreted to be part of the Wabigoon dyke swarm. The mafic dykes consistently exhibit a sharp and mm- to cm-width chilled margin with the surrounding bedrock host. Felsic dykes are identified throughout the northern and eastern parts of the Revell batholith area.

6.1.2 Structure

Previous mapping by Stone et al. (2011) in the Revell batholith area included only limited structural observations, primarily foliation trajectories. The majority of the structural information presented above comprises a new structural dataset for the Revell batholith area. The orientation information for all observed ductile structures in the Revell batholith area is summarized above in Table 5.1.4.1 and for all brittle structures in Table 5.1.4.2a. This section highlights some key findings from the structural dataset.

Igneous flow foliation tends to parallel the curved northwestern boundary of the Revell batholith. There is a good correlation between foliation trajectories documented by Stone et al. (2011) and nearby measurements of tectonic foliation made during detailed mapping, with both suggesting an overall east-west trend and steep dip, with local variability.

Subvertical joints, dipping greater than 65°, are the most common structural feature at the outcrop scale across the Revell batholith area. Two broad orientation peaks highlight the dominant northeast and northwest trends of observed subvertical joints. Subvertical joints may represent magmatic cooling joints or tectonically induced fractures, however any interpretation currently remains speculative. Subhorizontal joints, dipping less than 25°, show minimal evidence of secondary mineralization or alteration and the majority are interpreted as unloading structures.

The majority of ductile and brittle-ductile shear zones occurrences are observed throughout the eastern portion of the Revell batholith area. Shear zones primarily strike east-northeast, north, south-southeast or east-southeast. Shear zones dip moderately to steeply, and are most commonly observed as centimetre to decimetre wide structures. Quartz is locally observed to infill shear zones. Kinematic markers suggest multiple episodes of shearing occurred on similarly oriented structures throughout the deformation history. These deformation features may have formed by localization along existing joints.

The majority of fault occurrences are observed throughout the eastern portion of the Revell batholith area. Dominant strike orientations for faults are north-northeast, northeast, east-southeast and south-southeast. Faults primarily dip steeply and often exhibit shallowly-plunging to sub-horizontal slickenlines suggesting a history of strike-slip motion. The observed damage to bedrock due to faulting, primarily in the form of tighter joint spacing or increased number of evident joint orientation families, is generally concentrated between 5 and 10 m beyond fault core zones. Epidote, chlorite, hematite and quartz occur locally as mineral infill on faults. Faults may have formed by localization along existing joints.

Proterozoic mafic dykes exhibit no evidence of ductile deformation, faulting or secondary mineral or alteration overprint. An increased density of joints along the southwestern contact between the bedrock host and the one mafic dyke studied in the scanline fracture mapping activity is the only evidence of localized brittle overprint of the mafic dykes.

6.2 Basket Lake-Indian Lake West Batholith Area

The Basket Lake-Indian Lake West batholith area is accessed via a network of logging and general use roads that are generally in good condition and accessible using a 4X4 vehicle. In few cases, overgrown older logging roads and open clear-cut areas were traversed by foot. Topography in the south of the Basket Lake-Indian Lake West batholith area is generally subdued and small ridges, with up to several metres of vertical relief, are only encountered rarely. Moderately high ridges with greater than 10 m vertical extent occur in the central portion of the Basket Lake-Indian Lake West batholith area, but these minor topographic variations do not limit accessibility.

Two end moraines cover the Basket Lake-Indian Lake West batholith area in varying, but often appreciable, thickness of overburden. Areas of bedrock exposure are more frequent in the northern portion of the Basket Lake-Indian Lake West batholith area and the majority of the southern portion of the area is covered by overburden. Considering the high degree of overburden cover in the south, predictive terrain modelling did successfully identify the few available outcrop areas. Average (estimated) overburden thickness around the edges of exposed bedrock outcrop areas varied between 0.3 and 1 m. The estimated overburden thickness at overburden stations was mostly between 1-3 m, or greater than 3 m. These observations are consistent with the previous understanding of the Quaternary geology of the Basket Lake-Indian Lake West batholith area (JDMA, 2013).

6.2.1 Lithology

Five lithological units are identified in the Basket Lake-Indian Lake West batholith area including granite, gneiss of predominantly tonalitic composition, mafic metavolcanic rocks, granodiorite and schist (Table 5.2.3 in Section 5.2), plus mafic and felsic dykes. The entire Basket Lake-Indian Lake West batholith area covered during detailed mapping is underlain by a homogeneous medium-grained granite. Lesser occurrences of gneiss, including tonalite gneiss, are observed but only rarely in greater proportion than the granite at any single bedrock observation location, and primarily as xenoliths within the granite. These occurrences of tonalite gneiss are found primarily in the northern part of the Basket Lake-Indian Lake West batholith area. The granite and the tonalite gneiss occurrences exhibit relatively high magnetic susceptibilities in comparison to the granite and tonalite units described above for the Revell batholith area. Less common lithological units, including mafic metavolcanic rocks, granodiorite and schist comprise only a small amount of the bedrock and occur only within the northern half of the Basket Lake-Indian Lake West batholith area. These minor units, along with the tonalite gneiss, primarily appear as xenoliths within the granite suggesting that they are the oldest components of the bedrock in this area.

Prior to the detailed mapping program, reconnaissance level mapping indicated that the bedrock underlying the Basket Lake-Indian Lake West batholith area consisted largely of massive granodiorite to granite, with an intervening sliver of tonalite (Sage et al., 1974; Stone, 2010a). This tonalite sliver separates the Basket Lake batholith and the Indian Lake batholith. Based on the observation that homogeneous granite underlies the entire Basket Lake-Indian Lake West batholith area, even in the area mapped as tonalite, it appears that the granite represents one continuous intrusive body. This observation is perhaps the most significant departure in mapped lithology from the historical information available for the area. Minor mafic metavolcanic rock occurrences throughout the northern half of the Basket Lake-Indian Lake West batholith area represent another new mapping observation.

Mafic dykes were observed at three locations along the same dyke segment in the Basket Lake-Indian Lake West batholith area. Previously mapped mafic dykes in the same approximate location were previously associated with the Kenora-Fort Frances mafic dyke swarm. However, the orientation and character of the mafic dykes observed during Detailed Geological Mapping in the Basket Lake-Indian Lake West batholith area are similar in character to those observed in the Revell batholith area and are similarly interpreted to be part of the Wabigoon dyke swarm.

6.2.2 Structure

Previous mapping by Sage et al. (1974) included limited documentation of structures, primarily foliations which were highly variable in both strike and dip. This previous mapping was done at a broad regional scale. The majority of the structural information presented above comprises a new structural dataset for the Basket Lake-Indian Lake West batholith area. The orientation information for all observed structures in the Basket Lake-Indian Lake West batholith area is summarized above in Table 5.2.4.1 and Table 5.2.4.2a. This section highlights some key findings from the structural dataset.

The foliation measurements show a relatively consistent distribution, with a prominent easterly trend. Foliation is generally steeply dipping and weakly developed. The limited number of observed shear zones shows similar orientations to shear zones observed elsewhere in the Ignace area. Shear zones dip moderately to steeply.

Subvertical joints, dipping greater than 65°, are the most common structural feature at the outcrop scale across the Basket Lake-Indian Lake West batholith area. Two broad orientation peaks highlight the dominant northeast and north trends of observed subvertical joints. Subvertical joints may represent magmatic cooling joints or tectonically induced fractures, however any interpretation currently remains speculative. Subhorizontal joints show no evidence of secondary mineralization or alteration and are interpreted as unloading structures.

Faults are consistently steeply dipping. Faults with dextral horizontal offset predominantly strike north-south and faults with sinistral horizontal offset predominantly strike west-northwest to north-northwest. Shallowly-plunging to sub-horizontal lineaments on fault planes suggests primarily strike-slip motion on both sinistral and dextral faults.

Field observations suggest that the damage to bedrock, primarily in the form of tighter joint spacing or increased number of evident joint orientation families, is generally limited to approximately 15-20 m beyond fault core zones.

Veins in the Basket Lake-Indian Lake West batholith area are mostly recorded as infilled with pegmatite. The orientations of veins show peaks striking east, east-southeast, northeast and north. Veins infilled with quartz or other minerals are rare in the Basket Lake-Indian Lake West batholith area. Ninety-six percent of all fractures exhibit no evidence of secondary mineralization or alteration. The most common secondary mineral infill is quartz which only locally coats joint surfaces and is seen in only few instances within and spatially associated with faults and veins.

6.3 Indian Lake East Batholith Area

The Indian Lake East batholith area is easily accessed via a network of logging and general use roads. These roads in the Indian Lake East batholith area are generally in good condition and accessible using a 4X4 vehicle. In few cases, overgrown older logging roads and clear cut areas were traversed by foot. A boat was also used to access some bedrock observation locations. Topography is generally subdued with small ridges of up to several metres in vertical relief. Local exceptions to this include the area to the southwest of Cecil Lake, and its eastern shoreline, where slightly higher relief is encountered.

The Indian Lake East batholith area is covered by an irregular blanket of overburden. Average (estimated) overburden thickness around the edges of exposed bedrock outcrop varies between 0.3 and 1 m. Although a large number of bedrock outcrops were predicted for the Indian Lake East batholith area, a high proportion were found to be overburden covered. These observations are consistent with our previous understanding of the Quaternary geology of the Indian Lake East batholith area (JDMA, 2013).

6.3.1 Lithology

Four lithological units are identified in the Indian Lake East batholith area including granite, tonalite gneiss, mafic metavolcanic rocks and granodiorite (Table 5.3.3 in Section 5.3), plus felsic dykes. Granite is by far the predominant main lithology and is uniformly distributed across the entire Indian Lake East batholith area. Tonalite gneiss is common only along the northeastern and southwestern margins of the mapped area. The tonalite gneiss varies in its type of occurrence from being the main component at bedrock observation locations to occurrences as metre-scale xenoliths within the surrounding granite host rock. Minor metre-scale mafic metavolcanic rock xenoliths occur predominantly along the northeastern and southwestern margins of the Indian Lake East batholith area in the vicinity of the contact between the granite and the tonalite gneiss.

The Indian Lake East batholith area surrounding Cecil Lake was previously mapped as massive granodiorite to granite at a reconnaissance scale, and as quartz diorite to quartz monzonite in the 1:126 000 scale map (Sage et al., 1974). The detailed mapping provides a much more comprehensive understanding of this portion of the Indian Lake batholith. Consistent with historic mapping no mafic dykes were observed during Detailed Geological Mapping in the Indian Lake East batholith area.

6.3.2 Structure

Previous mapping by Sage et al. (1974) included limited documentation of structures, primarily few measurements of foliation. The majority of the structural information presented above comprises a new structural dataset for the Indian Lake East batholith area. The orientation information for all observed structures in the Indian Lake East batholith area is summarized above in Table 5.3.4.1 and Table 5.3.4.2a. This section highlights some key findings from the structural dataset.

A weakly developed planar tectonic foliation is observed throughout the granite of the Indian Lake East batholith area. Foliation is generally steeply dipping and strikes east-west or northeast-southwest. Igneous flow foliation also occurs throughout the Indian Lake East batholith area and strikes broadly east-northeast or east-southeast. The foliation measurements show a relatively consistent distribution, with a prominent easterly trend. Ductile and brittle-ductile shear zones are rare in the Indian Lake East batholith area.

Subvertical joints, dipping greater than 65°, are the most common structural feature at the outcrop scale across the Indian Lake East batholith area. Two broad orientation peaks highlight the dominant northeast and south-southeast trends of observed subvertical joints. Subvertical joints may represent magmatic cooling joints or tectonically induced fractures, however any interpretation currently remains speculative. The majority of subhorizontal joints show no evidence of secondary mineralization or alteration and are interpreted as unloading structures. East-southeast-striking faults are interpreted to exhibit dextral horizontal offset. There is no visible damage to the bedrock beyond about 15 to 20 m from the center of any observed fault zone.

Veins are rare in the Indian Lake East batholith area. The main orientations of veins are east-northeast and southeast. Almost 90% of all observed fractures are unfilled by secondary minerals or show evidence of alteration. Hematite alteration and quartz infill are the most commonly observed secondary features within faults, veins and joints.

6.4 Structural History of the Ignace Area

A brief synthesis of lithological and structural observations from the detailed mapping activity is provided below as a general summary of the geological history of the Ignace area.

The oldest fabric is the tectonic foliation and gneissosity observed in tonalite gneiss and other xenolith occurrence types preserved locally within the tonalite-granodiorite intrusive complex. An igneous flow foliation formed during the emplacement of the granodiorite-tonalite, and the geometry of the flow foliation may reflect the geometry of the magma chamber. An early set of steeply-dipping fractures formed throughout the intrusive bodies and are locally filled with felsic dykes. These felsic dykes are most likely associated with the younger granite bodies emplaced in the Revell and Indian Lake batholiths.

Ductile and brittle-ductile shearing, and tectonic foliation development, were synchronous with regional quartz mobilization into the shear zones, parallel to the foliation, and precipitating as extension and shear veins. A distinctive bleaching around some fractures also developed. Variable shear zone orientations and slip senses suggest a protracted history of shearing, evidenced also by a brittle component of deformation on about half of the observed shear zones.

Subsequently, faults accommodate localized, primarily transcurrent, slip. Dextral and sinistral horizontal offsets on similarly oriented structures suggests multiple episodes of movement. Faults are locally infilled with hydrothermal minerals, such as epidote, chlorite, and muscovite. Hematite alteration is observed in few fractures.

All of the lithological units and structural features described above fit within the Archean portion of the geological history as it is currently understood for the Ignace area (e.g., Table 3.3.1). All of these features pre-date the emplacement of the mafic dykes observed in the Ignace area. These west-northwest-trending mafic dykes are interpreted, based on previous mapping and field observations, to be part of the ca. 1.9 Ga Wabigoon Swarm of Proterozoic dykes. The only structural overprint evident in these dykes are steeply- to shallowly-dipping, unfilled, joints. Subhorizontal joints, in particular, appear to be the youngest structures throughout the Ignace area. They are inferred to be related to unloading, possibly in connection with post-glacial uplift.

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Report Signature Page

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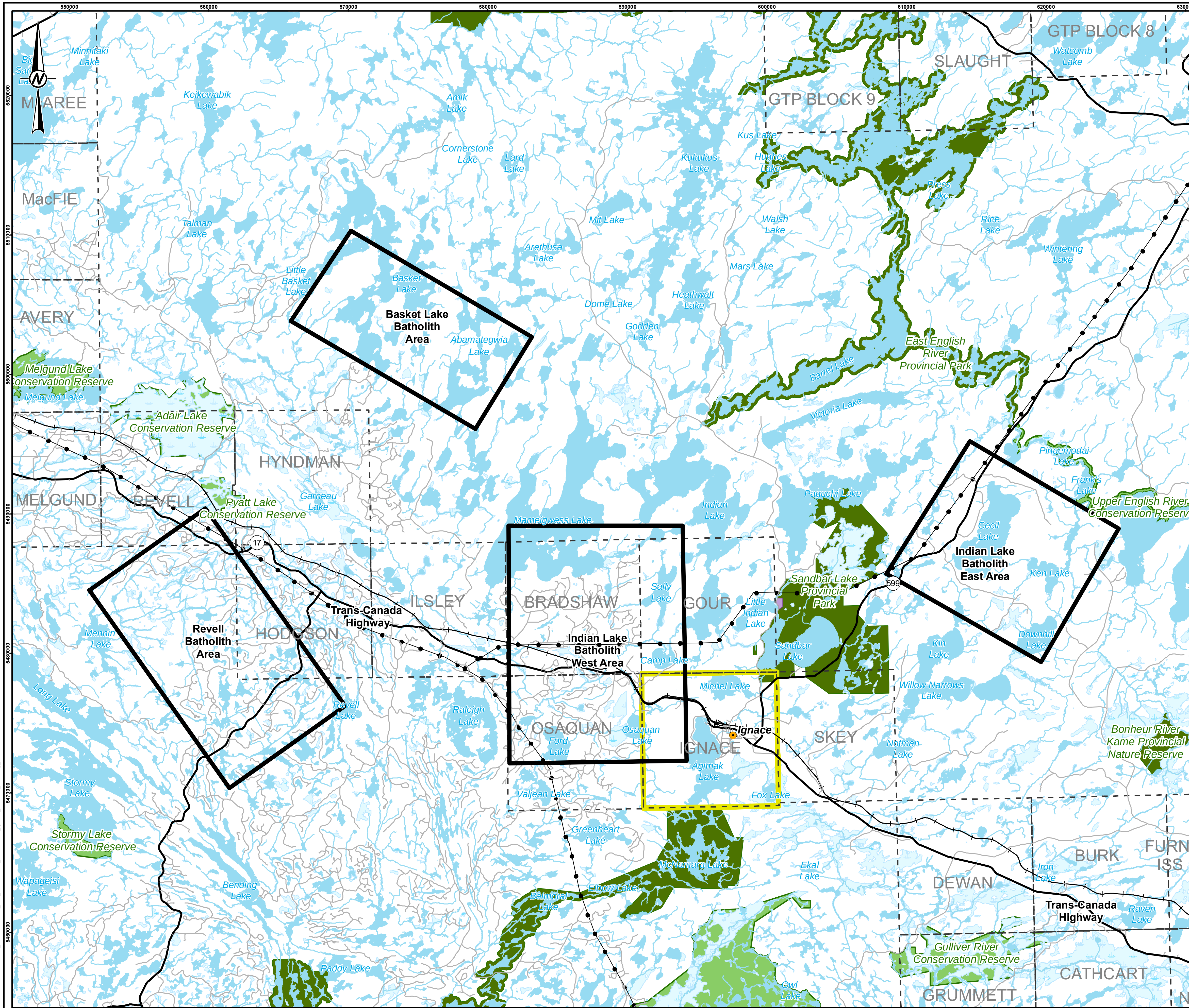

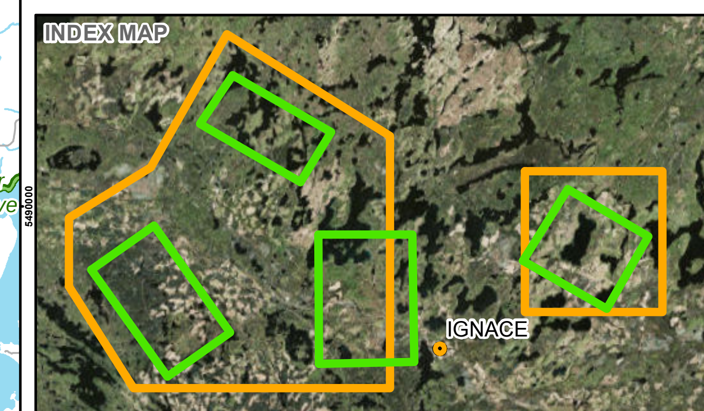

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CLIENT
NWMO
IGNACE, ONTARIO

PROJECT
IGNACE DETAILED MAPPING REPORT

TITLE
IGNACE STUDY AREA

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

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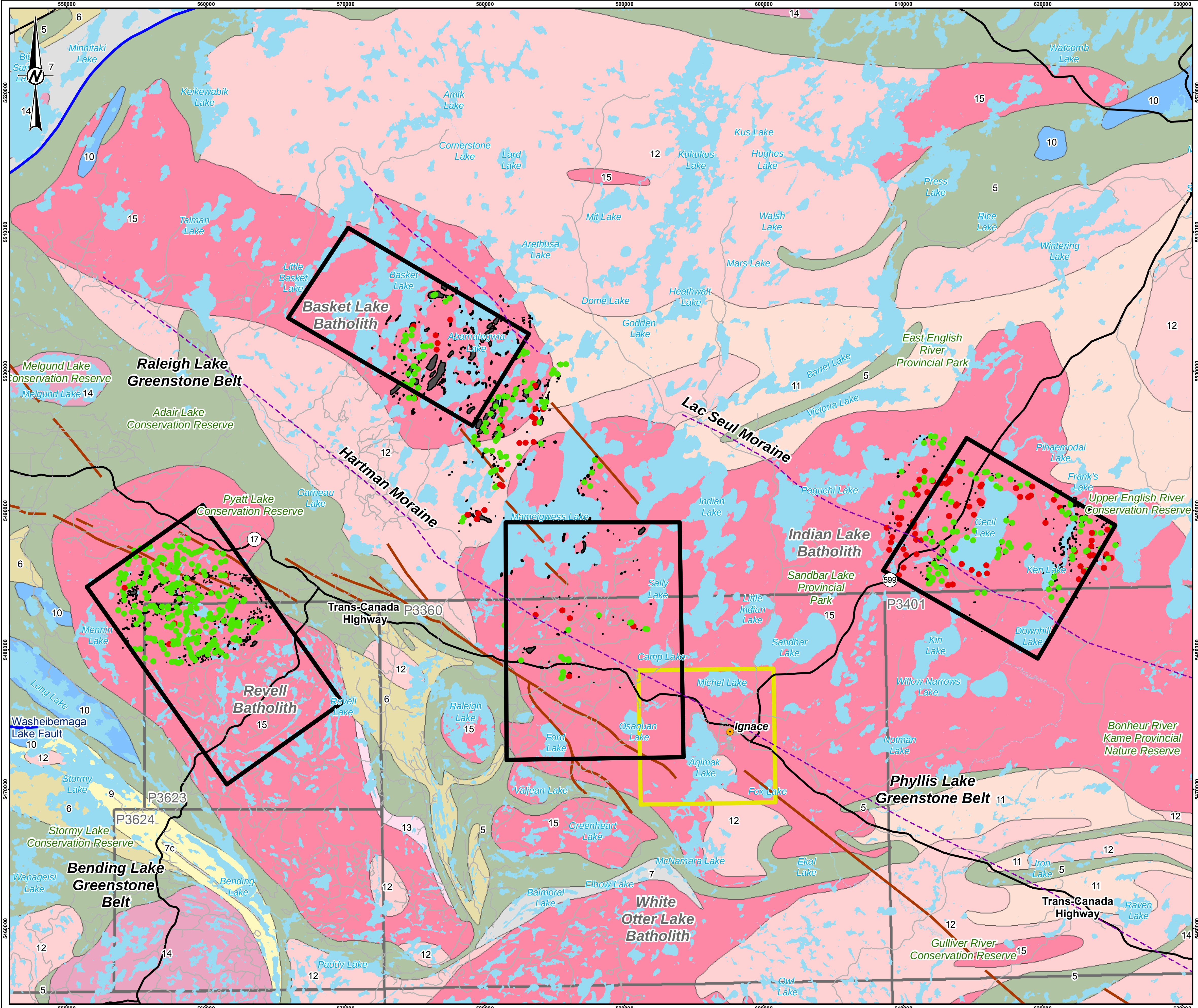


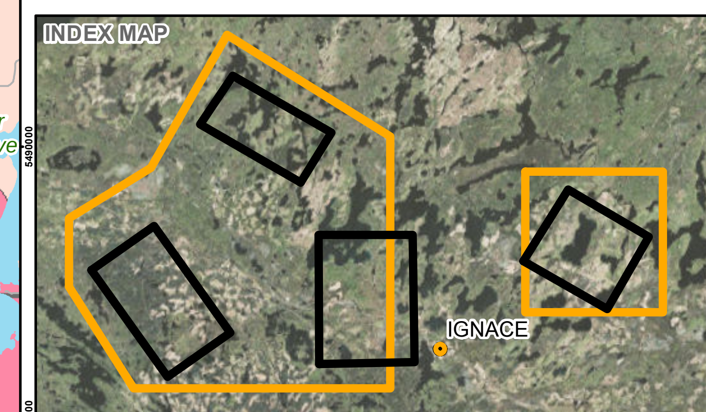
LEGEND

- Withdrawal Area
- Municipal Boundary (Township of Ignace)
- Community
- Main Road
- Local Road
- Waterbody
- Outcrop (472)
- Overburden (108)
- End moraine
- OGS Mapped Dyke
- OGS Mapped Fault
- Predicted Outcrop

Bedrock Geology

- 15 Massive granodiorite to granite
- 14-Diorite-monzodiorite-gra... suite
- 13 Muscovite-bearing granitic rock
- 12 Foliated tonalite suite
- 11 Gneissic tonalite suite
- 10 Mafic and ultramafic rocks
- 9 Coarse clastic metasedimentary rocks
- 7 Metasedimentary rocks
- 7c Marble, chert, iron formation, minor metavolcanic rocks
- 6 Felsic to intermediate metavolcanic rocks
- 5 Mafic to intermediate metavolcanic rocks

INDEX MAP



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2A. STONE ET AL. 2007 (P3360)
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2D. STONE & HALLE 2005 (P3401)

CLIENT
NWMO
IGNACE, ONTARIO

PROJECT
IGNACE DETAILED MAPPING REPORT

TITLE
IGNACE AREA MAPPING OBSERVATION LOCATIONS

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
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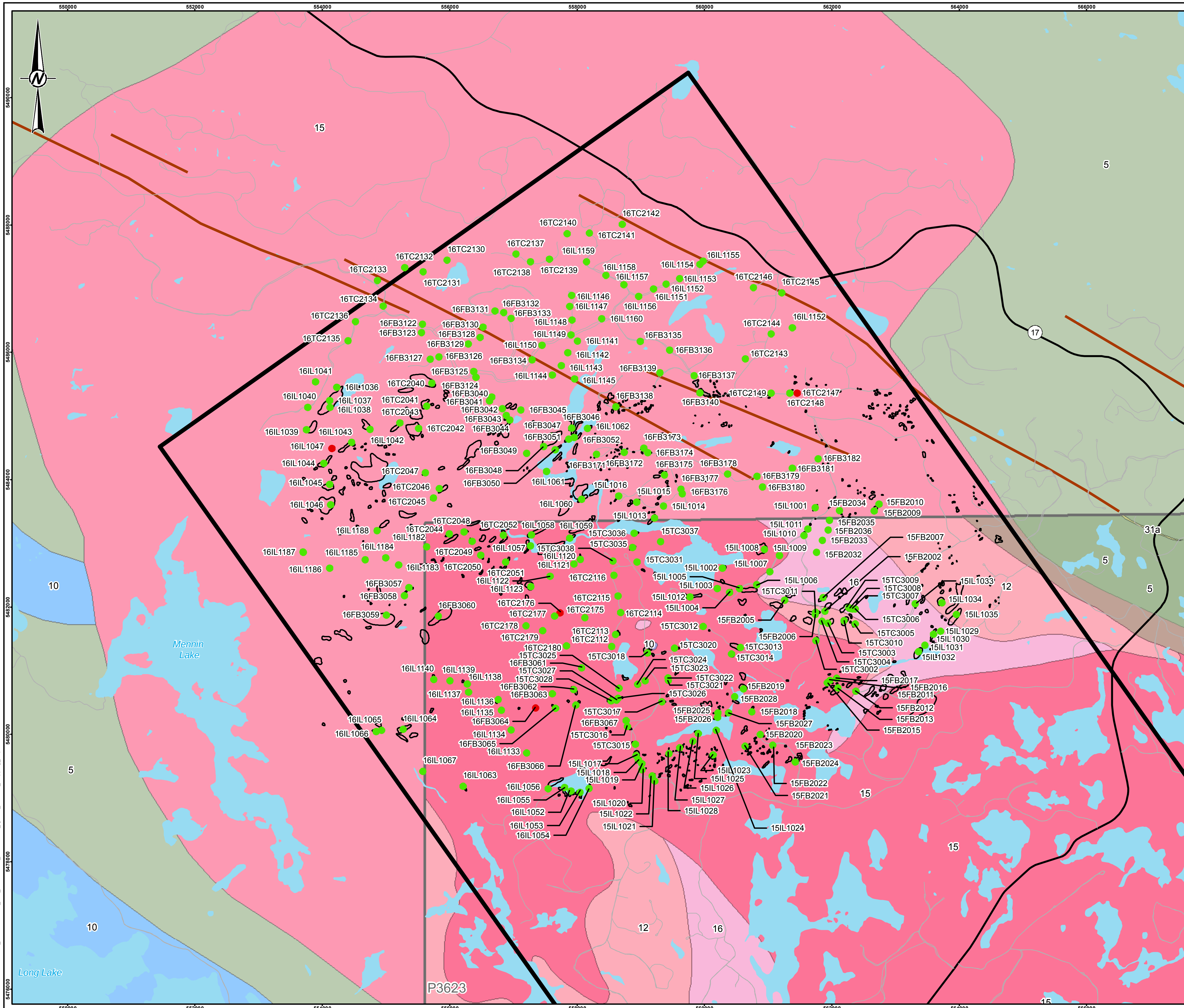
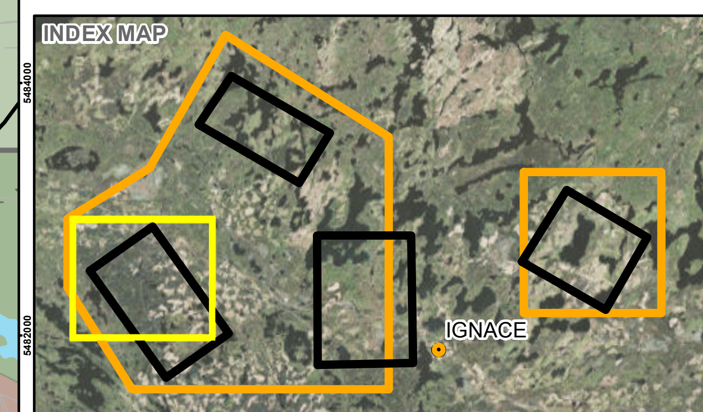


LEGEND

- Withdrawal Area
- Main Road
- Local Road
- Waterbody
- Outcrop (256)
- Overburden (4)
- OGS Mapped Dyke
- Predicted Outcrop

Bedrock Geology

- 31 Sibley Gp.
- 16 Hornblendite - nepheline syenite suite
- 15 Massive granodiorite to granite
- 12 Foliated tonalite suite
- 10 Mafic and ultramafic rocks
- 5 Mafic to intermediate metavolcanic rocks



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CLIENT
NWMO
IGNACE, ONTARIO

PROJECT
IGNACE DETAILED MAPPING REPORT

TITLE
REVELL BATHOLITH AREA - MAPPING OBSERVATION LOCATIONS

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

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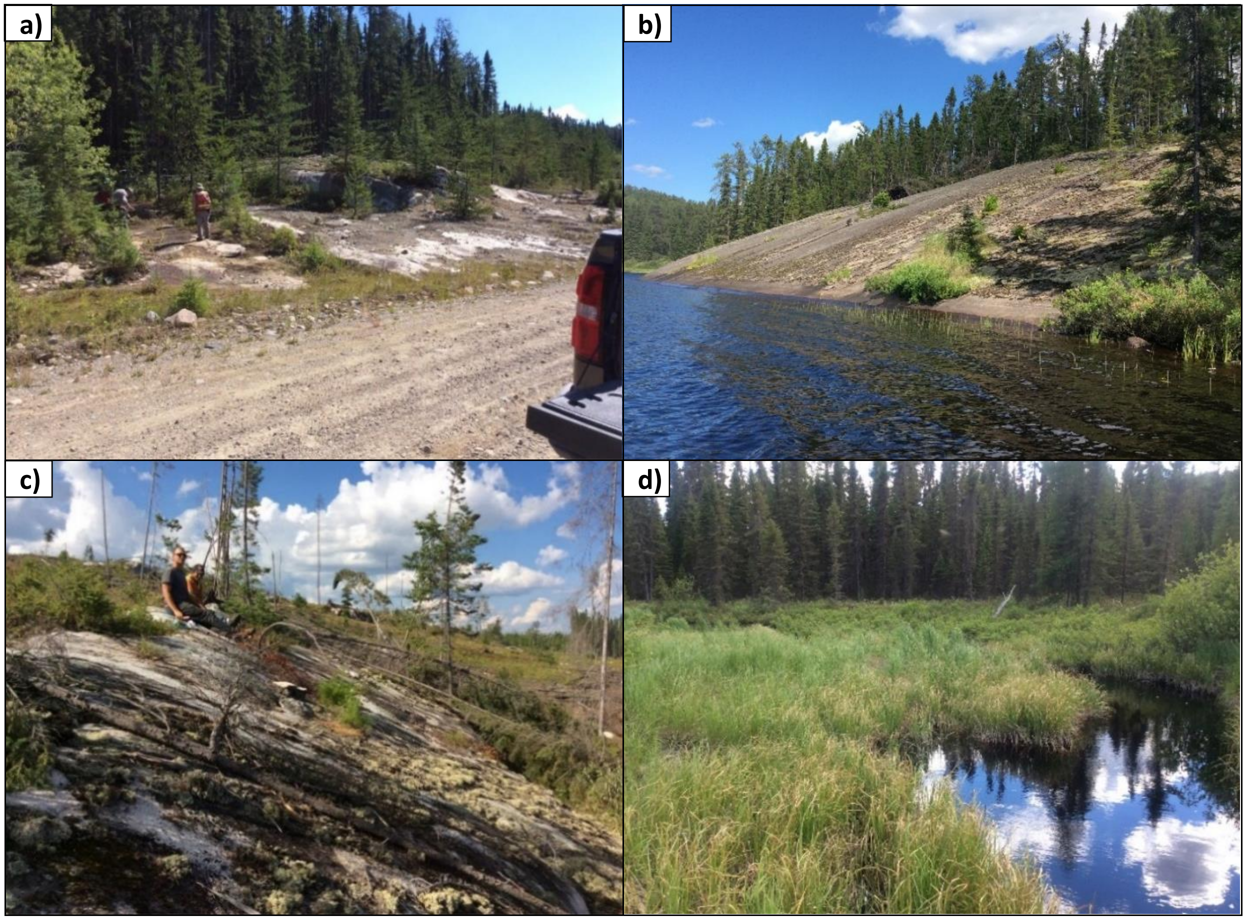


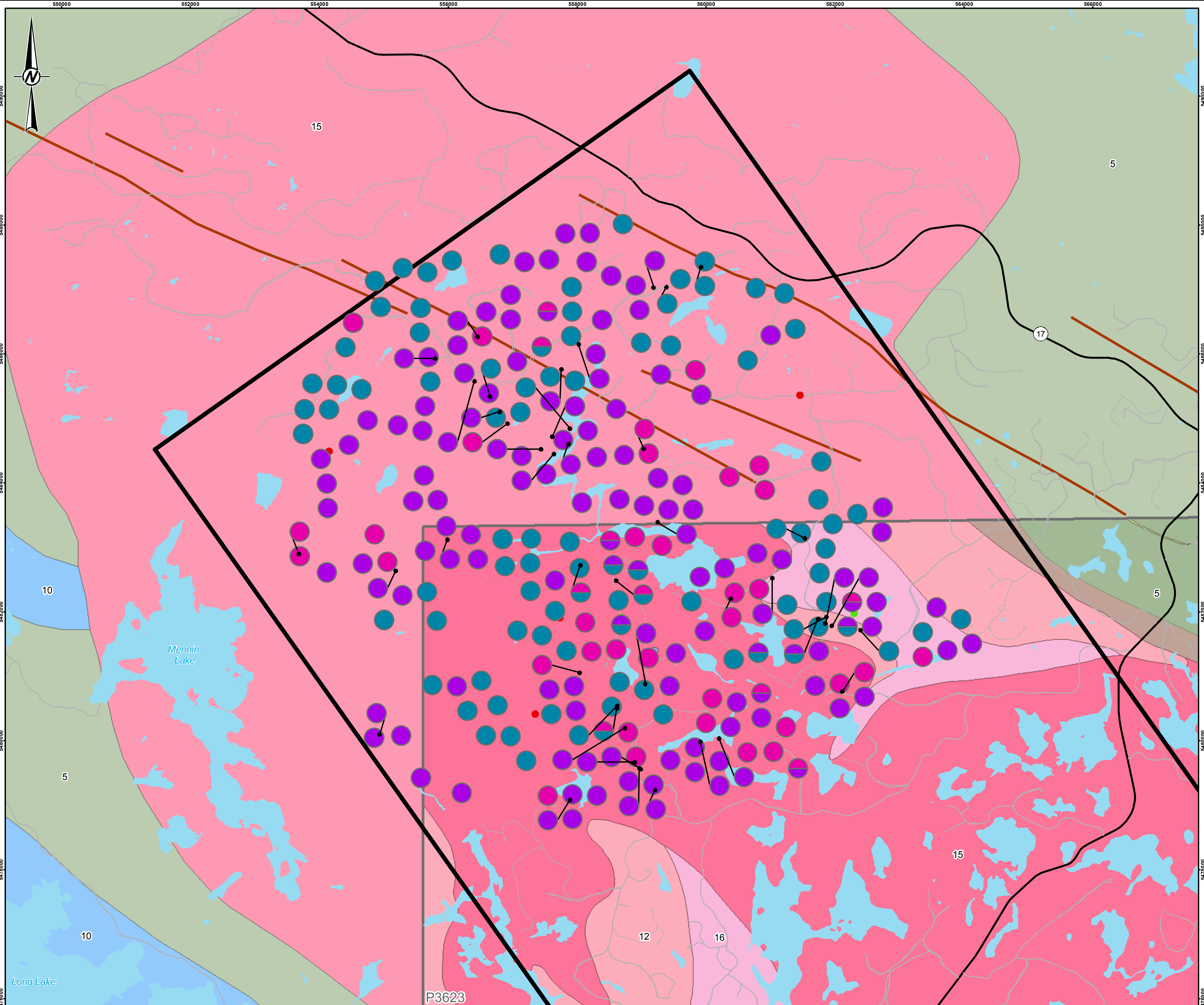
Figure 5.1.2: REVELL BATHOLITH AREA – Field Examples of Accessibility and Bedrock Exposure

a - Typical secondary forestry road used for access. View to the northeast, person for scale (Station 16FB3136).

b - River system providing access to the southwestern Revell batholith area. View to the northwest (Station 16IL1062).

c – Example of the degree of bedrock exposure in the recently logged areas of the northern and eastern portions of the Revell batholith area. View to the north, person for scale (Station 16IL1160).

d - North-striking lineament expressed as a small creek. View to the west (100 m west of Station 16TC3029).



LEGEND

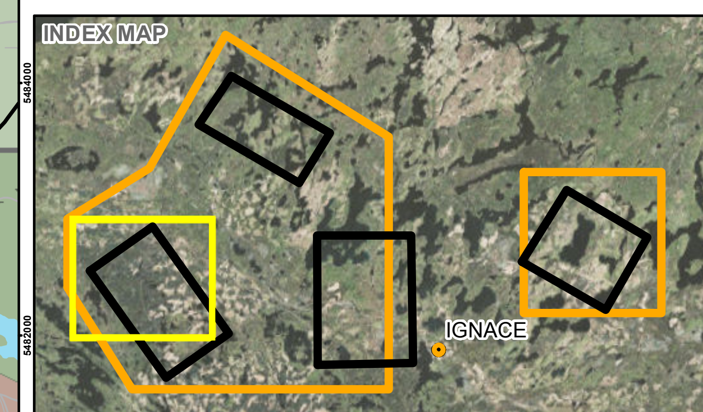
- Withdrawal Area
- Main Road
- Local Road
- Waterbody
- Outcrop (3)
- Overburden (4)

Major Lithology

- Granite(43)
- Granodiorite(130)
- Tonalite(91)
- OGS Mapped Dyke
- Detailed Geology Boundary

Bedrock Geology

- 31 Sibley Gp.
- 16 Hornblendite - nepheline syenite suite
- 15 Massive granodiorite to granite
- 12 Foliated tonalite suite
- 10 Mafic and ultramafic rocks
- 5 Mafic to intermediate metavolcanic rocks



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REFERENCE(S)
1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
2A. STONE, HELLEBRANDT & LANGE 2011 (P3623)
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015) AND DOMTAR (2015)

CLIENT
NWMO
IGNACE, ONTARIO

PROJECT
IGNACE DETAILED MAPPING REPORT

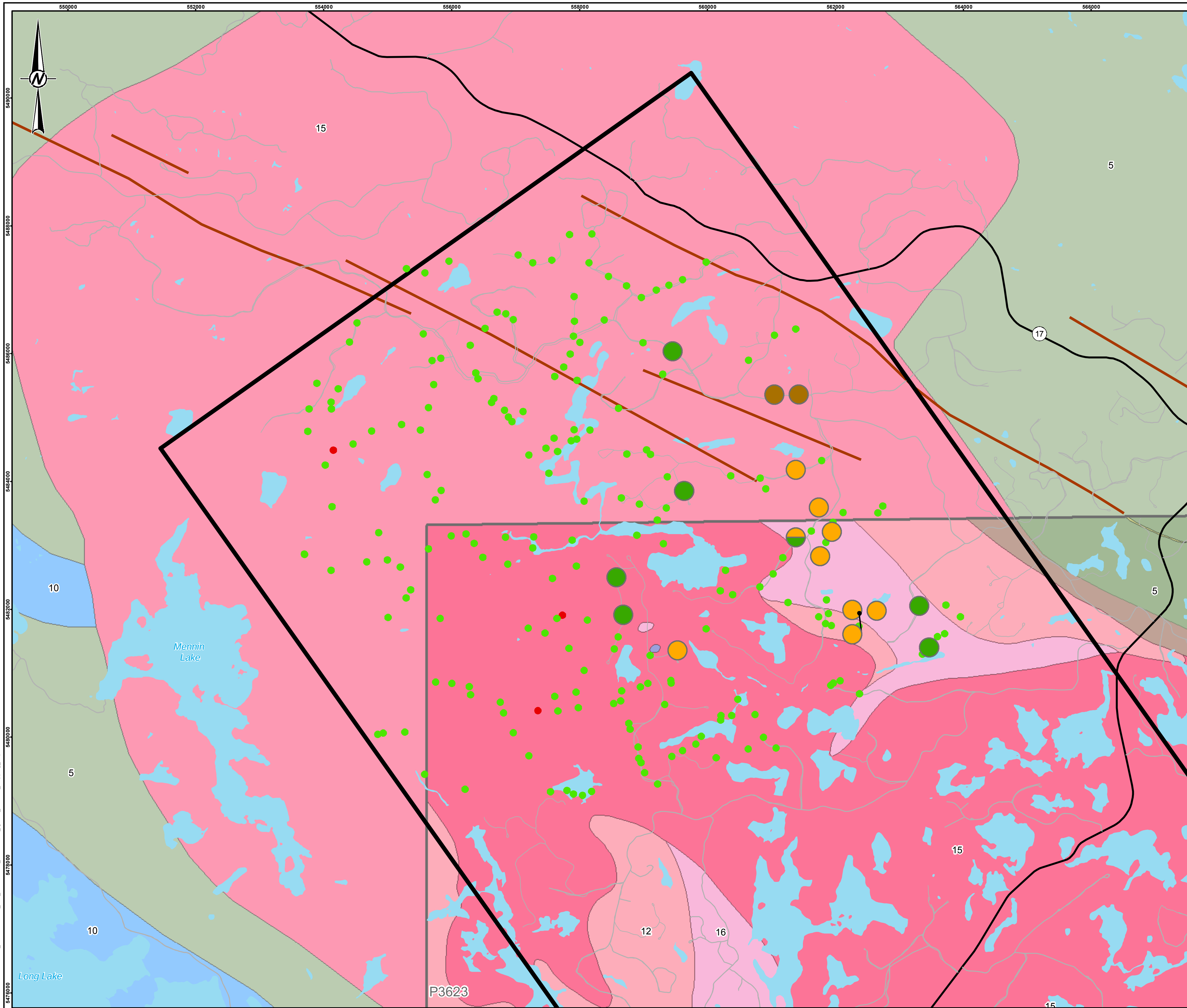
TITLE
REVELL BATHOLITH AREA - MAIN LITHOLOGICAL UNITS

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1532407			5.1.3a



LEGEND

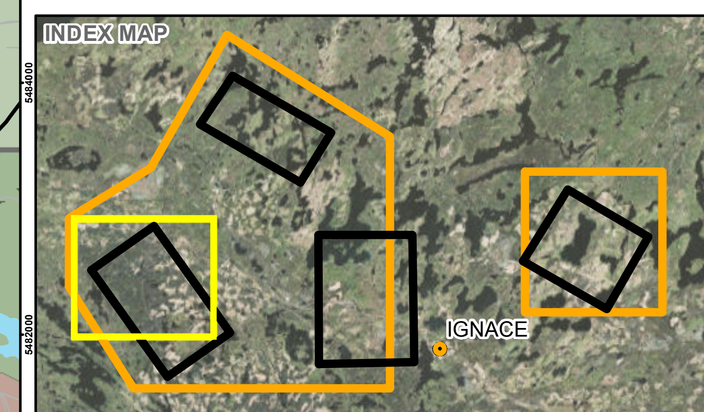
- Withdrawal Area
- Main Road
- Local Road
- Waterbody
- Outcrop (208)
- Overburden (4)

Minor Lithology

- Diorite / Quartz Diorite (9)
- Metamafic Rocks (7)
- Schist (2)
- OGS Mapped Dyke
- Detailed Geology Boundary

Bedrock Geology

- 31 Sibley Gp.
- 16 Hornblendite - nepheline syenite suite
- 15 Massive granodiorite to granite
- 12 Foliated tonalite suite
- 10 Mafic and ultramafic rocks
- 5 Mafic to intermediate metavolcanic rocks



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REFERENCE(S)
1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
2A. STONE, HELLEBRANDT & LANGE 2011 (P3623)
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015) AND DOMTAR (2015)

CLIENT
NWMO
IGNACE, ONTARIO

PROJECT
IGNACE DETAILED MAPPING REPORT

TITLE
REVELL BATHOLITH AREA - MINOR LITHOLOGICAL UNITS

CONSULTANT

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1532407			5.1.3b

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:
25mm

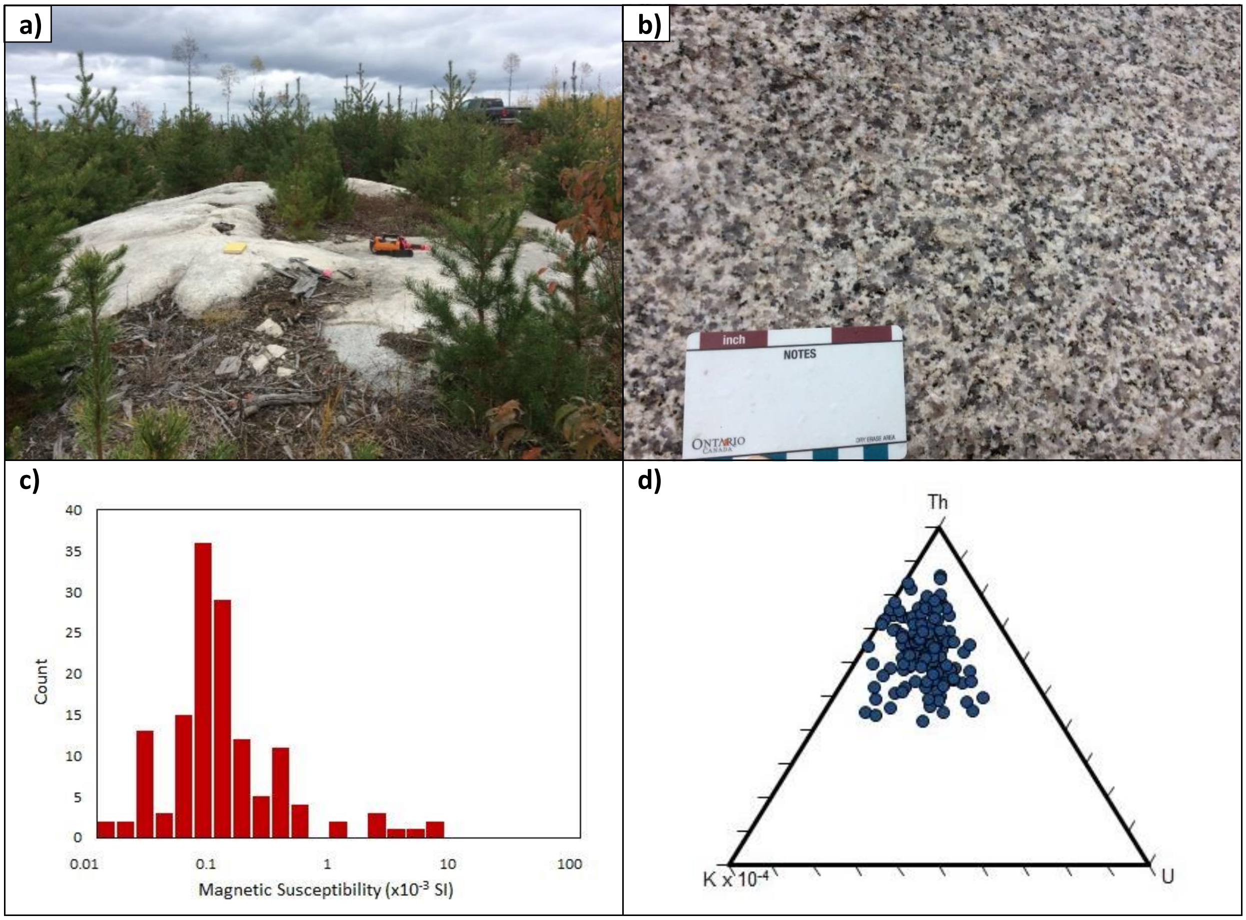


Figure 5.1.4: REVELL BATHOLITH AREA – Field Examples of Main Lithology – Granodiorite

a – Field example of granodiorite at outcrop scale. View to the east, hammer for scale (Station 15IL1016).

b – Close-up of granodiorite showing mineral composition and texture. View to the northeast, card for scale (Station 16IL1039).

c – Logarithmic plot of magnetic susceptibility for granodiorite. (N=141).

d – Ternary plot of gamma ray spectrometer data for granodiorite (N=143).

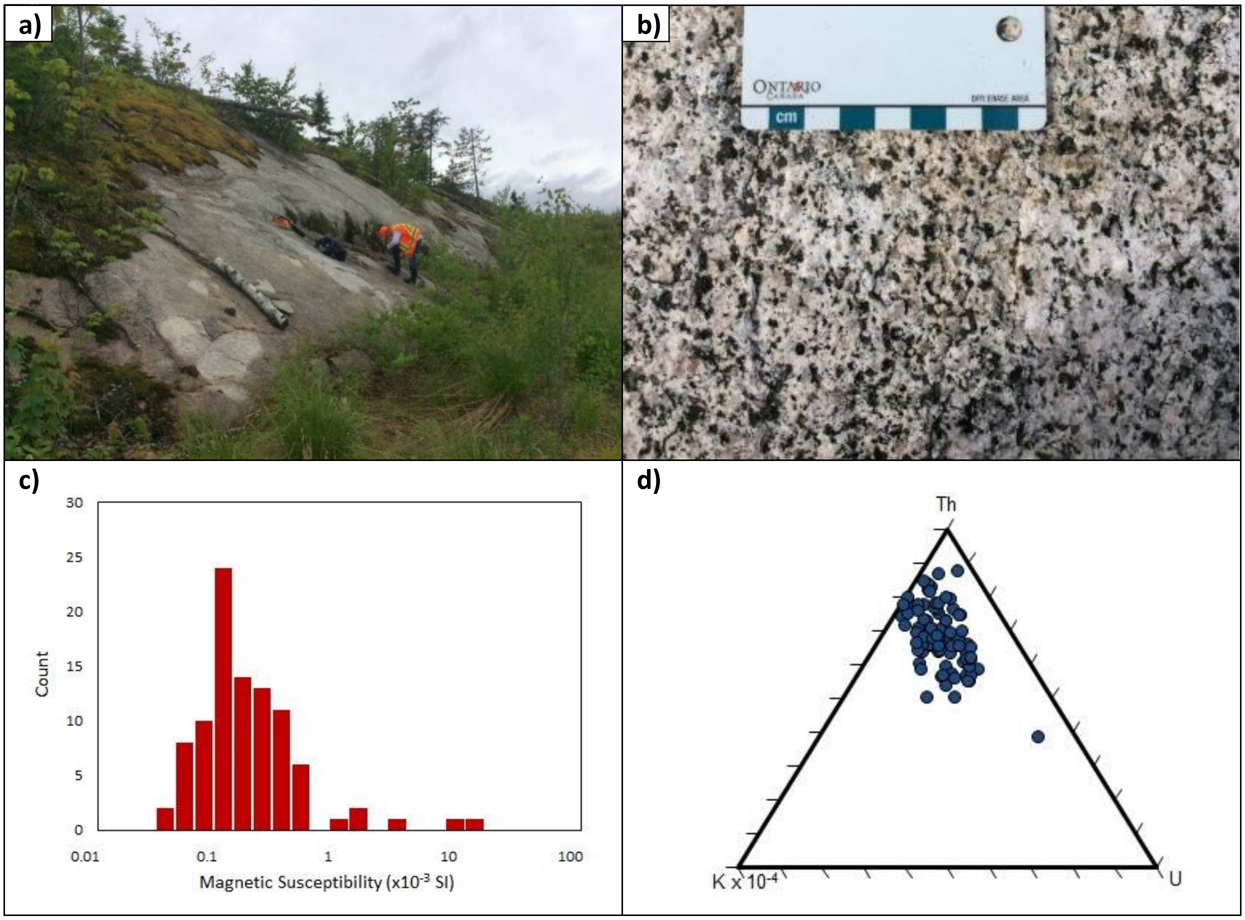


Figure 5.1.5: REVELL BATHOLITH AREA – Field Examples of Main Lithology – Tonalite

a – Field example of tonalite at outcrop scale. View to the north, person for scale (Station 16IL1041)

b – Close-up of tonalite showing mineral composition and texture. Unoriented photo, card for scale (Station 15TC3017).

c – Logarithmic plot of magnetic susceptibility for tonalite (N=94).

d – Ternary plot of gamma ray spectrometer data for tonalite (N=90).

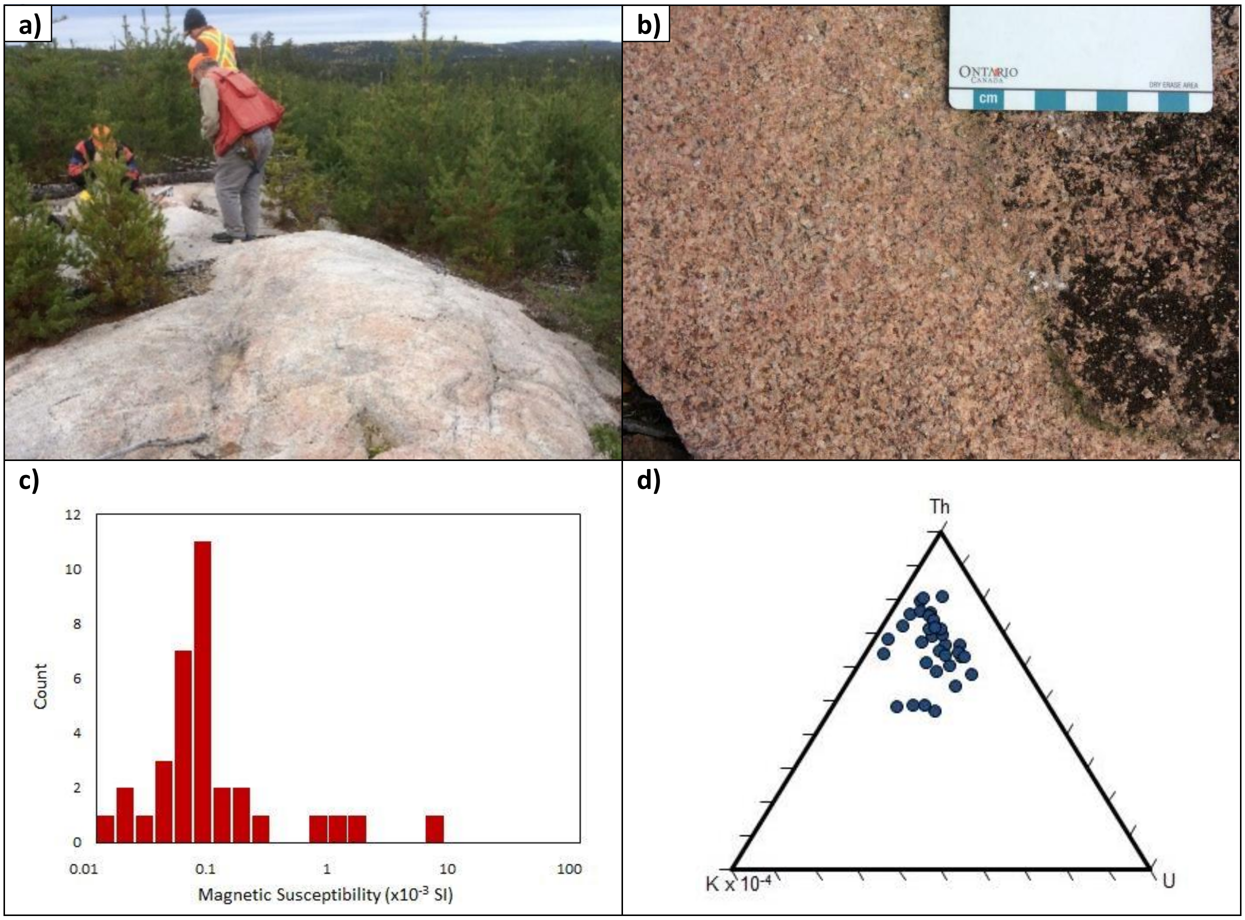


Figure 5.1.6: REVELL BATHOLITH AREA – Field Examples of Main Lithology – Granite

a – Field example of granite at outcrop scale. View to the southwest, person for scale (Station 15TC3018).

b – Close-up of granite showing mineral composition and texture. Unoriented photo, card for scale (Station 15IL1004).

c – Logarithmic plot of magnetic susceptibility for granite (N=34).

d – Ternary plot of gamma ray spectrometer data for granite (N=36).

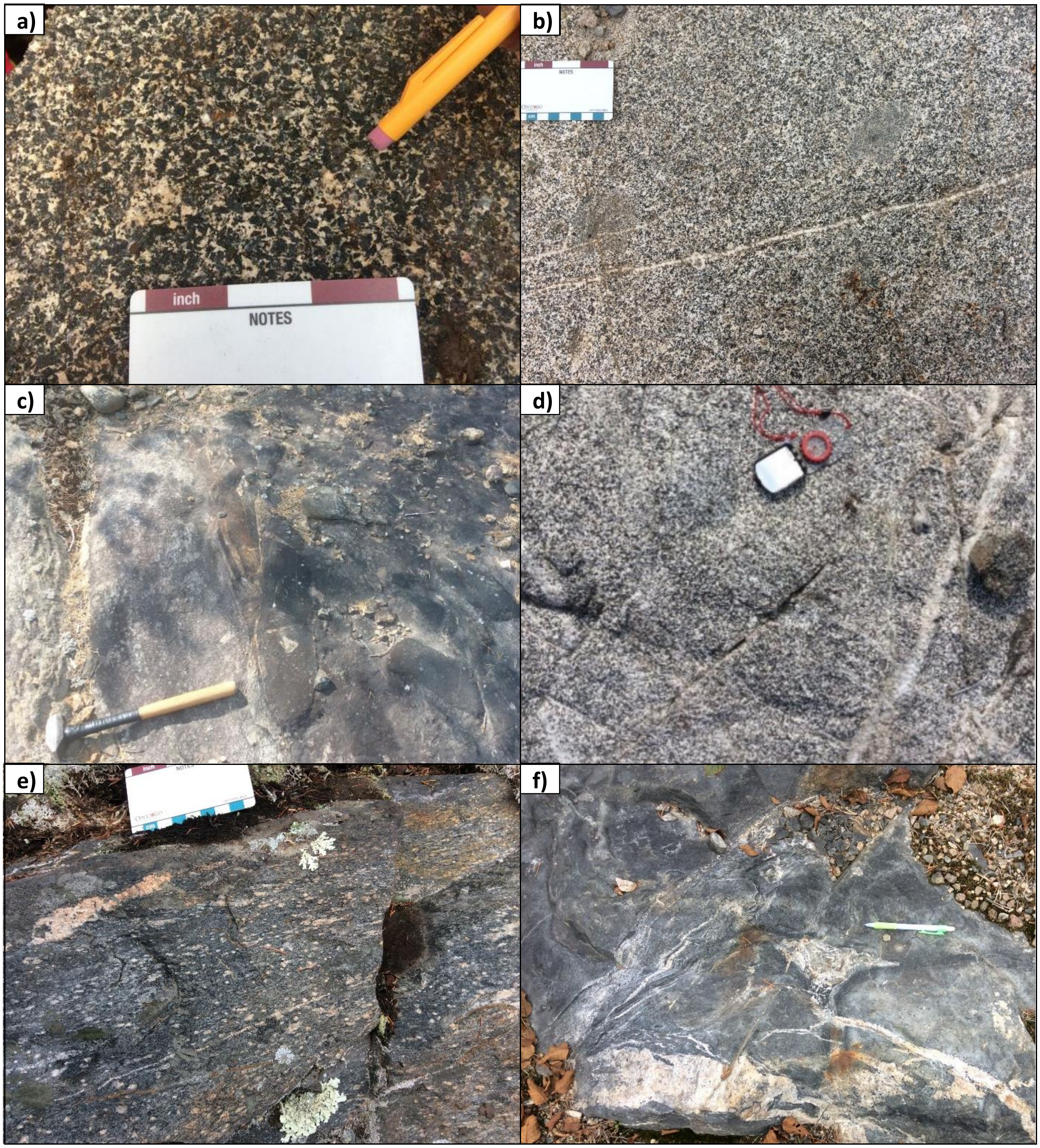


Figure 5.1.7: REVELL BATHOLITH AREA – Field Examples of Minor Lithological Units

a - Photo of diorite. Unoriented sample photo, card for scale (Station 15IL1001).

b - Photo of quartz diorite. Unoriented photo, card for scale (Station 15IL1010).

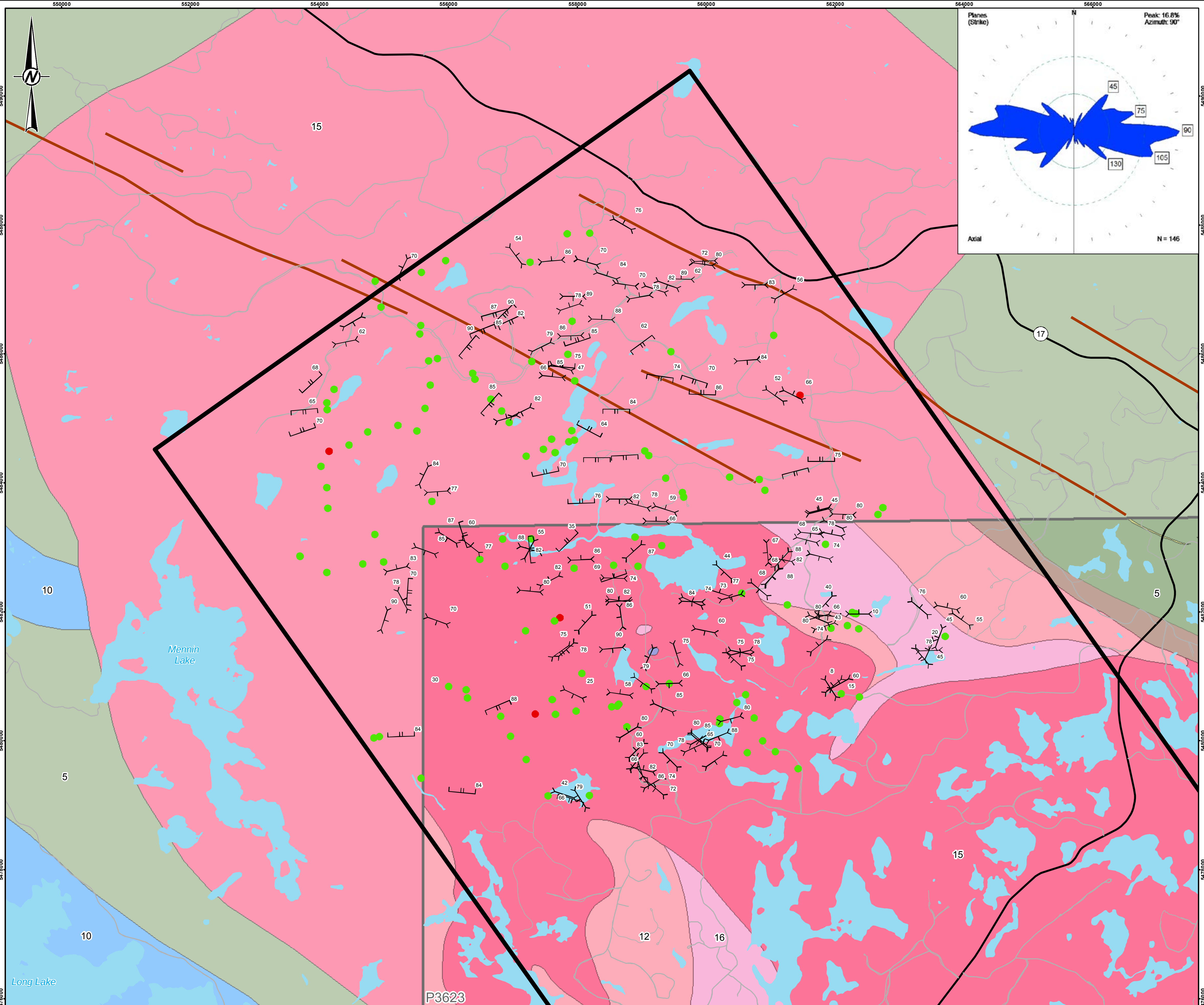
c - Photo of weathered schist with mafic metavolcanic rafts. View to the east, hammer for scale (Station 16TC2148).

d - Photo of gabbro. View to the northwest, compass for scale (Station 16FB3177).

Figure 5.1.7 (Cont'd): REVELL BATHOLITH AREA – Field Examples of Minor Lithological Units

e - Photo of mafic volcanic flow. View to the northwest, card for scale (Station 15IL1031).

f - Photo of pillow basalt. View to the east, pencil for scale (Station 15IL1033).



LEGEND

- Withdrawal Area
- Main Road
- Local Road
- Waterbody
- Outcrop (111)
- Overburden (4)
- Fracture Cleavage (1)
- Tectonic Foliation (120)
- Gneissic Layering (1)
- Igneous Flow Foliation (31)
- OGS Mapped Dyke
- Detailed Geology Boundary

Bedrock Geology

- 31 Sibley Gp.
- 16 Hornblendite - nepheline syenite suite
- 15 Massive granodiorite to granite
- 12 Foliated tonalite suite
- 10 Mafic and ultramafic rocks
- 5 Mafic to intermediate metavolcanic rocks

0 2 4

1:60,000 KILOMETRES

REFERENCE(S)

1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
2A. STONE, HELLEBRANDT & LANGE 2011 (P3623)
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015) AND DOMTAR (2015)

CLIENT
NWMO
IGNACE, ONTARIO

PROJECT
IGNACE DETAILED MAPPING REPORT

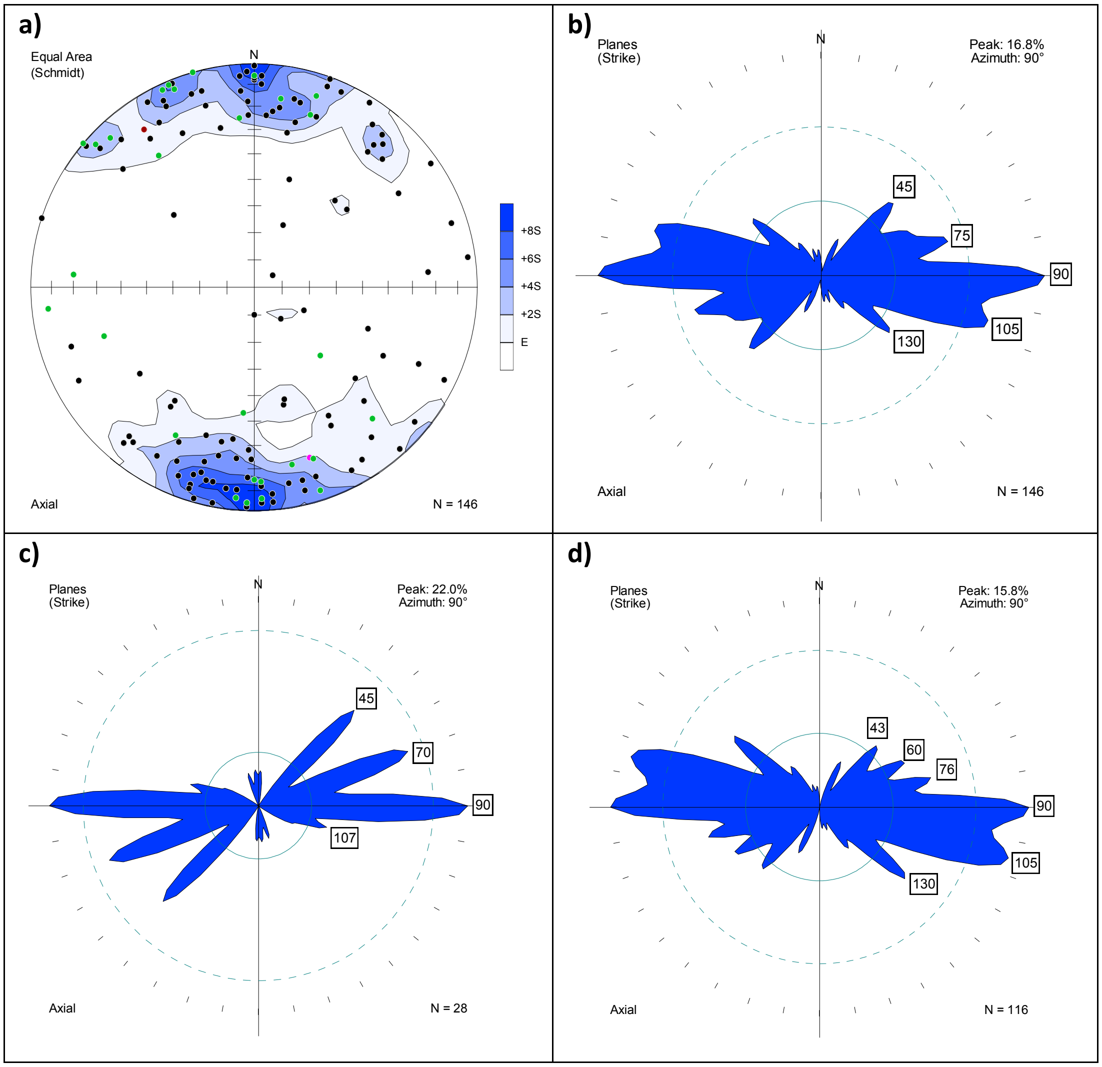
TITLE
REVELL BATHOLITH AREA - FOLIATION

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1532407			5.1.8



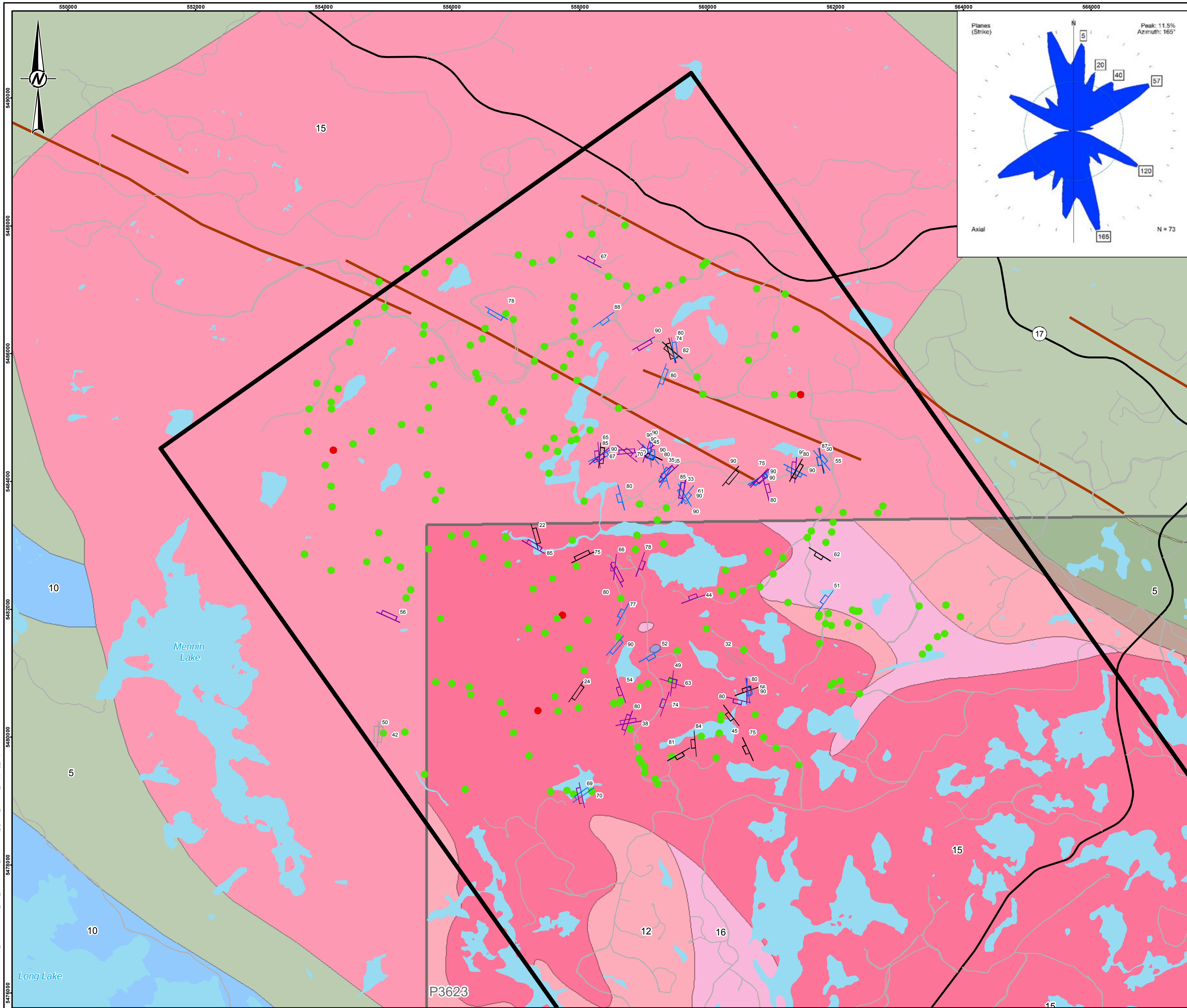
<u>Figure 5.1.9: REVELL BATHOLITH AREA – Foliation Orientation Data</u>

a - All foliation data displayed as equal area lower hemisphere stereonet plot of poles to foliation planes. Tectonic foliation: black circles (N=116). Igneous flow foliation: green circles (N=28). Gneissic layering: pink circle (N=1). Fracture cleavage: blue circle (N=1). Contours show multiples of the standard deviation S above the expectant count E calculated using Gaussian K-100.

b - All foliation data displayed as rose diagram of trends of foliation planes (N=146). Bins for rose diagrams are 10°.

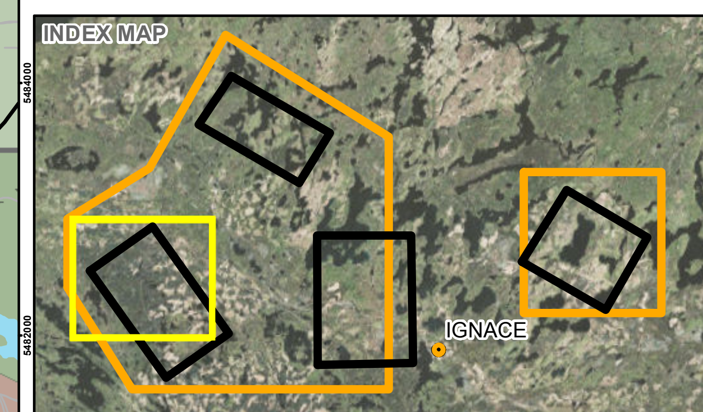
c - Igneous flow foliation data displayed as rose diagram of trends of foliation planes (N=28). Bins for rose diagrams are 10°.

d - Tectonic foliation data displayed as rose diagram of trends of foliation planes (N=116). Bins for rose diagrams are 10°.



LEGEND
- Withdrawal Area
- Main Road
- Local Road
- Waterbody
- Outcrop (210)
- Overburden (4)
- Brittle-ductile shear zones - Dextral (18)
- Brittle-ductile shear zones - Sinistral (12)
- Brittle-ductile shear zones - Unknown Slip (8)
- Ductile Shear zone - Dextral (12)
- Ductile Shear zone - Sinistral (12)
- Ductile Shear zone - Reverse (3)
- Ductile Shear zone - Unknown Slip (8)
- OGS Mapped Dyke
- Detailed Geology Boundary

Bedrock Geology
- 31 Sibley Gp.
- 16 Hornblendite - nepheline syenite suite
- 15 Massive granodiorite to granite
- 12 Foliated tonalite suite
- 10 Mafic and ultramafic rocks
- 5 Mafic to intermediate metavolcanic rocks



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REFERENCE(S)
1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
2A. STONE, HELLEBRANDT & LANGE 2011 (P3623)
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015) AND DOMTAR (2015)

CLIENT
NWMO
IGNACE, ONTARIO

PROJECT
IGNACE DETAILED MAPPING REPORT

TITLE
REVELL BATHOLITH AREA - DUCTILE AND BRITTLE-DUCTILE SHEAR ZONES

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1532407			5.1.10

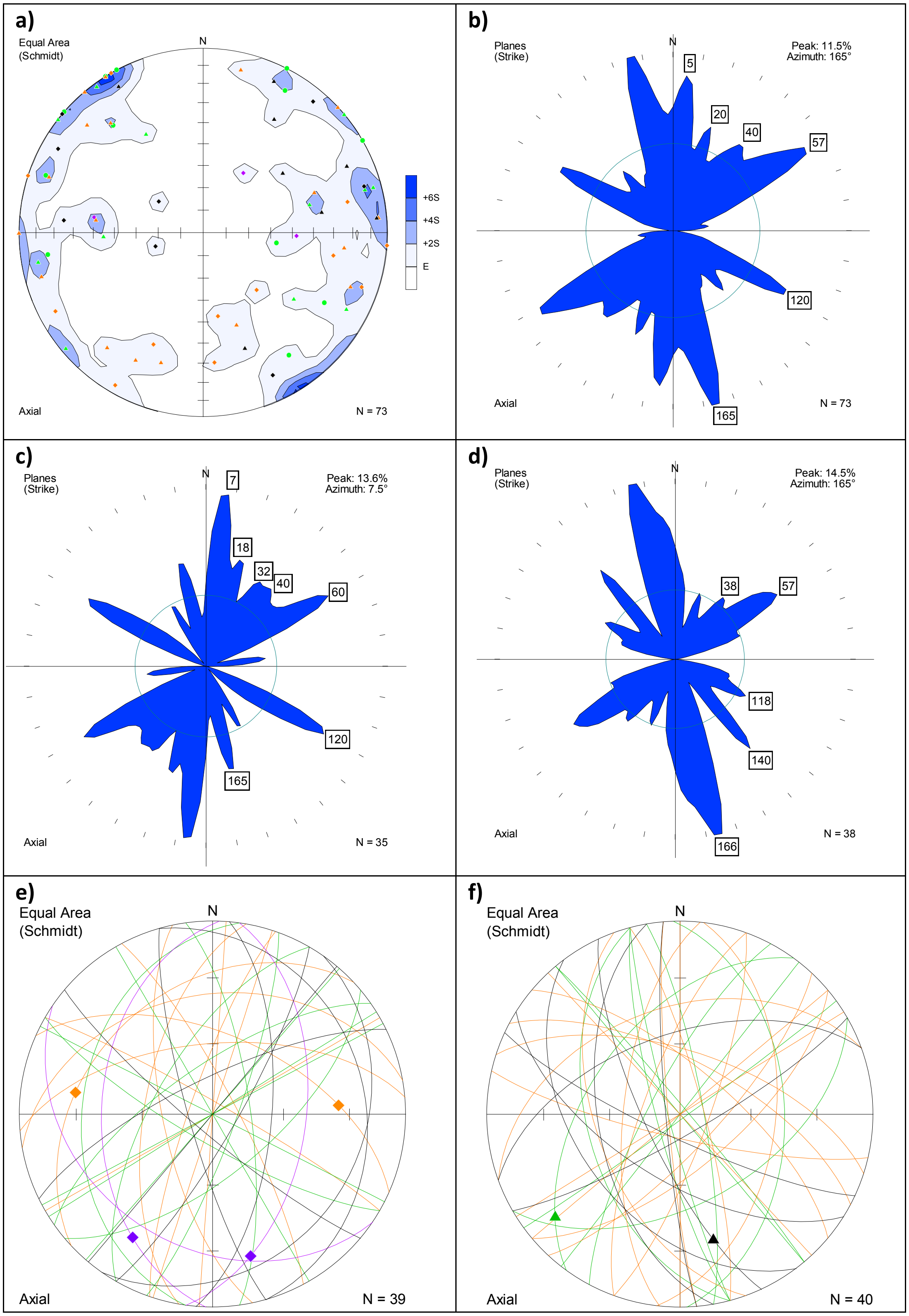

a)
Equal Area
(Schmidt)
N
+6S
+4S
+2S
E
Axial
N = 73
b)
Planes
(Strike)
N
Peak: 11.5%
Azimuth: 165°
5
20
40
57
120
165
Axial
N = 73
c)
Planes
(Strike)
N
Peak: 13.6%
Azimuth: 7.5°
7
18
32
40
60
120
165
Axial
N = 35
d)
Planes
(Strike)
N
Peak: 14.5%
Azimuth: 165°
38
57
118
140
166
Axial
N = 38
e)
Equal Area
(Schmidt)
N
Axial
N = 39
f)
Equal Area
(Schmidt)
N
Axial
N = 40

Figure 5.1.11: REVELL BATHOLITH AREA – Ductile and Brittle-Ductile Shear Zone Orientation Data

a - All shear zones displayed as equal area lower hemisphere stereonet plot of poles to shear planes. Ductile shear zones are displayed as diamonds, brittle ductile shear zones as triangles. Dextral brittle-ductile shear zones: orange triangles (N=18). Sinistral brittle-ductile shear zones: green triangles (N=12). Dextral ductile shear zones: orange diamonds (N=12). Sinistral ductile shear zones: green diamonds (N=12). Reverse ductile shear zones: purple diamonds (N=3). Structures brittle-ductile shear zones with unknown slip: black triangles (N=8). Ductile shear zones with unknown slip: black diamonds (N=8). Contours show multiples of the standard deviation S above the expectant count E calculated using Gaussian K-100.

b - All shear zone data displayed as rose diagram of trends of shear planes (N=73). Bins for rose diagrams are 10°.

c - Ductile shear zone data displayed as rose diagram of trends of shear planes (N=35). Bins for rose diagrams are 10°.

d - Brittle-ductile shear zone data displayed as rose diagram of trends of shear planes (N=38). Bins for rose diagrams are 10°.

e - Ductile shear zones with lineation displayed as equal area lower hemisphere stereonet plot of great circles (N=35) and associated lineations (N=4). Dextral structures: orange lines (N=12). Sinistral structures: green lines (N=12). Reverse structures: purple lines (N=3). Structures with unknown slip sense: black (N=8).

f - Brittle-ductile shear zones with lineation displayed as equal area lower hemisphere stereonet plot of great circles (N=38) and associated lineations (N=2). Dextral structures: orange lines (N=18). Sinistral structures: green lines (N=12). Structures with unknown slip sense: black (N=8).

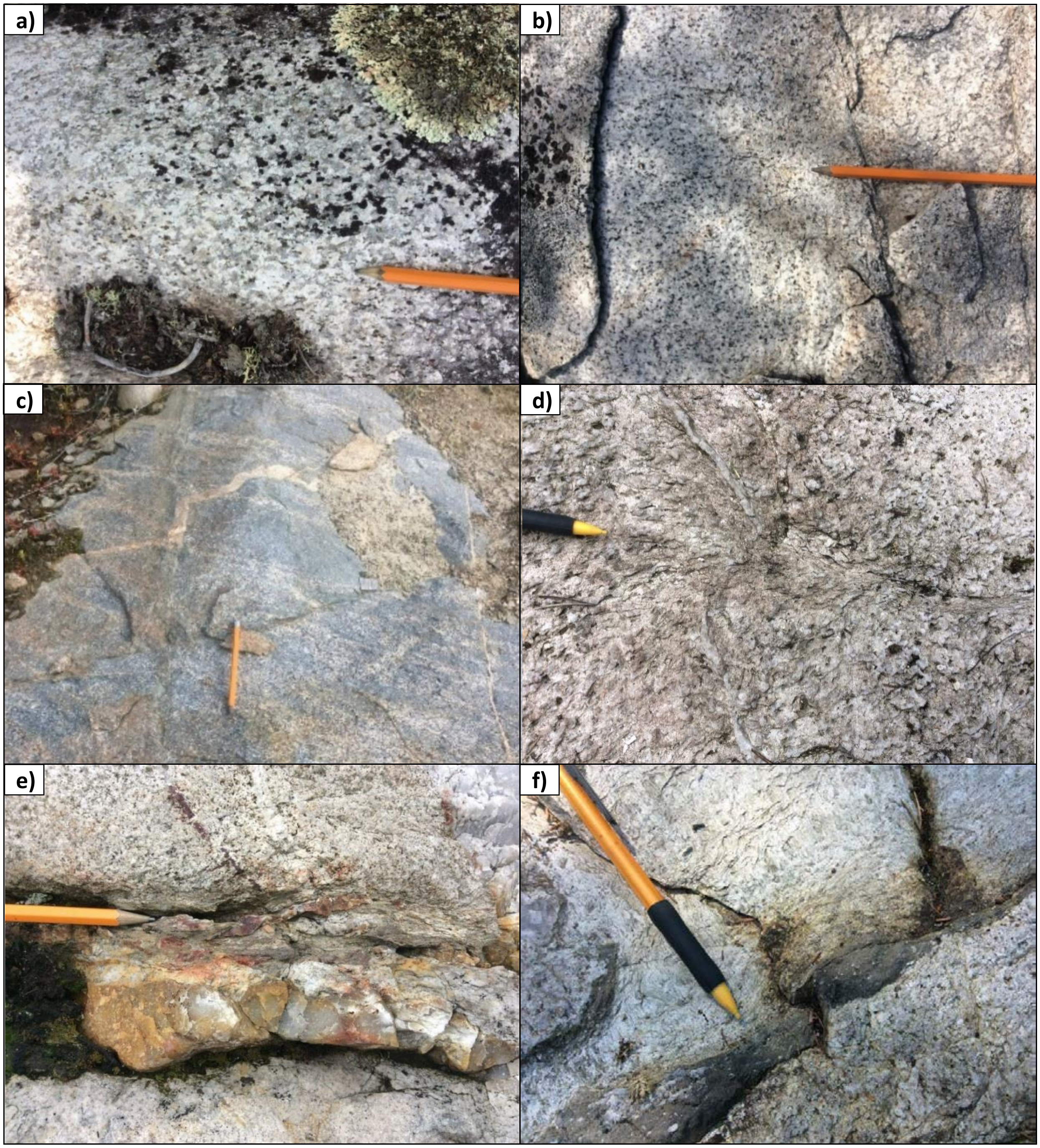


Figure 5.1.12: REVELL BATHOLITH AREA – Field Examples of Ductile Structures

a - Igneous flow foliation in tonalite. View to the north, pencil for scale (Station 16IL1155).

b - Weakly defined biotite tectonic foliation in granodiorite (088/86). View to the north, pencil for scale indicates strike orientation of foliation (Station 16IL1149).

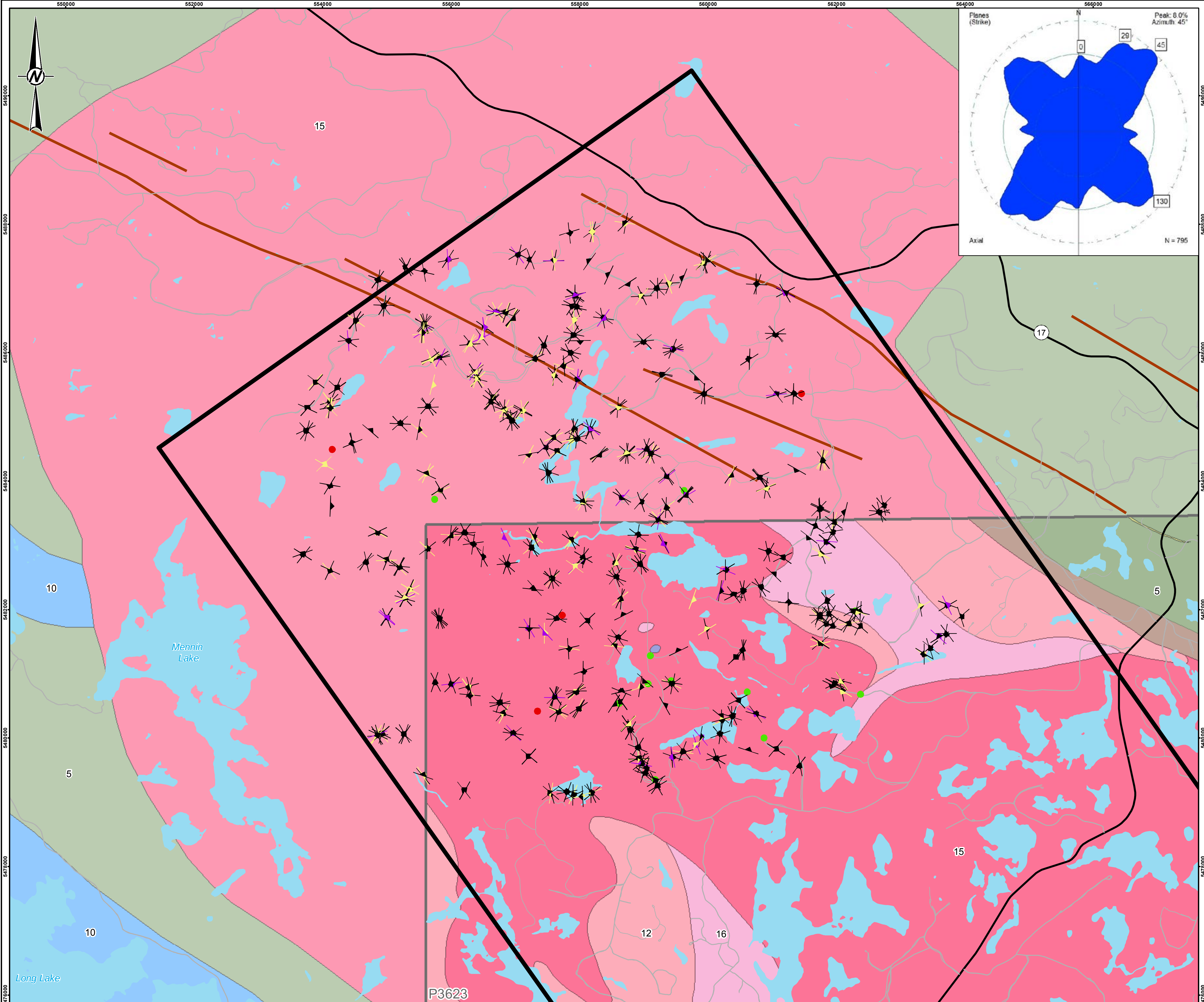
c - Gneissic layering in a tonalite gneiss xenolith (252/69). View to the north, pencil for scale (Station 16TC21160).

Figure 5.1.12 (Cont'd): REVELL BATHOLITH AREA – Field Examples of Ductile Structures

d - Ductile shear zone showing sinistral drag on a quartz vein (235/70) offset by a dextral ductile shear zone (168/69). Dextral shear zone is parallel to the pencil. View to the west, pencil for scale (Station 16IL1053).

e - Brittle-ductile shear zone (250/44) with quartz vein infill and hematite staining. Plan view to the north, pencil for scale (Station 15IL1012).

f - Close-up photo of a shear zone with linear fabric. Ductile reverse shear zone (008/50) with pseudotachylite, pencil indicates direction of lineation. View to the south, pencil for scale (Station 16IL1066).

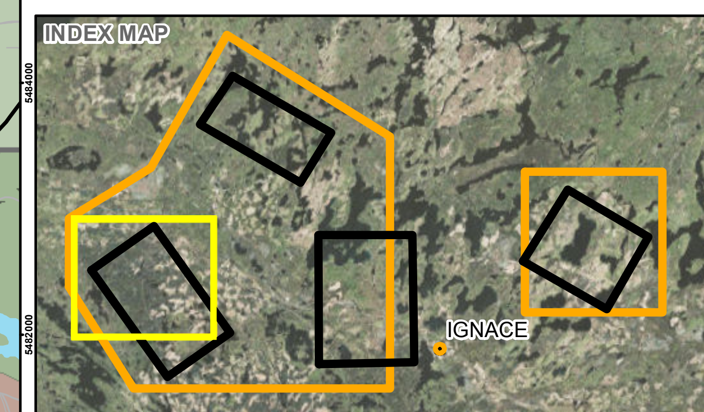


LEGEND

- Withdrawal Area
- Main Road
- Local Road
- Waterbody
- Outcrop (11)
- Overburden (4)
- Sub horizontal joint: 0° - 24° (43)
- Intermediate joint: 25° - 65° (156)
- Sub vertical joint: 66° - 90° (596)
- OGS Mapped Dyke
- Detailed Geology Boundary

Bedrock Geology

- 31 Sibley Gp.
- 16 Hornblendite - nepheline syenite suite
- 15 Massive granodiorite to granite
- 12 Foliated tonalite suite
- 10 Mafic and ultramafic rocks
- 5 Mafic to intermediate metavolcanic rocks



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REFERENCE(S)
1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
2A. STONE, HELLEBRANDT & LANGE 2011 (P3623)
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015) AND DOMTAR (2015)

CLIENT
NWMO
IGNACE, ONTARIO

PROJECT
IGNACE DETAILED MAPPING REPORT

TITLE
REVELL BATHOLITH AREA - JOINTS

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1532407			5.1.13

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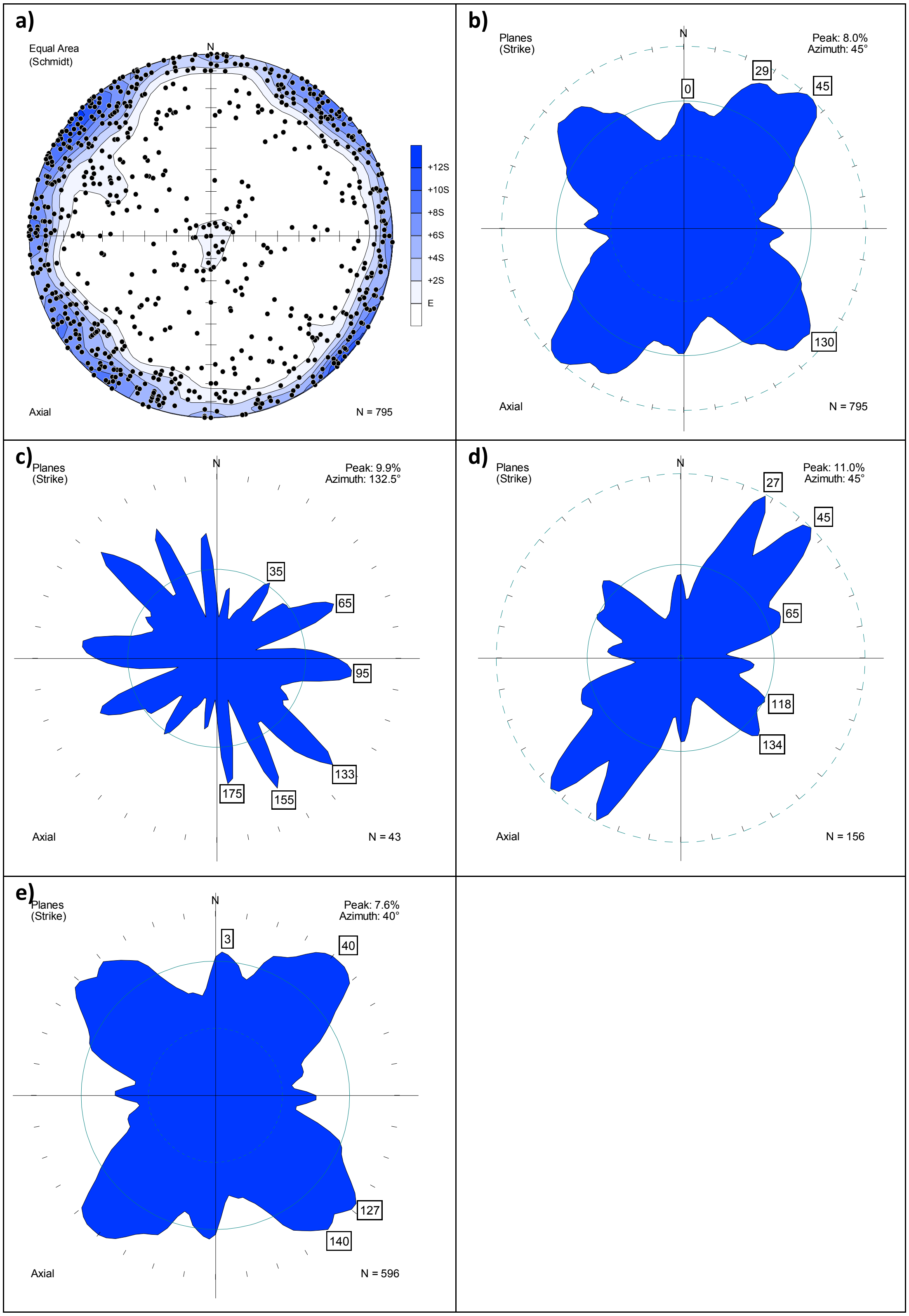
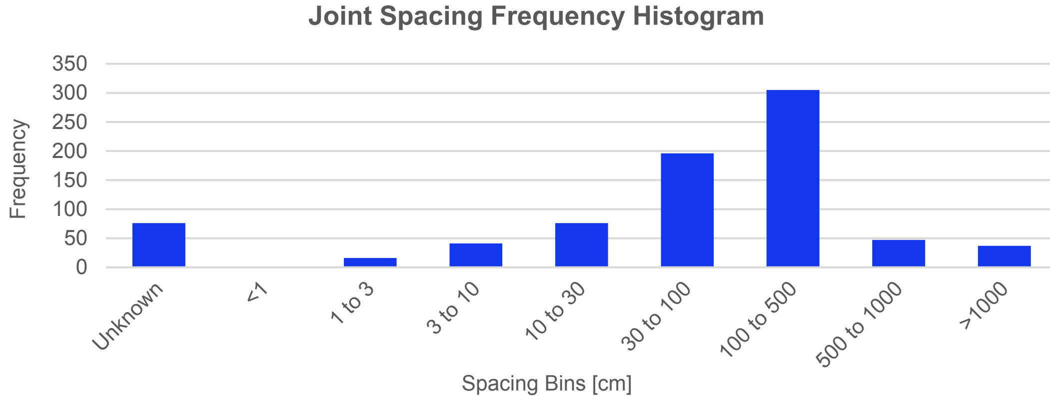
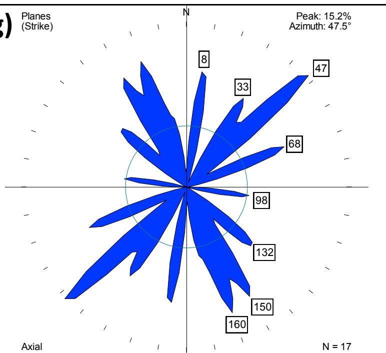

a)
Equal Area
(Schmidt)
N
+12S
+10S
+8S
+6S
+4S
+2S
E
Axial
N = 795
b)
Planes
(Strike)
N
Peak: 8.0%
Azimuth: 45°
0
29
45
130
Axial
N = 795
c)
Planes
(Strike)
N
Peak: 9.9%
Azimuth: 132.5°
35
65
95
133
155
175
Axial
N = 43
d)
Planes
(Strike)
N
Peak: 11.0%
Azimuth: 45°
27
45
65
118
134
Axial
N = 156
e)
Planes
(Strike)
N
Peak: 7.6%
Azimuth: 40°
3
40
127
140
Axial
N = 596

f)

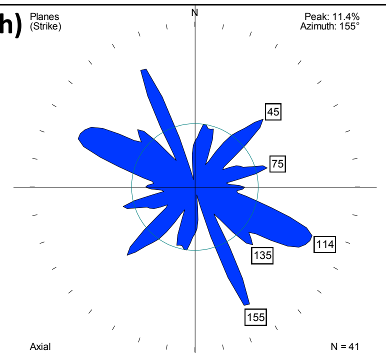


g)



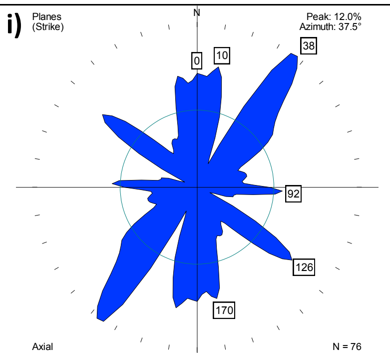
1-3 cm (incl. 1 at <1cm)

h)



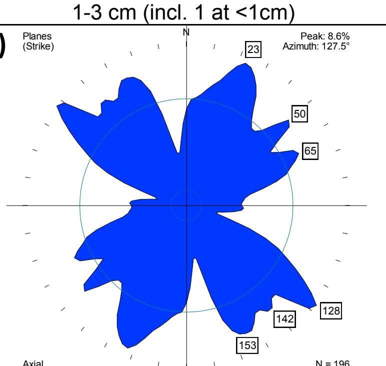
3-10 cm

i)



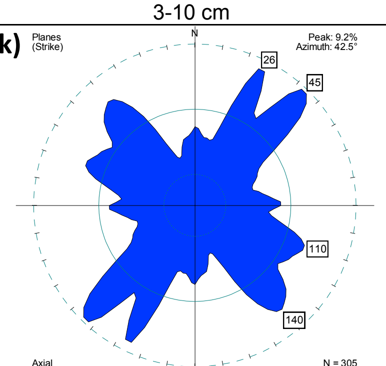
10-30 cm

j)



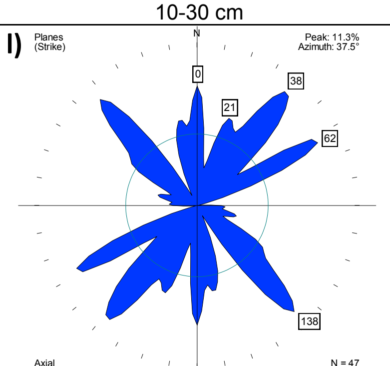
30-100 cm

k)



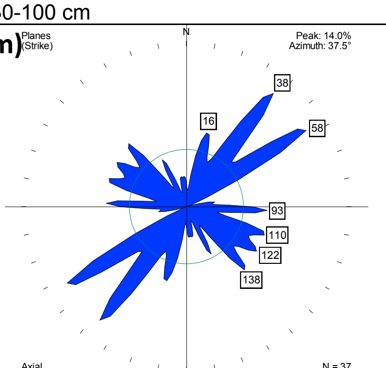
100-500 cm

l)



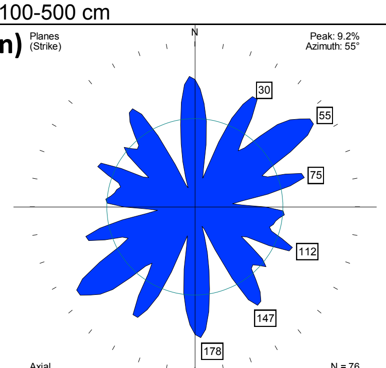
500-1000

m)



>1000

n)



None/unknown

Figure 5.1.14: REVELL BATHOLITH AREA – Joint Orientation Data and Joint Spacing Summary

a - All joint data displayed as equal area lower hemisphere stereonet plot of poles to joints (N=795). Contours show multiples of the standard deviation S above the expectant count E calculated using Gaussian K-100.

b - All joint data displayed as rose diagram of trends of joint planes (N=795). Bins for rose diagrams are 10°.

c - Shallow-dipping joints (<25° dip) displayed as rose diagram of trends of joint planes (N=43). Bins for rose diagrams are 10°.

d. – Moderately-dipping joints (25°-65°) displayed as rose diagram of trends of joint planes (N=156). Bins for rose diagrams are 10°.

e - Steep joints (>65° dip) displayed as rose diagram of trends of joint planes (N=596). Bins for rose diagrams are 10°.

f - Joint spacing histograms showing frequency distribution of all joint spacing classes.

g - Joint data with spacing <1 cm and 1-3 cm displayed as rose diagram of trends of joint planes (N=17). Bins for rose diagrams are 10°.

h - Joint data with spacing 3-10 cm displayed as rose diagram of trends of joint planes (N=41). Bins for rose diagrams are 10°.

i - Joint data with spacing 10-30 cm displayed as rose diagram of trends of joint planes (N=76). Bins for rose diagrams are 10°.

j - Joint data with spacing 30-100 cm displayed as rose diagram of trends of joint planes (N=196). Bins for rose diagrams are 10°.

k - Joint data with spacing 100-500 cm displayed as rose diagram of trends of joint planes (N=305). Bins for rose diagrams are 10°.

l - Joint data with spacing 500-1000 cm displayed as rose diagram of trends of joint planes (N=47). Bins for rose diagrams are 10°.

m - Joint data with spacing >1000 cm displayed as rose diagram of trends of joint planes (N=37). Bins for rose diagrams are 10°.

n - Joint data with unknown spacing displayed as rose diagram of trends of joint planes (N=76). Bins for rose diagrams are 10°.

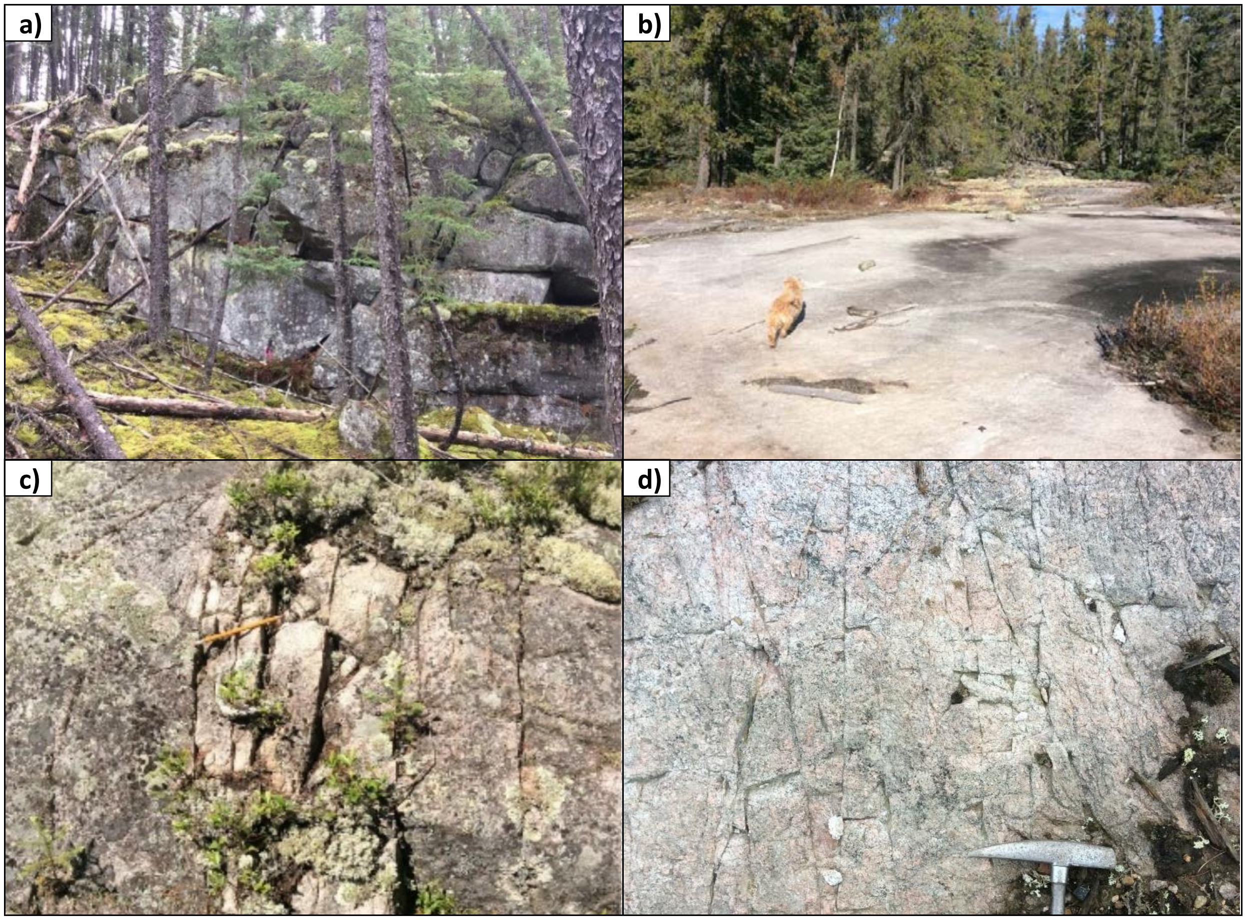


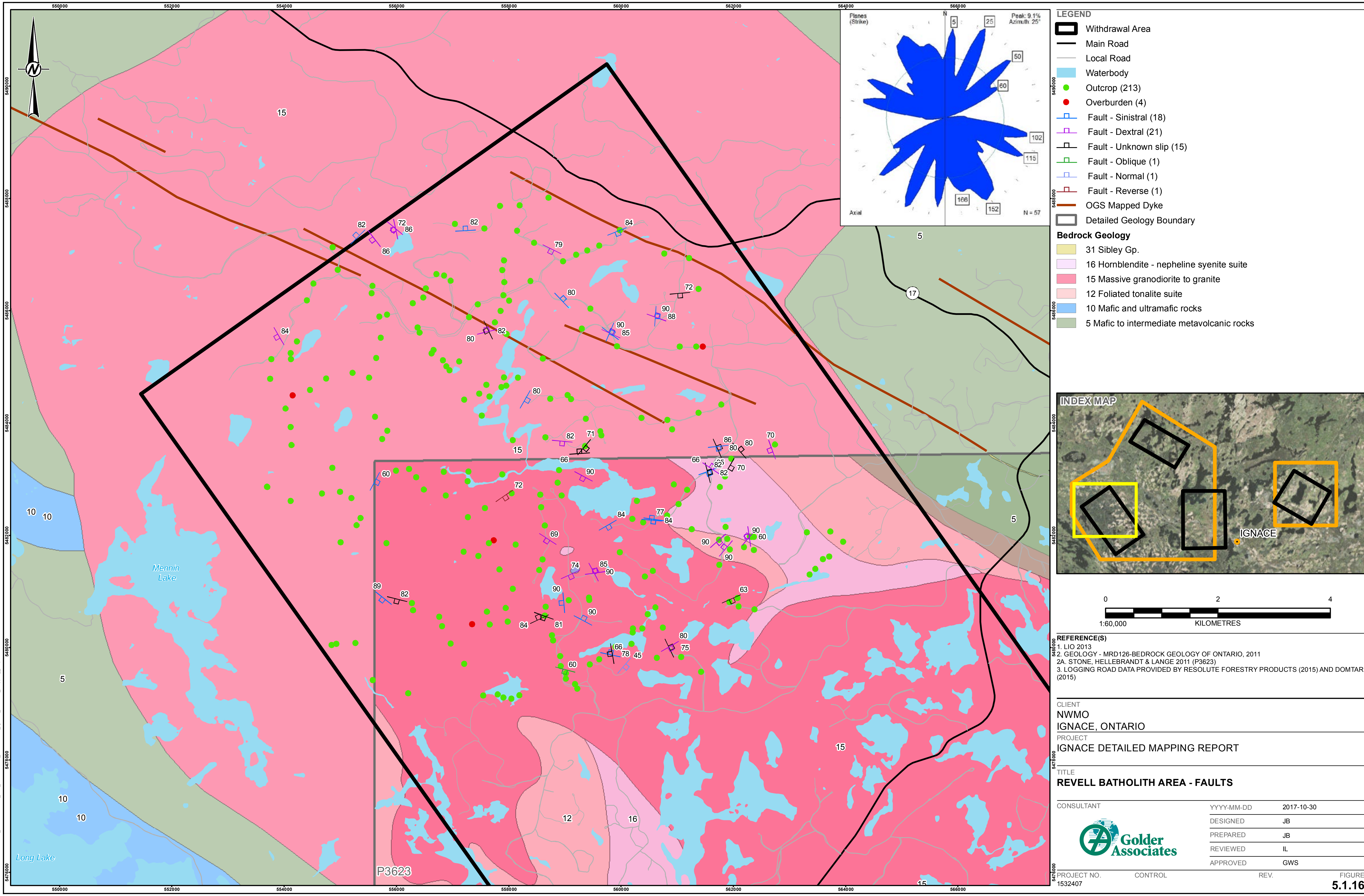
Figure 5.1.15: REVELL BATHOLITH AREA – Field Examples of Joints

a - Example of subhorizontal joint set. View to the west, hammer for scale (Station 15IL1025).

b - Example of >1000 cm joint spacing. View to the northeast, dog for scale (Station 15FB2020).

c - Example of 3-10 cm joint spacing. View to the northwest, pencil for scale (Station 16IL1064).

d - Example of multiple joint sets. View to the north, hammer for scale (Station 15IL1028).


LEGEND
Withdrawal Area
Main Road
Local Road
Waterbody
Outcrop (213)
Overburden (4)
Fault - Sinistral (18)
Fault - Dextral (21)
Fault - Unknown slip (15)
Fault - Oblique (1)
Fault - Normal (1)
Fault - Reverse (1)
OGS Mapped Dyke
Detailed Geology Boundary
Bedrock Geology
31 Sibley Gp.
16 Hornblendite - nepheline syenite suite
15 Massive granodiorite to granite
12 Foliated tonalite suite
10 Mafic and ultramafic rocks
5 Mafic to intermediate metavolcanic rocks
Planes (Strike)
Peak: 9.1%
Azimuth: 25°
Axial
N = 57
INDEX MAP
IGNACE
Mennin Lake
Long Lake
P3623
1:60,000
KILOMETRES
REFERENCE(S)
1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
2A. STONE, HELLEBRANDT & LANGE 2011 (P3623)
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015) AND DOMTAR (2015)
CLIENT
NWMO
IGNACE, ONTARIO
PROJECT
IGNACE DETAILED MAPPING REPORT
TITLE
REVELL BATHOLITH AREA - FAULTS
CONSULTANT
Golder Associates
YYYY-MM-DD 2017-10-30
DESIGNED JB
PREPARED JB
REVIEWED IL
APPROVED GWS
PROJECT NO. 1532407
CONTROL
REV.
FIGURE 5.1.16
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

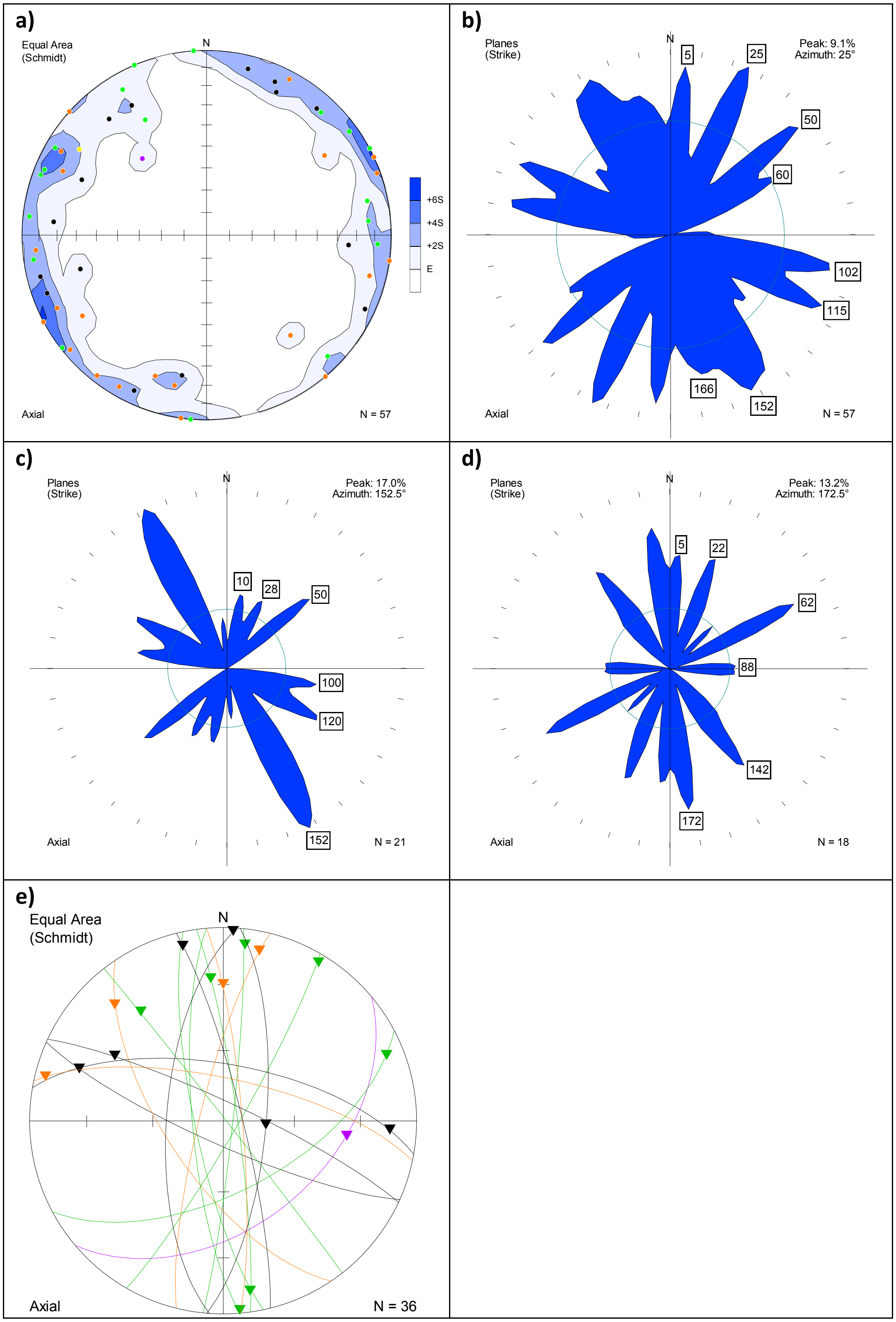

a)
Equal Area
(Schmidt)
N
+6S
+4S
+2S
E
Axial
N = 57
b)
Planes
(Strike)
N
Peak: 9.1%
Azimuth: 25°
5
25
50
60
102
115
166
152
Axial
N = 57
c)
Planes
(Strike)
N
Peak: 17.0%
Azimuth: 152.5°
10
28
50
100
120
152
Axial
N = 21
d)
Planes
(Strike)
N
Peak: 13.2%
Azimuth: 172.5°
5
22
62
88
142
172
Axial
N = 18
e)
Equal Area
(Schmidt)
N
Axial
N = 36

Figure 5.1.17: REVELL BATHOLITH AREA – Fault Orientation Data

a - All fault data displayed as equal area lower hemisphere stereonet plot of poles to fault planes. Dextral faults: orange circles (N=21). Sinistral faults: green circles (N=18). Reverse faults: purple circles (N=1). Normal faults: yellow circles (N=1). Faults with oblique and unknown slip: black circles (N=16). Contours show multiples of the standard deviation S above the expectant count E calculated using Gaussian K-100.

b - All fault data displayed as rose diagram of trends of fault planes (N=57). Bins for rose diagrams are 10°.

c - Dextral fault data displayed as rose diagram of trends of fault planes (N=21). Bins for rose diagrams are 10°.

d - Sinistral fault data displayed as rose diagram of trends of fault planes (N=18). Bins for rose diagrams are 10°.

e - Faults displayed as great circles (N=18) and associated slickenline lineations (N=18) displayed by their pitch on the corresponding fault plane. Dextral faults: orange lines (N=4). Sinistral faults: green lines (N=7). Normal faults: purple line (N=1). Unknown slip: black lines (N=6).

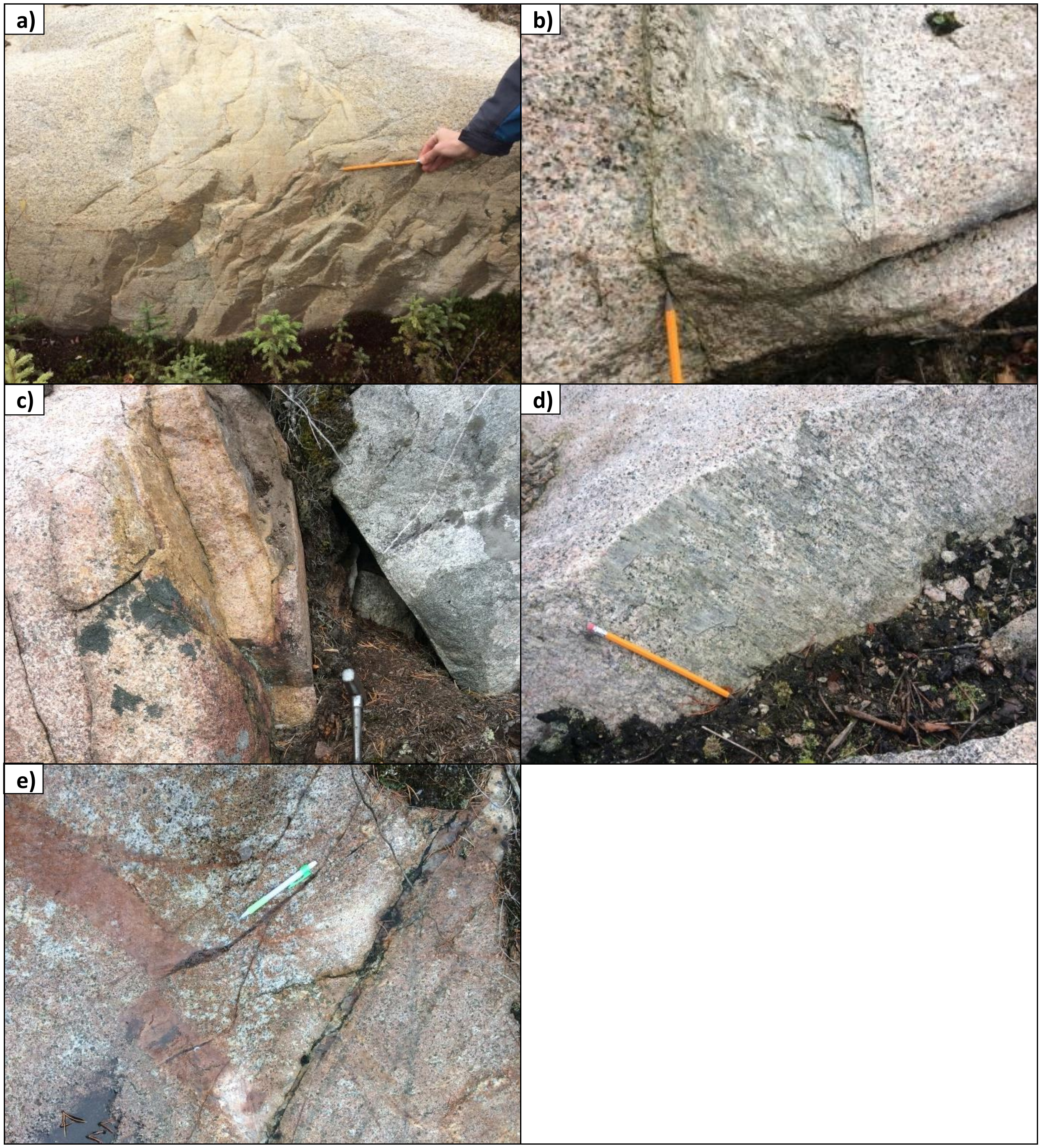


Figure 5.1.18: REVELL BATHOLITH AREA – Field Examples of Faults

a - Series of closely spaced sinistral fault planes (030/84) with horizontal slickenlines defining a m-scale fault zone. View to the northwest, pencil for scale indicating slip direction (Station 15IL1012).

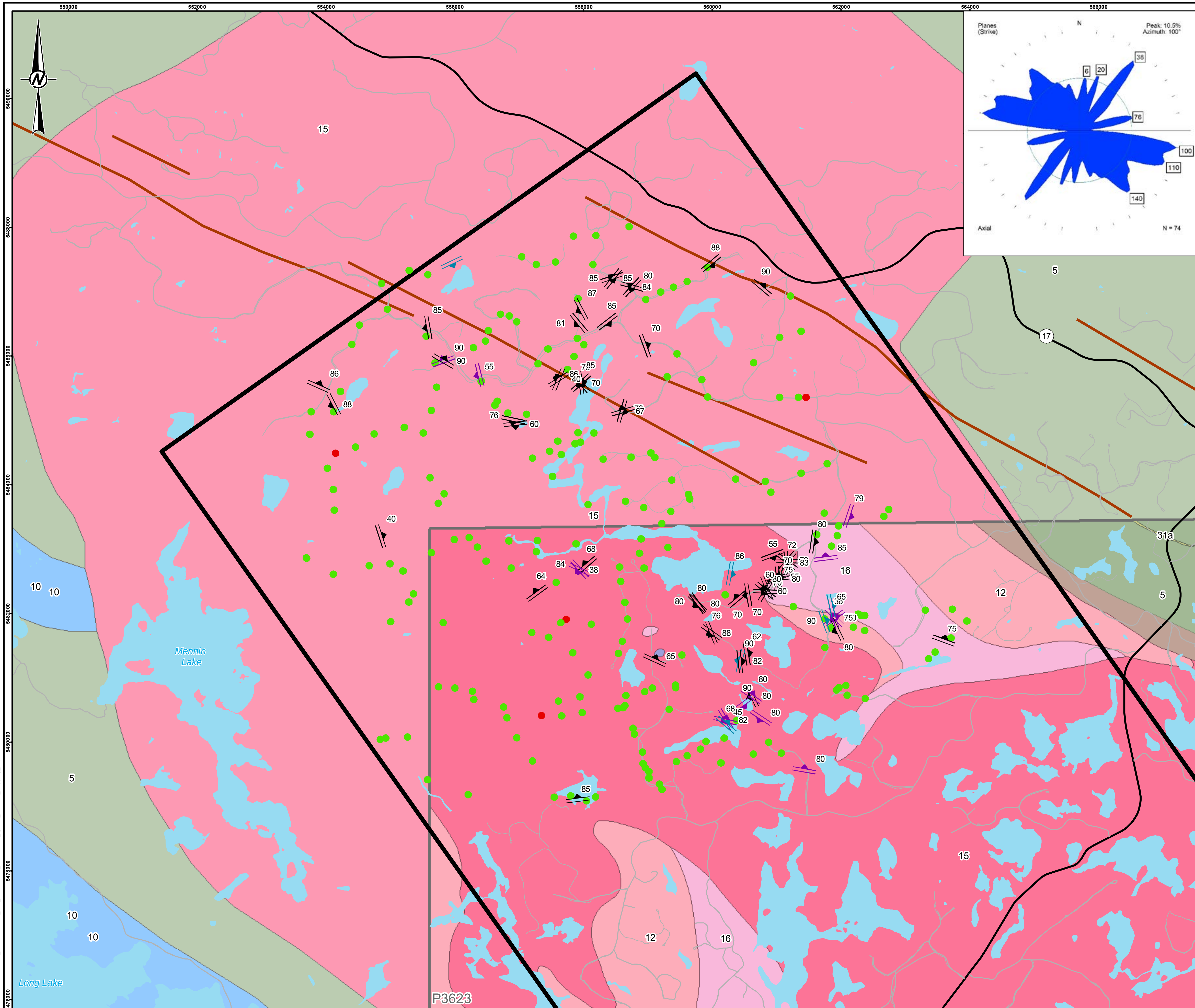
b - Brittle overprint and epidote alteration at the margin of a pre-existing ductile shear zone (060/81). View to the southwest, pencil for scale (Station 15IL1027).

Figure 5.1.18 (Cont'd): REVELL BATHOLITH AREA – Field Examples of Faults

c - Fault (345/60) associated with iron oxide (hematite) staining. View to the northwest, hammer for scale (15IL1019).

d - Plunging slickenlines (105/36) on an oblique slip fault (050/45) with quartz on the slip plane. View to the south, pencil for scale (Station 15IL1023).

e - Apparent dextral offset of aplite dyke on quartz-filled fault. Pencil for scale (Station 15IL1007).



LEGEND

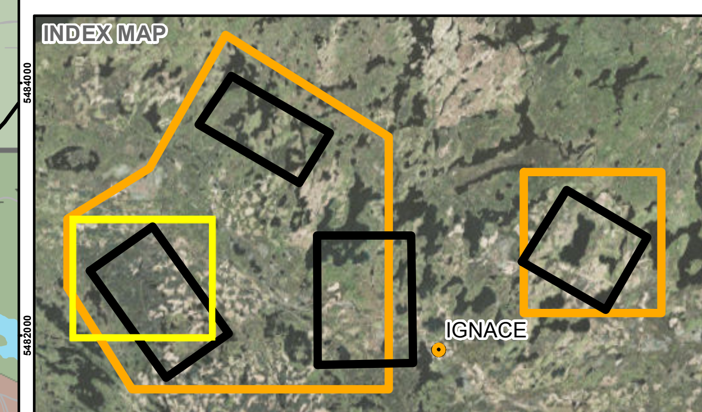
- Withdrawal Area
- Main Road
- Local Road
- Waterbody
- Outcrop (206)
- Overburden (4)

Vein

- Extension (54)
- Shear (6)
- Other (15)
- OGS Mapped Dyke
- Detailed Geology Boundary

Bedrock Geology

- 31 Sibley Gp.
- 16 Hornblendite - nepheline syenite suite
- 15 Massive granodiorite to granite
- 12 Foliated tonalite suite
- 10 Mafic and ultramafic rocks
- 5 Mafic to intermediate metavolcanic rocks



0 2 4

1:60,000 KILOMETRES

REFERENCE(S)
1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
2A. STONE, HELLEBRANDT & LANGE 2011 (P3623)
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015) AND DOMTAR (2015)

CLIENT
NWMO
IGNACE, ONTARIO

PROJECT
IGNACE DETAILED MAPPING REPORT

TITLE
REVELL BATHOLITH AREA - VEINS

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1532407			5.1.19

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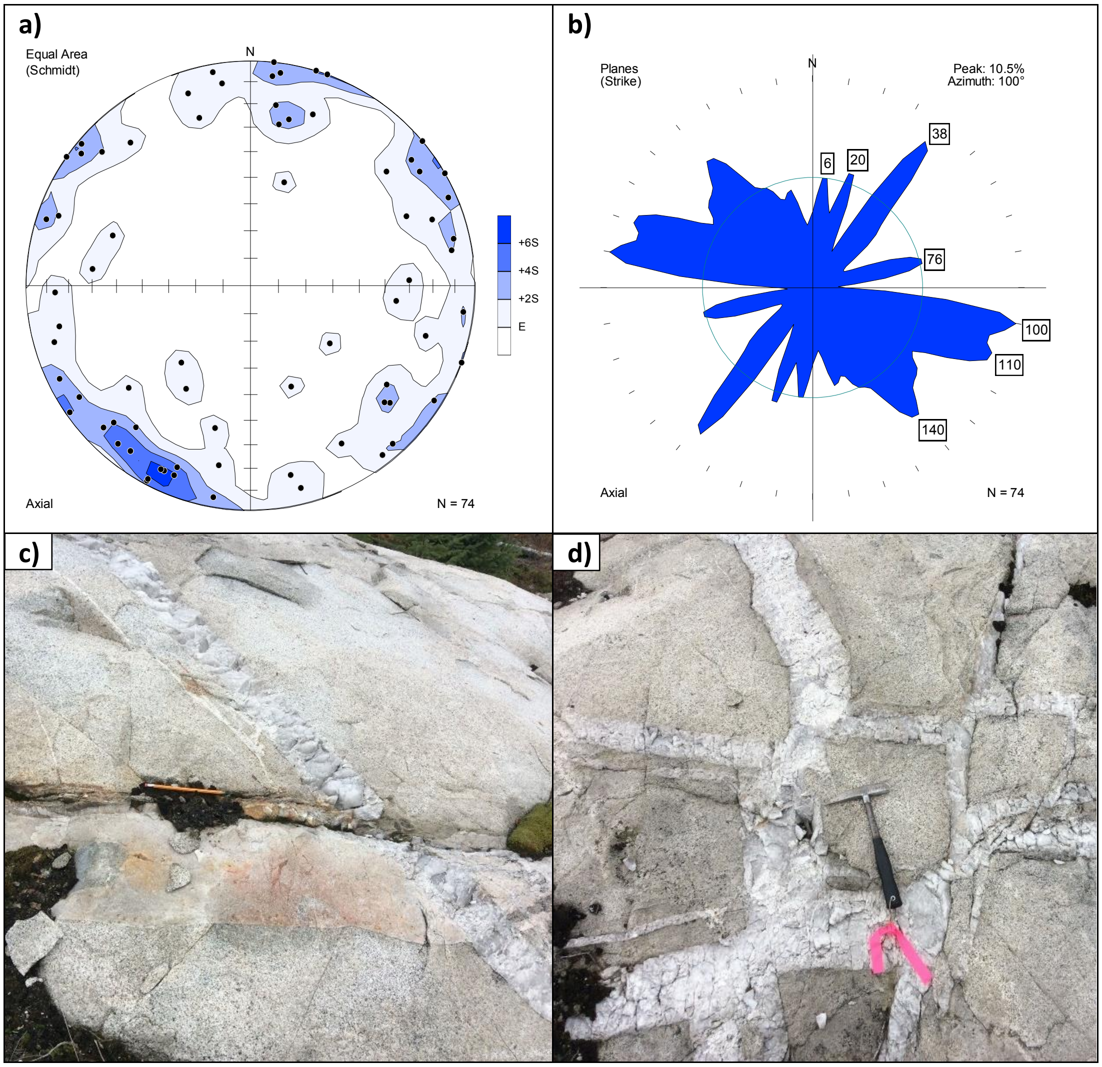


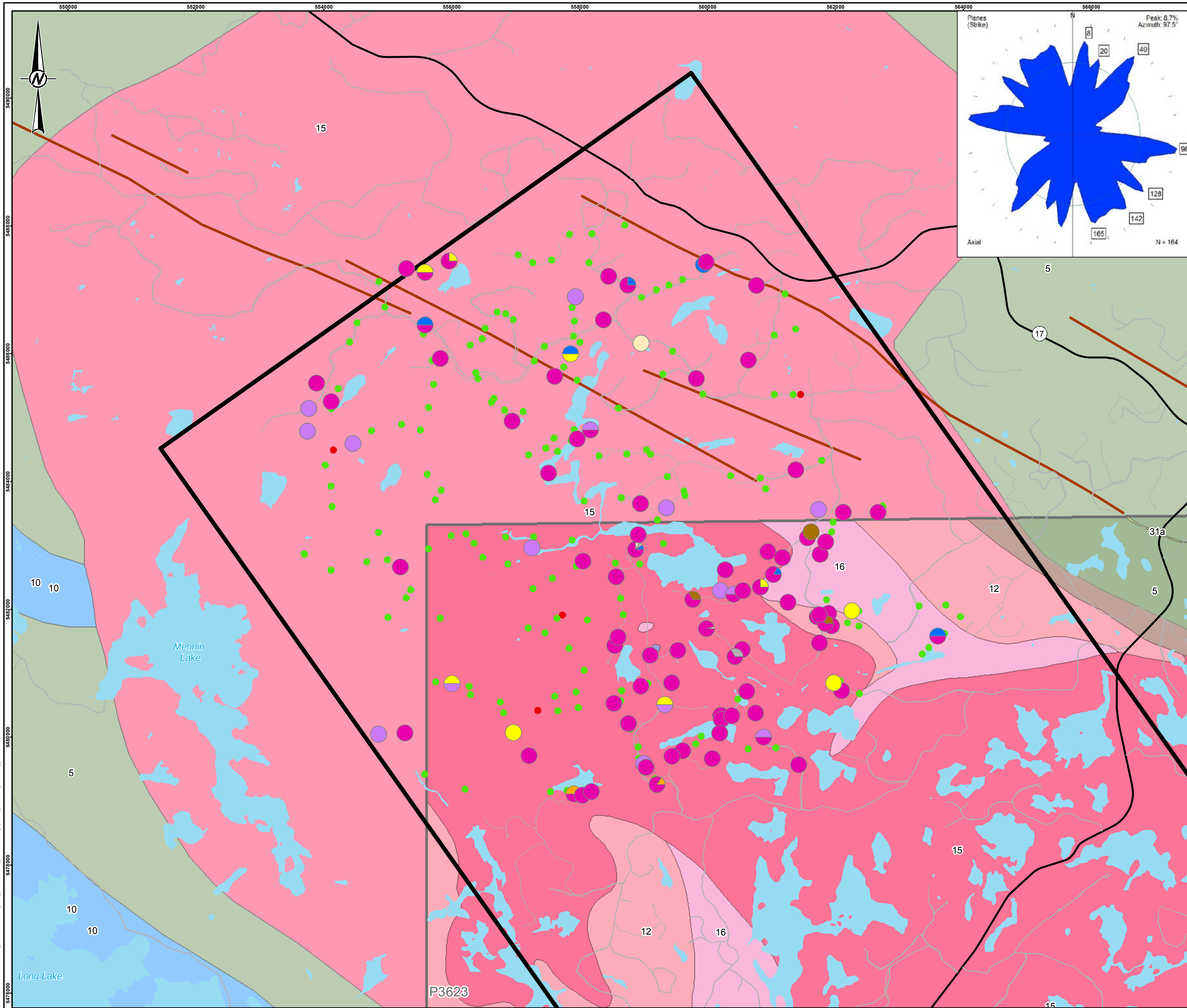
Figure 5.1.20: REVELL BATHOLITH AREA – Vein Orientation Data and Field Examples

a - All veins displayed as equal area lower hemisphere stereonet plot of poles to veins (N=74). Contours show multiples of the standard deviation S above the expectant count E calculated using Gaussian K-100.

b - All vein data displayed as rose diagram of trends of veins (N=74). Bins for rose diagrams are 10°.

c - Photo of an extensional quartz vein, crosscutting an aplite dyke. View to the southwest, pencil for scale (Station 15IL1012).

d - Photo of a network of quartz veins. View to the north, hammer for scale (Station 15IL1012).

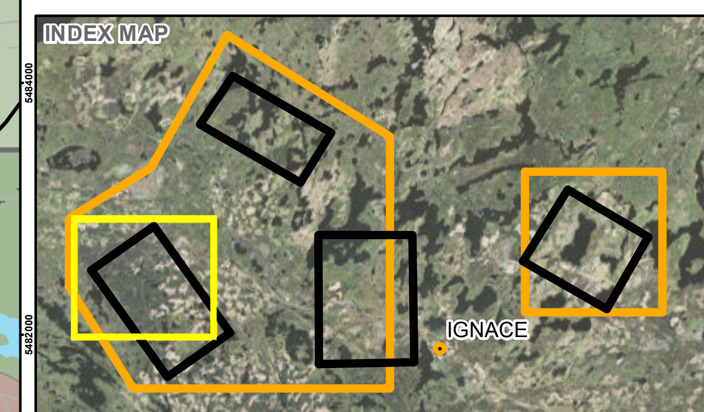


LEGEND

- Withdrawal Area
- Main Road
- Local Road
- Waterbody
- Outcrop
- Overburden
- OGS Mapped Dyke
- Detailed Geology Boundary
- Secondary Minerals and Alteration
- Alkali Feldspar (7)
- Biotite (2)
- Chlorite (3)
- Epidote (9)
- Hematite (15)
- Plagioclase (3)
- Pyrite (2)
- Quartz (77)

Bedrock Geology

- 31 Sibley Gp.
- 16 Hornblendite - nepheline syenite suite
- 15 Massive granodiorite to granite
- 12 Foliated tonalite suite
- 10 Mafic and ultramafic rocks
- 5 Mafic to intermediate metavolcanic rocks



0 2 4

1:60,000 KILOMETRES

REFERENCE(S)
1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
2A. STONE, HELLEBRANDT & LANGE 2011 (P3623)
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015) AND DOMTAR (2015)

CLIENT
NWMO
IGNACE, ONTARIO

PROJECT
IGNACE DETAILED MAPPING REPORT

TITLE
REVELL BATHOLITH AREA - SECONDARY MINERAL INFILL AND ALTERATION

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1532407			5.1.21

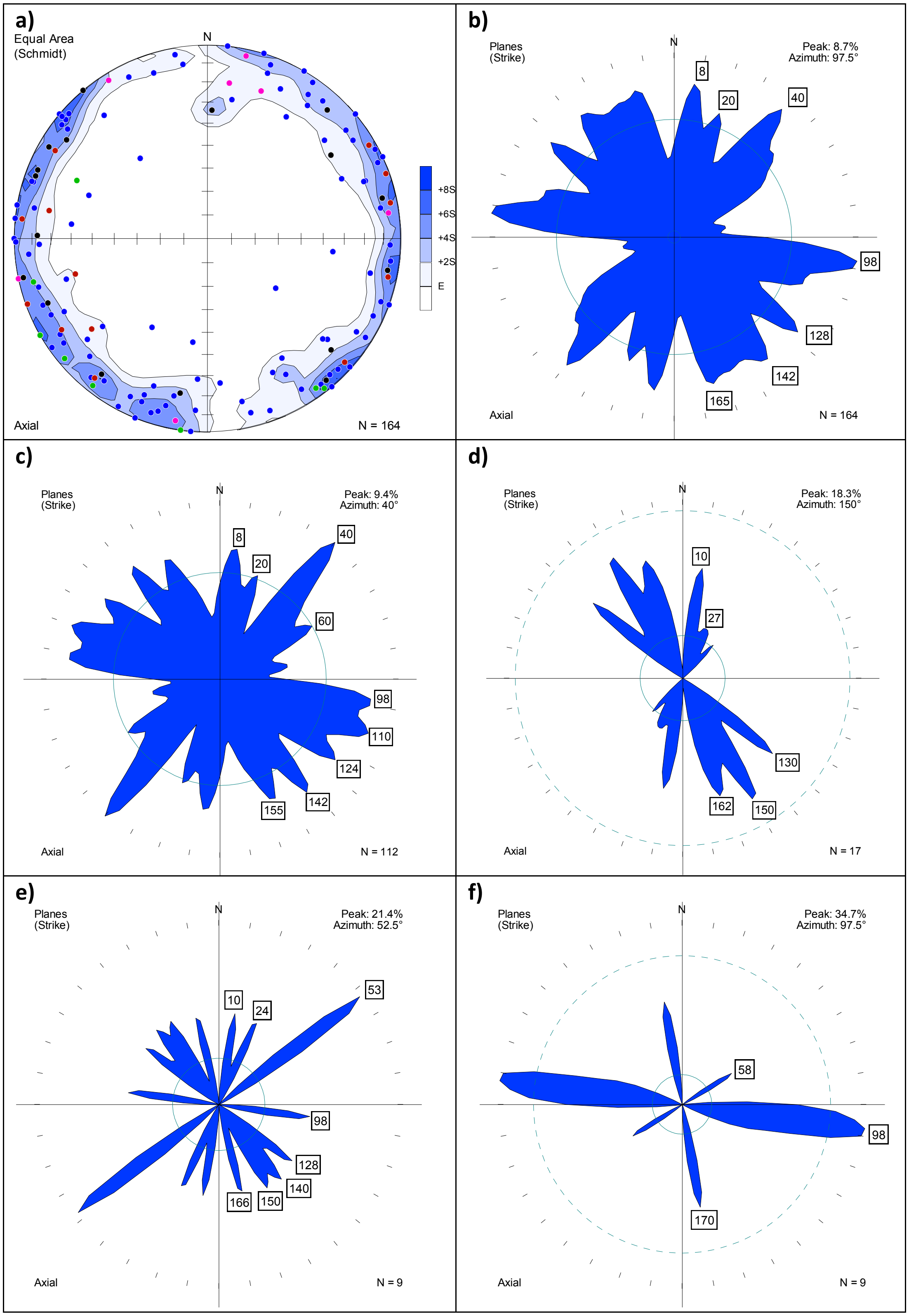

a)
Equal Area
(Schmidt)
N
+8S
+6S
+4S
+2S
E
Axial
N = 164
b)
Planes
(Strike)
N
Peak: 8.7%
Azimuth: 97.5°
8
20
40
98
128
142
165
Axial
N = 164
c)
Planes
(Strike)
N
Peak: 9.4%
Azimuth: 40°
8
20
40
60
98
110
124
142
155
Axial
N = 112
d)
Planes
(Strike)
N
Peak: 18.3%
Azimuth: 150°
10
27
130
162
150
Axial
N = 17
e)
Planes
(Strike)
N
Peak: 21.4%
Azimuth: 52.5°
10
24
53
98
128
140
166
150
Axial
N = 9
f)
Planes
(Strike)
N
Peak: 34.7%
Azimuth: 97.5°
58
98
170
Axial
N = 9

Figure 5.1.22: REVELL BATHOLITH AREA – Secondary Minerals and Alteration Orientation Data

a - All mineral infill data displayed as equal area lower hemisphere stereonet plot of poles to joints, faults, or veins (N=164). Quartz infill: blue (N=112). Hematite infill: red (N=17). Epidote infill: light green (N=9). Feldspar infill: pink (N=9). Other infill (bleaching, breccia, chlorite, biotite, pyrite): black (N=17). Contours show multiples of the standard deviation S above the expectant count E calculated using Gaussian K-100.

b - All mineral infill data displayed as rose diagram of trends of joints, faults, or veins (N=164). Bins for rose diagrams are 10°.

c - Quartz infill data displayed as rose diagram of trends of joints, faults, or veins (N=112). Bins for rose diagrams are 10°.

d - Hematite infill data displayed as rose diagram of trends of joints, faults, or veins (N=17). Bins for rose diagrams are 10°.

e - Epidote infill data displayed as rose diagram of trends of joints, faults, or veins (N=9). Bins for rose diagrams are 10°.

f - Feldspar infill data displayed as rose diagram of trends of joints, faults, or veins (N=9). Bins for rose diagrams are 10°.

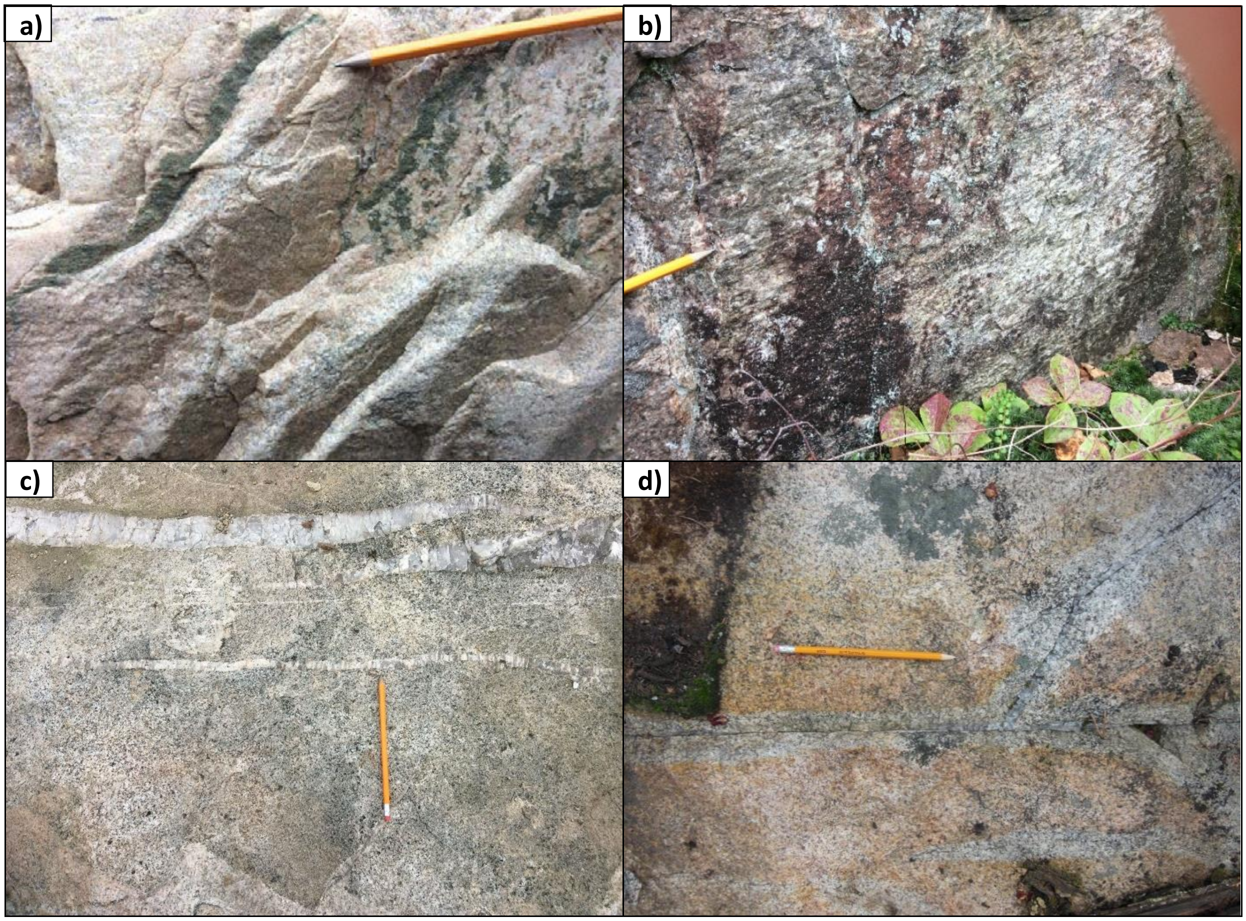


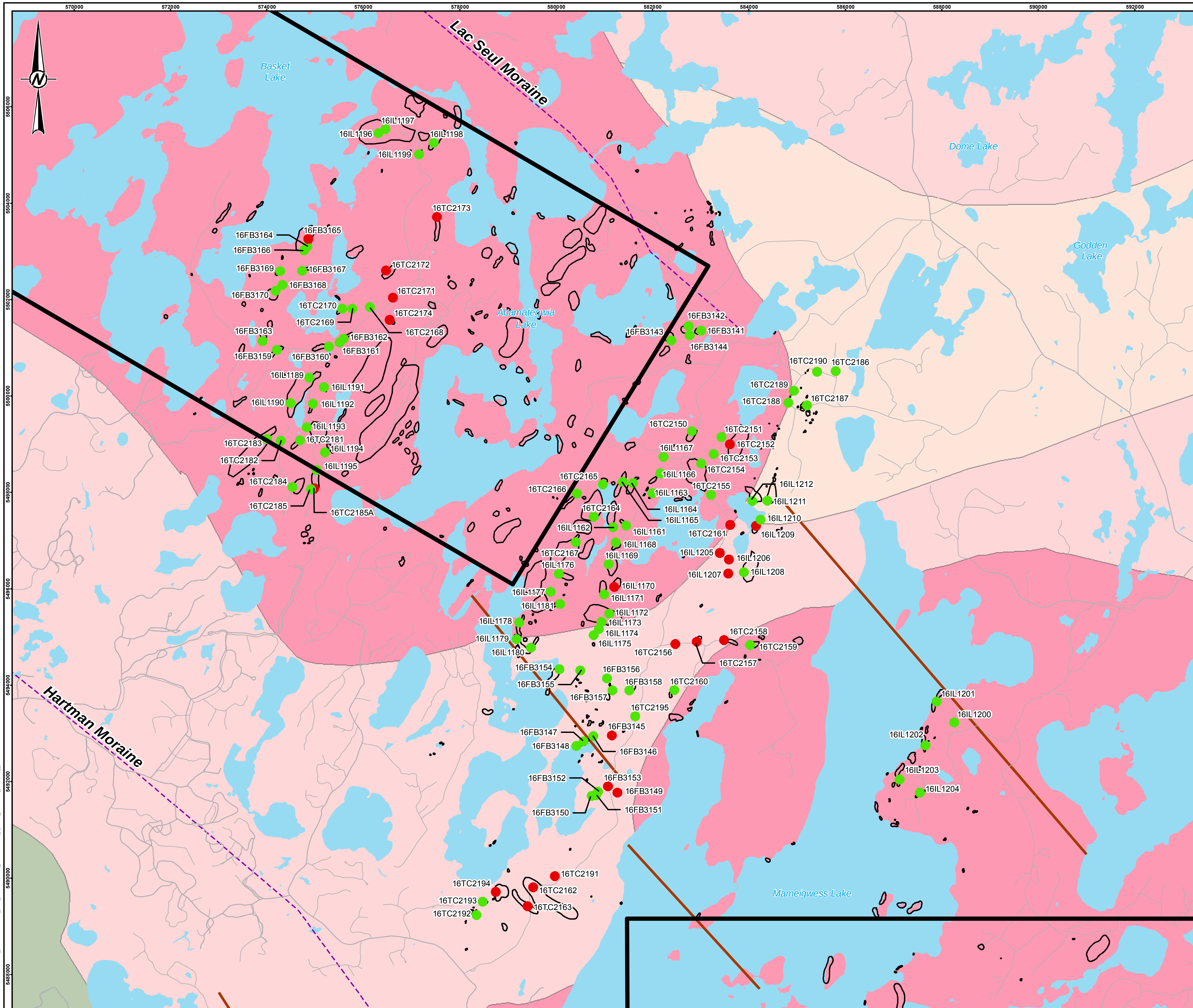
Figure 5.1.23: REVELL BATHOLITH AREA – Field Examples of Secondary Minerals and Alteration

a - Chlorite slickenlines, on a series of cm-spaced fault planes oriented 045/80. View to the north, pen for scale (Station15IL1012).

b - Epidote and hematite staining on fault surface (355/82). View to the west, pencil for scale (Station 15IL1015).

c - Quartz infill in extensional veins. View to the north, pencil or scale (Station 15IL1012).

d - Faults with prominent bleaching and partial filling with quartz veins. View to the west, pencil for scale (Station 15FB2025).

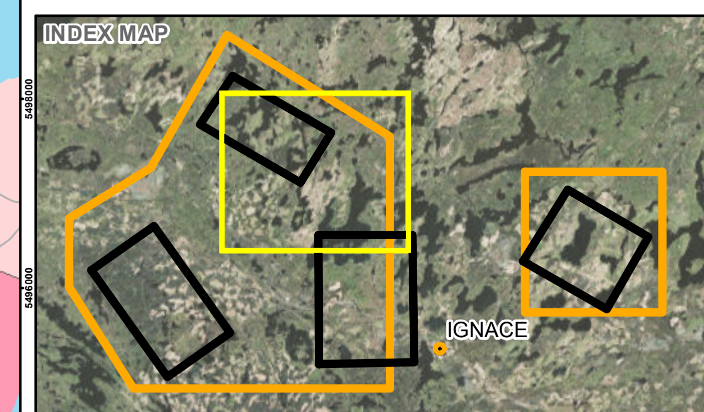


LEGEND

- Withdrawal Area
- Local Road
- Waterbody
- Outcrop (93)
- Overburden (23)
- End moraine
- OGS Mapped Dyke
- Predicted Outcrop

Bedrock Geology

- 15 Massive granodiorite to granite
- 12 Foliated tonalite suite
- 11 Gneissic tonalite suite
- 5 Mafic to intermediate metavolcanic rocks



0 3 6
1:80,000 KILOMETRES

REFERENCE(S)

1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015) AND DOMTAR (2015)

CLIENT
NWMO
IGNACE, ONTARIO

PROJECT
IGNACE DETAILED MAPPING REPORT

TITLE
BASKET LAKE - INDIAN LAKE WEST BATHOLITH AREA (NORTH) MAPPING OBSERVATION LOCATIONS

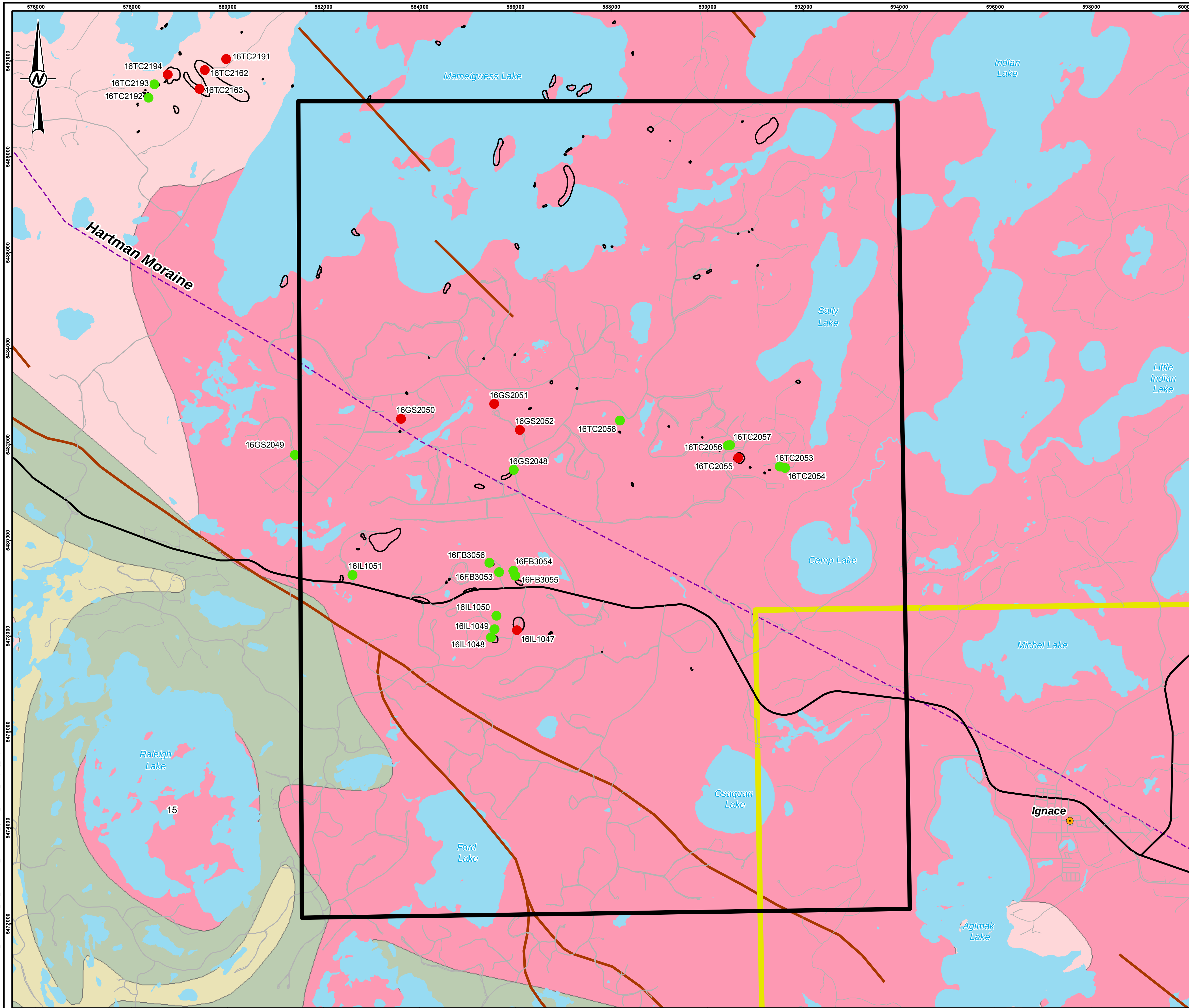
CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1532407			5.2.1a

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

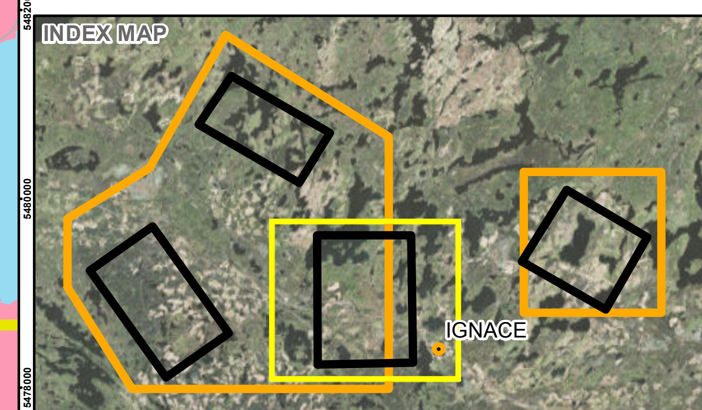


LEGEND

- Withdrawal Area
- Municipal Boundary (Township of Ignace)
- Community
- Main Road
- Local Road
- Waterbody
- Outcrop (17)
- Overburden (9)
- End moraine
- OGS Mapped Dyke
- Predicted Outcrop

Bedrock Geology

- 15 Massive granodiorite to granite
- 12 Foliated tonalite suite
- 6 Felsic to intermediate metavolcanic rocks
- 5 Mafic to intermediate metavolcanic rocks



0 3 6

1:80,000 KILOMETRES

REFERENCE(S)
1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015) AND DOMTAR (2015)

CLIENT
NWMO
IGNACE, ONTARIO

PROJECT
IGNACE DETAILED MAPPING REPORT

TITLE
BASKET LAKE - INDIAN LAKE WEST BATHOLITH AREA (SOUTH) MAPPING OBSERVATION LOCATIONS

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1532407			5.2.1b

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

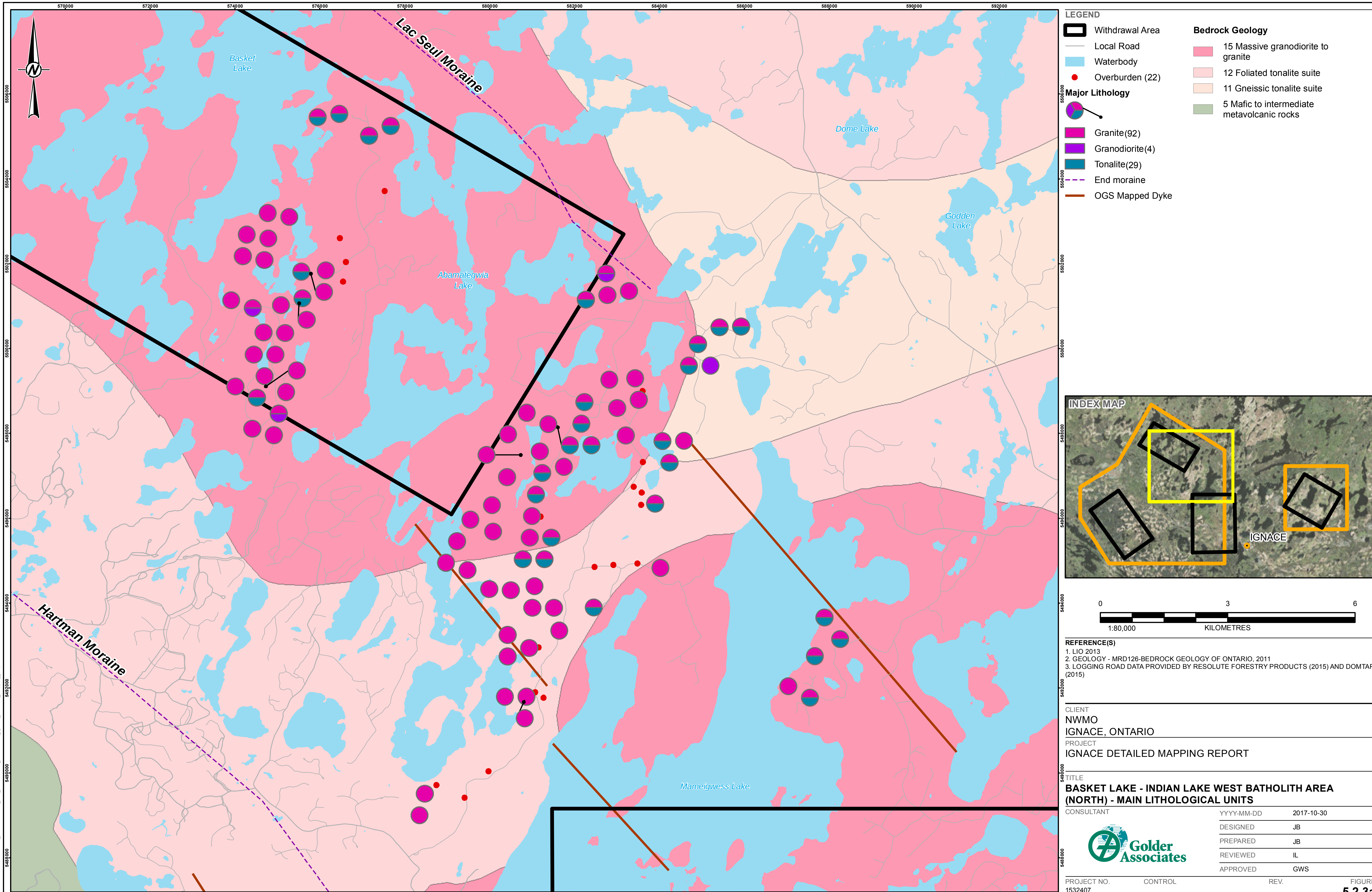
Figure 5.2.2: BASKET LAKE – INDIAN LAKE WEST BATHOLITH AREA – Field Examples of Accessibility and Bedrock Exposure

a - Typical secondary forestry road used for access. View to the south, truck for scale (Station 16TC2173).

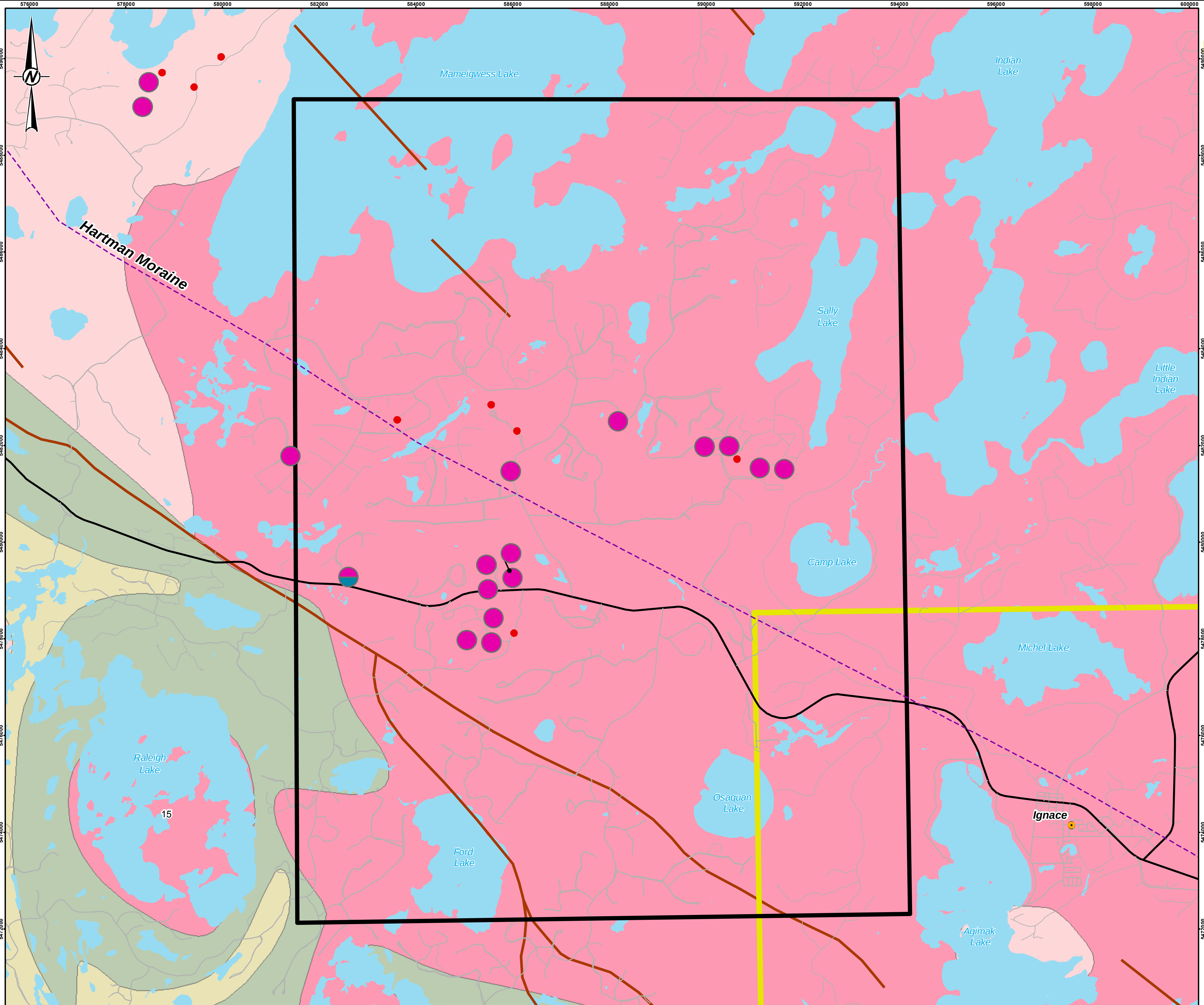
b - Large topographic high and surrounding forests. View to the north, person for scale (Station 16IL1179).

c - Flat, stained, glacially smoothed pavement outcrop. View to the south, person for scale (Station 16IL1166).

d - Overburden cover along the edge of a flat bedrock exposure showing at least one metre thick sand cover. View to the north, person for scale (Station 16TC2124).



Lac Seul Moraine
Basket Lake
Abamategwia Lake
Dome Lake
Godden Lake
Hartman Moraine
Mameigwess Lake
LEGEND
Withdrawal Area
Local Road
Waterbody
Overburden (22)
Major Lithology
Granite(92)
Granodiorite(4)
Tonalite(29)
End moraine
OGS Mapped Dyke
Bedrock Geology
15 Massive granodiorite to granite
12 Foliated tonalite suite
11 Gneissic tonalite suite
5 Mafic to intermediate metavolcanic rocks
INDEX MAP
IGNACE
0
3
6
1:80,000
KILOMETRES
REFERENCE(S)
1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015) AND DOMTAR (2015)
CLIENT
NWMO
IGNACE, ONTARIO
PROJECT
IGNACE DETAILED MAPPING REPORT
TITLE
BASKET LAKE - INDIAN LAKE WEST BATHOLITH AREA (NORTH) - MAIN LITHOLOGICAL UNITS
CONSULTANT
Golder Associates
YYYY-MM-DD 2017-10-30
DESIGNED JB
PREPARED JB
REVIEWED IL
APPROVED GWS
PROJECT NO. 1532407
CONTROL
REV.
FIGURE 5.2.3a



LEGEND

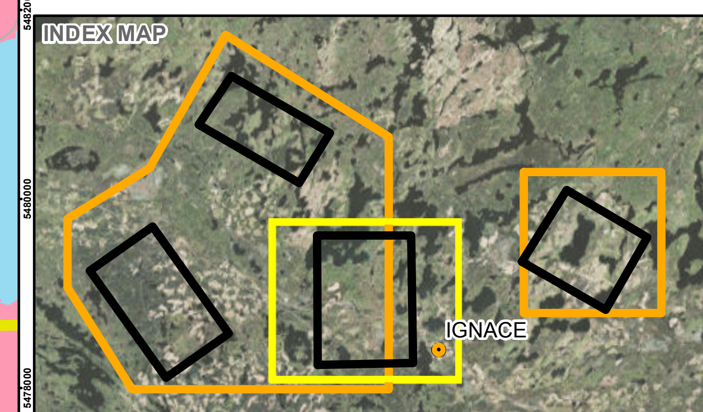
- Withdrawal Area
- Municipal Boundary (Township of Ignace)
- Community
- Main Road
- Local Road
- Waterbody
- Overburden (9)

Major Lithology

- Granite (17)
- Granodiorite (0)
- Tonalite (1)
- End moraine
- OGS Mapped Dyke

Bedrock Geology

- 15 Massive granodiorite to granite
- 12 Foliated tonalite suite
- 6 Felsic to intermediate metavolcanic rocks
- 5 Mafic to intermediate metavolcanic rocks



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REFERENCE(S)
1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015) AND DOMTAR (2015)

CLIENT
NWMO
IGNACE, ONTARIO

PROJECT
IGNACE DETAILED MAPPING REPORT

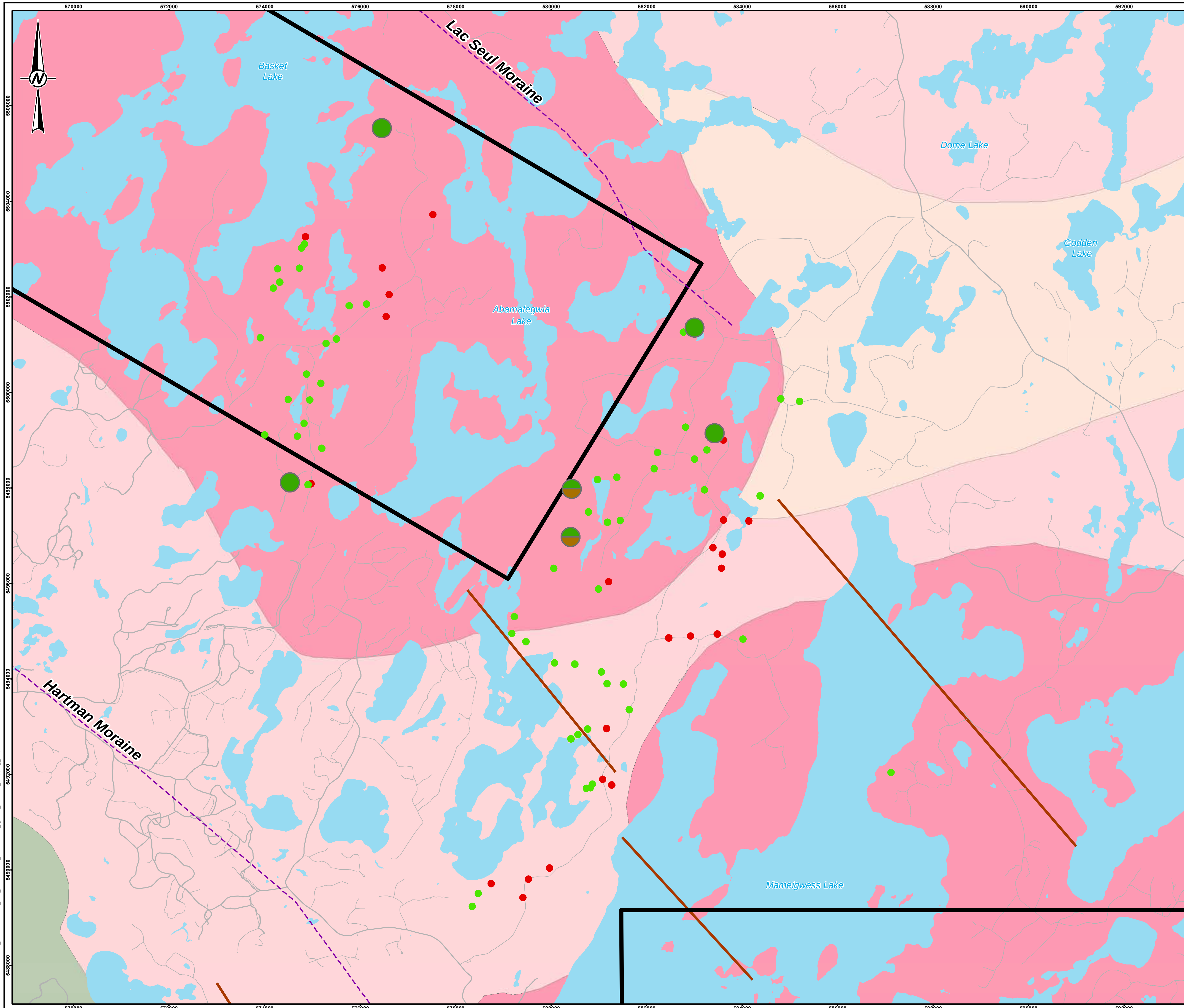
TITLE
BASKET LAKE - INDIAN LAKE WEST BATHOLITH AREA (SOUTH) - MAIN LITHOLOGICAL UNITS

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1532407			5.2.3b



LEGEND

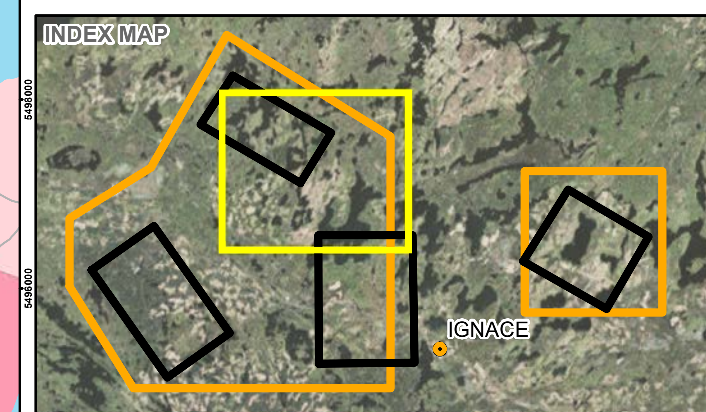
- Withdrawal Area
- Local Road
- Waterbody
- Outcrop (56)
- Overburden (23)

Minor Lithology

- Diorite / Quartz Diorite (0)
- Mafic Metavolcanic Rocks (6)
- Schist (2)
- End moraine
- OGS Mapped Dyke

Bedrock Geology

- 15 Massive granodiorite to granite
- 12 Foliated tonalite suite
- 11 Gneissic tonalite suite
- 5 Mafic to intermediate metavolcanic rocks



0 3 6

1:80,000 KILOMETRES

REFERENCE(S)
1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015) AND DOMTAR (2015)

CLIENT
NWMO
IGNACE, ONTARIO

PROJECT
IGNACE DETAILED MAPPING REPORT

TITLE
BASKET LAKE - INDIAN LAKE WEST BATHOLITH AREA (NORTH) - MINOR LITHOLOGICAL UNITS

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-05-10
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1532407			5.2.4a

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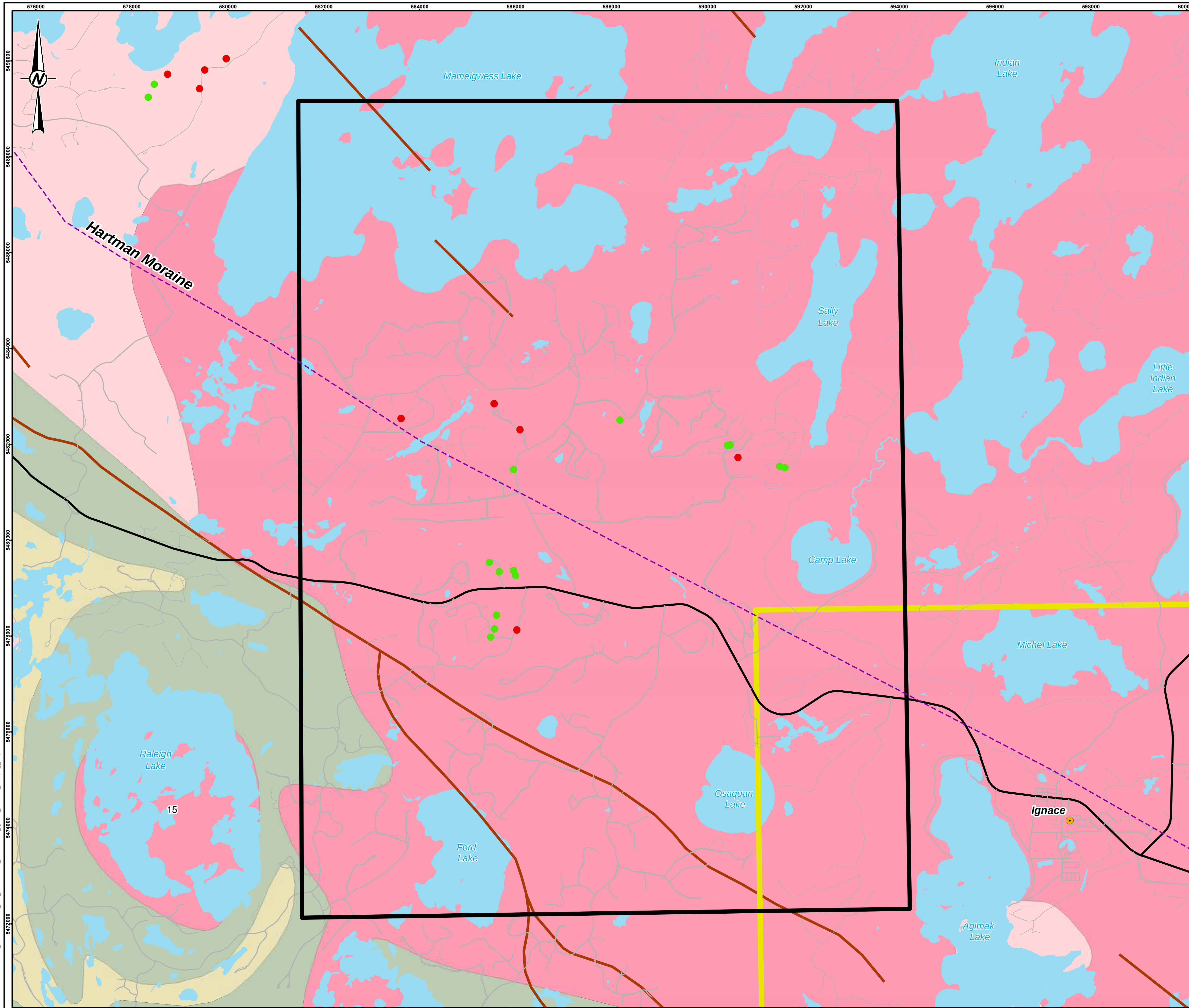
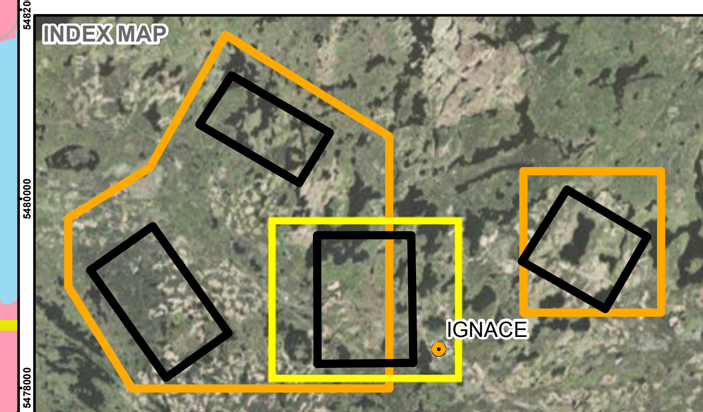


LEGEND

- Withdrawal Area
- Municipal Boundary (Township of Ignace)
- Community
- Main Road
- Local Road
- Waterbody
- Outcrop (15)
- Overburden (9)
- End moraine
- OGS Mapped Dyke

Bedrock Geology

- 15 Massive granodiorite to granite
- 12 Foliated tonalite suite
- 6 Felsic to intermediate metavolcanic rocks
- 5 Mafic to intermediate metavolcanic rocks



DRAFT

0 3 6

1:80,000 KILOMETRES

REFERENCE(S)
1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015) AND DOMTAR (2015)

CLIENT
NWMO
IGNACE, ONTARIO

PROJECT
IGNACE DETAILED MAPPING REPORT

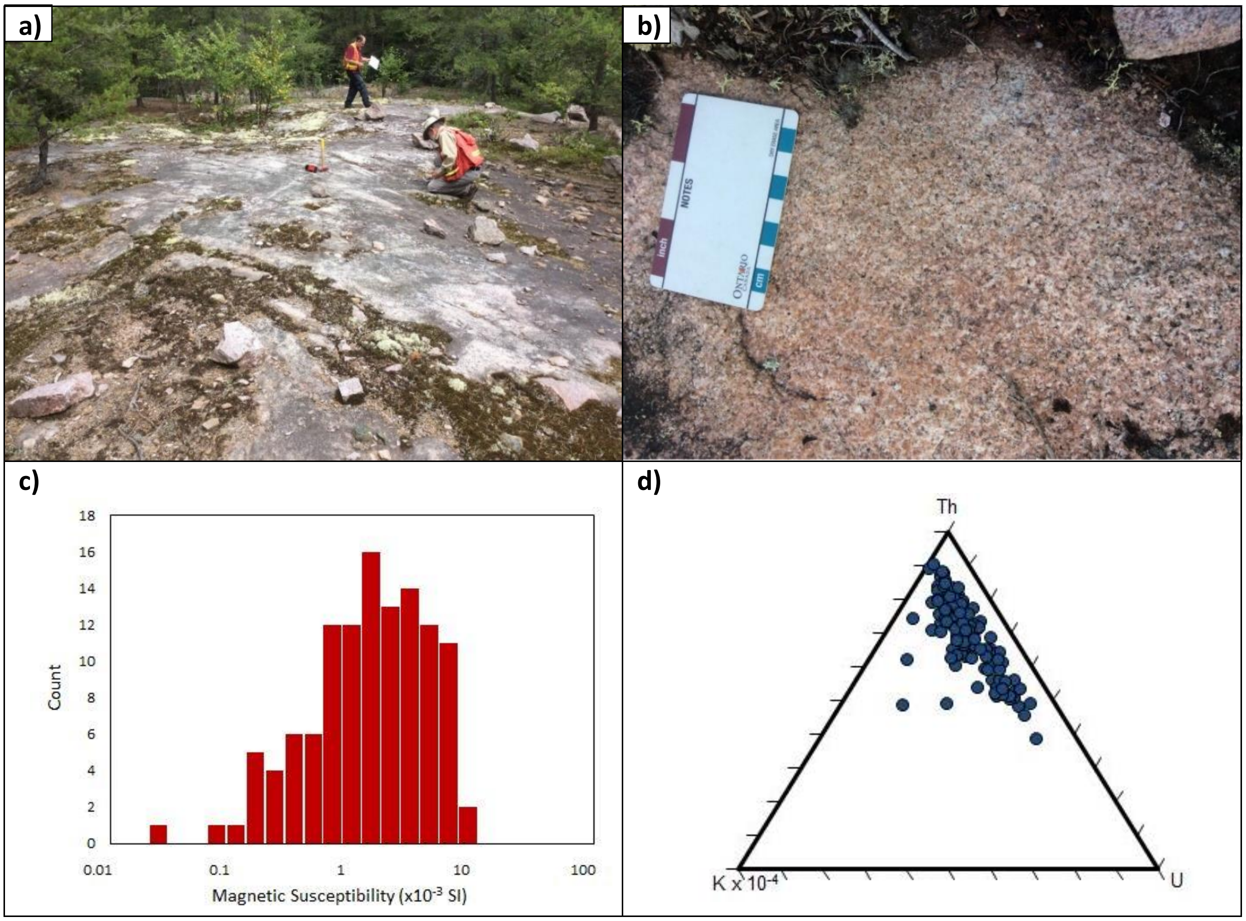
TITLE
BASKET LAKE - INDIAN LAKE WEST BATHOLITH AREA (SOUTH) - MINOR LITHOLOGICAL UNITS

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1532407			5.2.4b



<u>Figure 5.2.5: BASKET LAKE – INDIAN LAKE WEST BATHOLITH AREA – Field Examples of Main Lithology - Granite</u>

a - Field example of granite at outcrop scale. Person for scale (Station 16FB3161).

b - Close-up photo of granite showing mineral composition and texture. Unoriented photo, card for scale (Station 16IL1194).

c - Logarithmic plot of magnetic susceptibility for granite (N=116).

d - Ternary plot of gamma ray spectrometer data for granite (N=123).

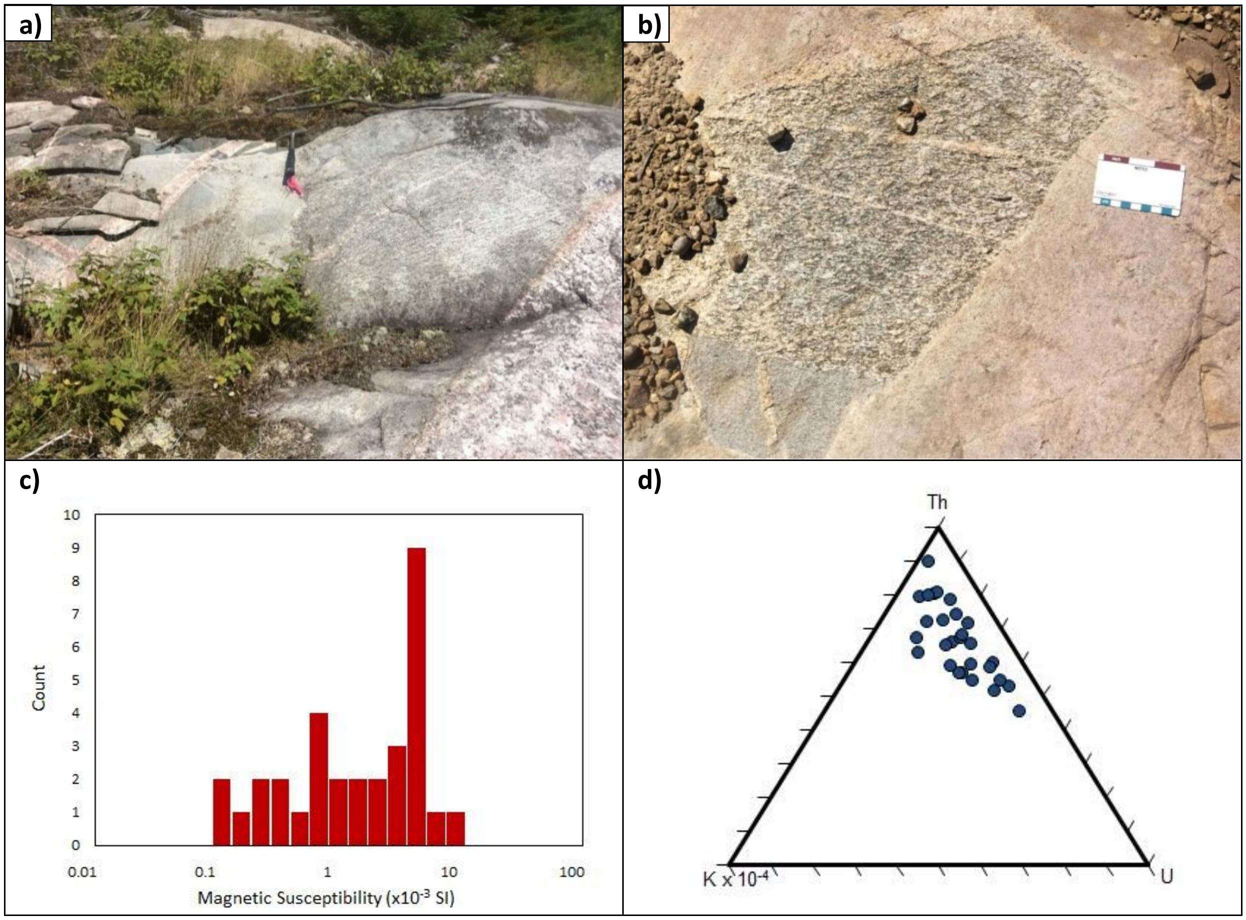


Figure 5.2.6: BASKET LAKE – INDIAN LAKE WEST BATHOLITH AREA – Field Examples of Main Lithology - Tonalite Gneiss

a - Field example of m-scale tonalite gneiss xenolith. View to the northeast, hammer for scale (Station 16IL1197).

b - Close-up of tonalite gneiss showing internal textural heterogeneity. View to the north, card for scale, (Station 16IL1200).

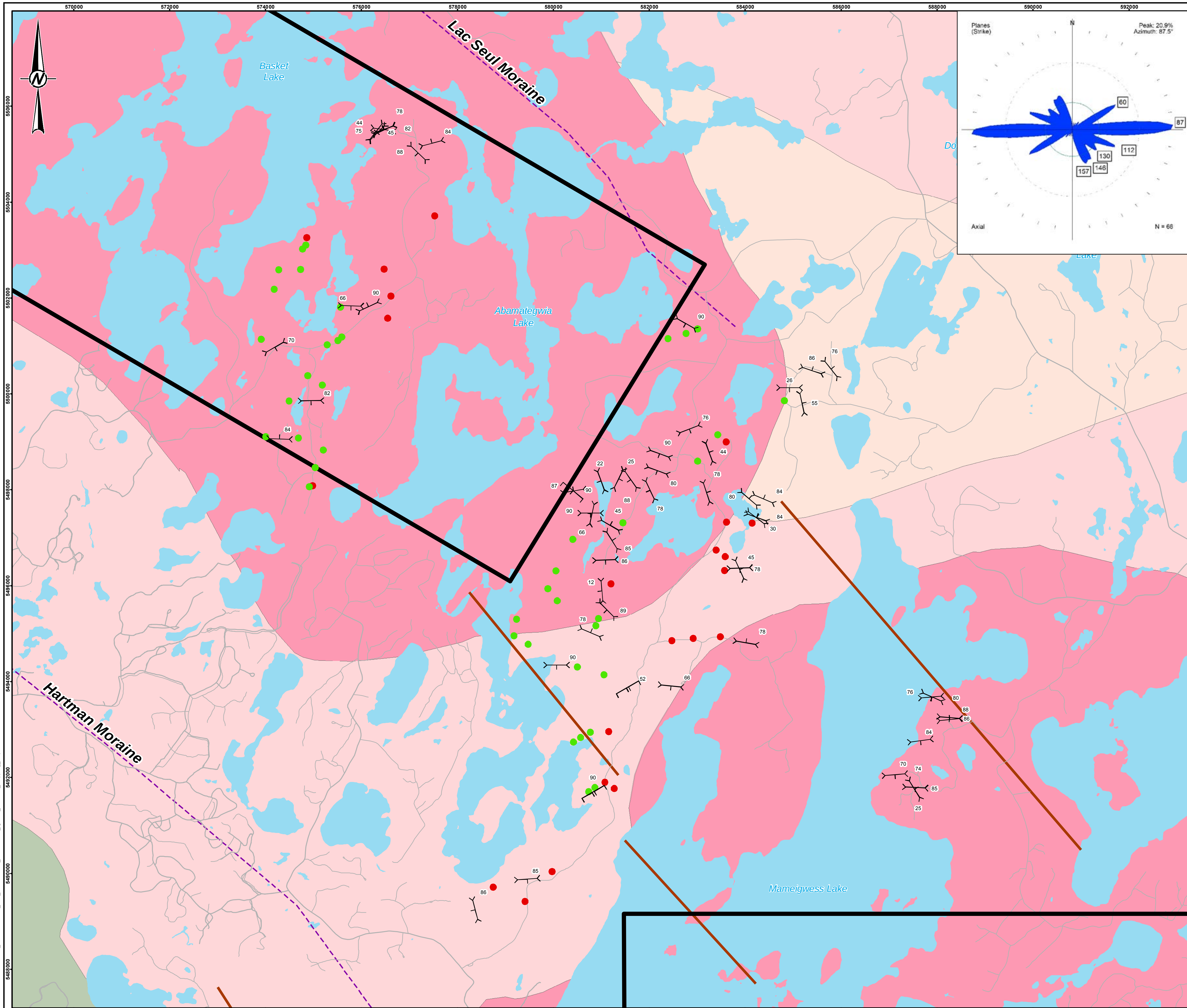
c - Logarithmic plot of magnetic susceptibility for tonalite gneiss (N=32).

d - Ternary plot of gamma ray spectrometer data for tonalite gneiss (N=28).

Figure 5.2.7: BASKET LAKE - INDIAN LAKE WEST BATHOLITH AREA – Field Examples of Minor Lithological Units

a - Amphibolite gneiss interlayered with felsic pegmatite. View to the north, hammer for scale (Station 16TC2184).

b - Granodiorite intruded by coarse-grained granitic pegmatite. View to the north, pencil for scale (Station 16IL1195).

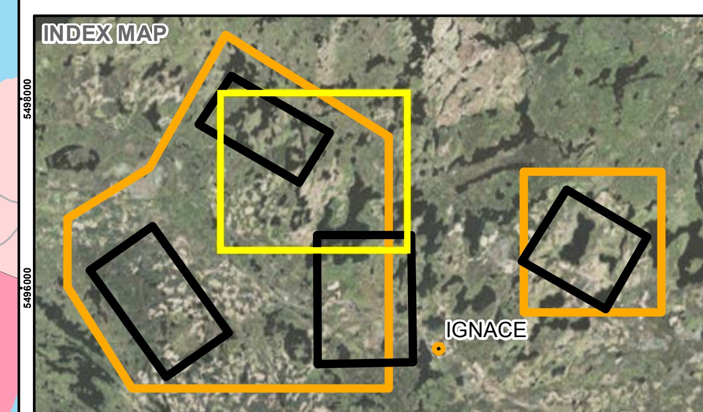


LEGEND

- Withdrawal Area
- Local Road
- Waterbody
- Outcrop (41)
- Overburden (22)
- Tectonic Foliation (55)
- Gneissic Layering (1)
- Igneous Flow Foliation (2)
- End moraine
- OGS Mapped Dyke

Bedrock Geology

- 15 Massive granodiorite to granite
- 12 Foliated tonalite suite
- 11 Gneissic tonalite suite
- 5 Mafic to intermediate metavolcanic rocks



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1:80,000 KILOMETRES

REFERENCE(S)
1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015) AND DOMTAR (2015)

CLIENT
NWMO
IGNACE, ONTARIO

PROJECT
IGNACE DETAILED MAPPING REPORT

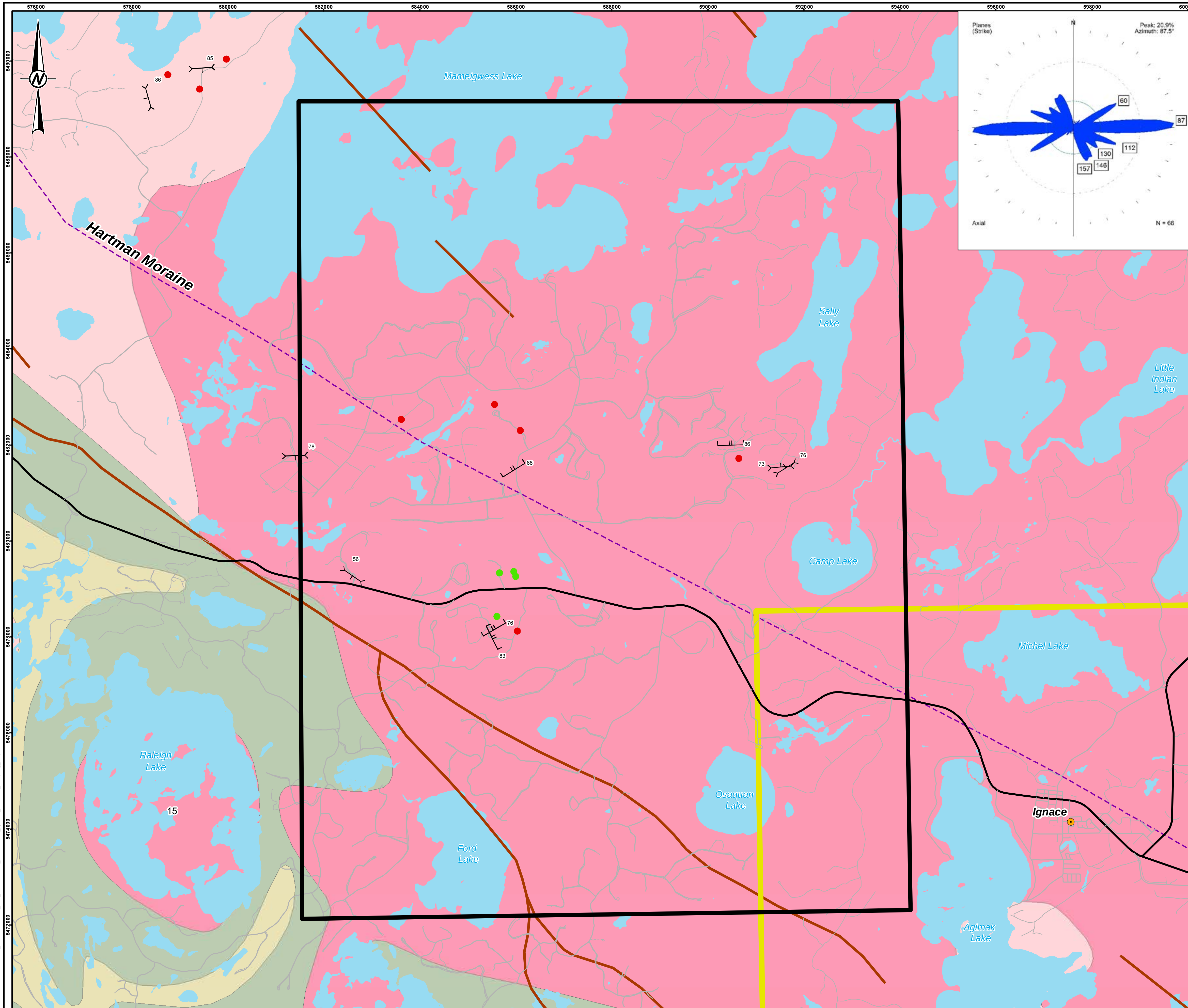
TITLE
BASKET LAKE - INDIAN LAKE WEST BATHOLITH AREA (NORTH) - FOLIATION

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-11-16
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1532407			5.2.8a

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

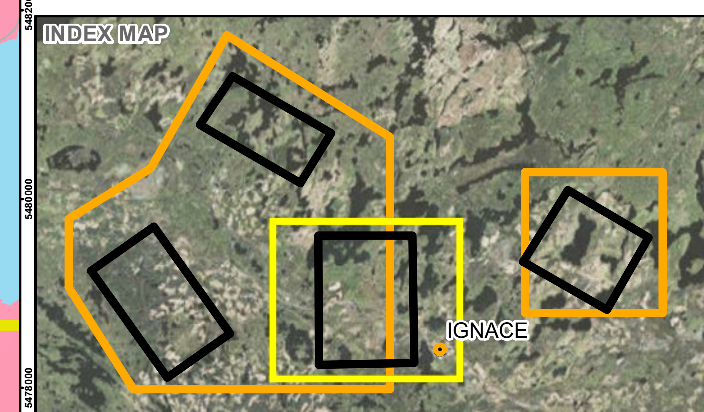


LEGEND

- Withdrawal Area
- Municipal Boundary (Township of Ignace)
- Community
- Main Road
- Local Road
- Waterbody
- Outcrop (4)
- Overburden (8)
- Tectonic Foliation (6)
- Igneous Flow Foliation (4)
- End moraine
- OGS Mapped Dyke

Bedrock Geology

- 15 Massive granodiorite to granite
- 12 Foliated tonalite suite
- 6 Felsic to intermediate metavolcanic rocks
- 5 Mafic to intermediate metavolcanic rocks



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REFERENCE(S)
1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015) AND DOMTAR (2015)

CLIENT
NWMO
IGNACE, ONTARIO

PROJECT
IGNACE DETAILED MAPPING REPORT

TITLE
BASKET LAKE - INDIAN LAKE WEST BATHOLITH AREA (SOUTH) - FOLIATION

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-11-16
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1532407			5.2.8b

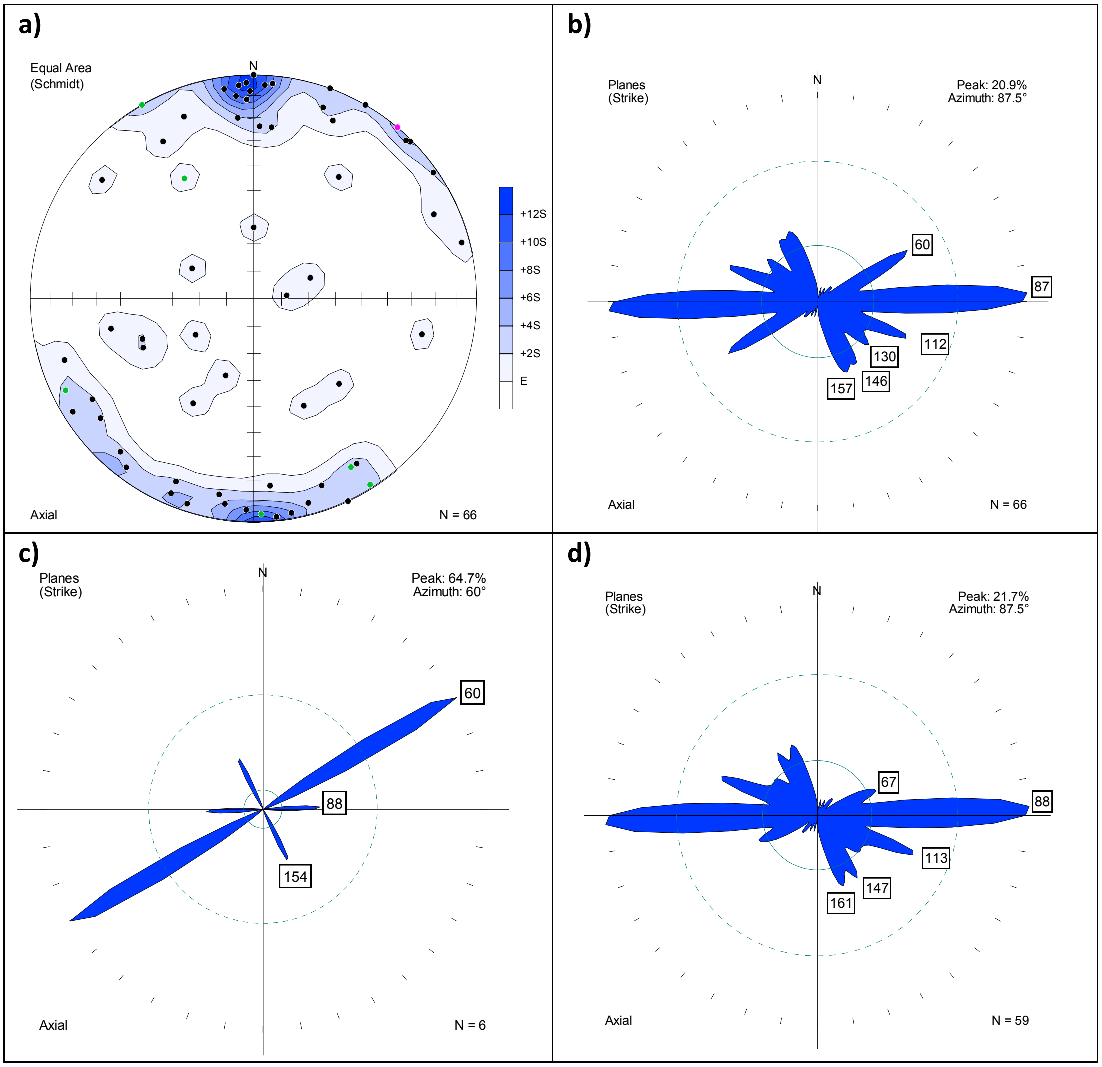


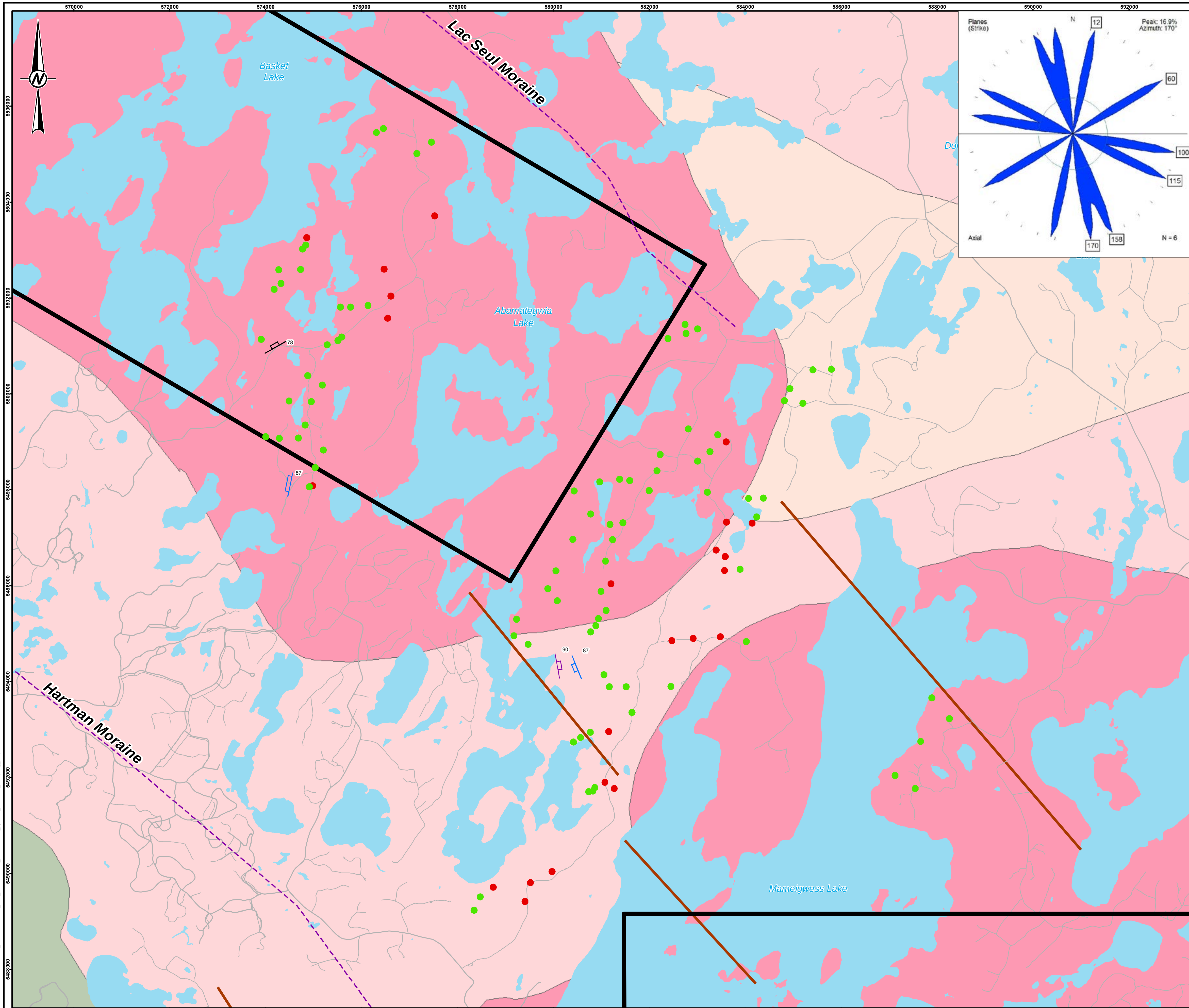
Figure 5.2.9: BASKET LAKE – INDIAN LAKE WEST BATHOLITH AREA - Foliation Orientation Data

a - All foliation data displayed as equal area lower hemisphere stereonet plot of poles to foliation planes. Tectonic foliation: black circles (N=59). Igneous flow foliation: green circles (N=6). Gneissic layering: pink circles (N=1). Contours show multiples of the standard deviation S above the expectant count E calculated using Gaussian K-100.

b - All foliation data displayed as rose diagram of trends of foliation planes (N=66). Bins for rose diagrams are 10°.

c - Igneous flow foliation displayed as equal area lower hemisphere stereonet plot of great circles of foliation planes (N=6).

d - Tectonic foliation data displayed as rose diagram of trends of foliation planes (N=59). Bins for rose diagrams are 10°.

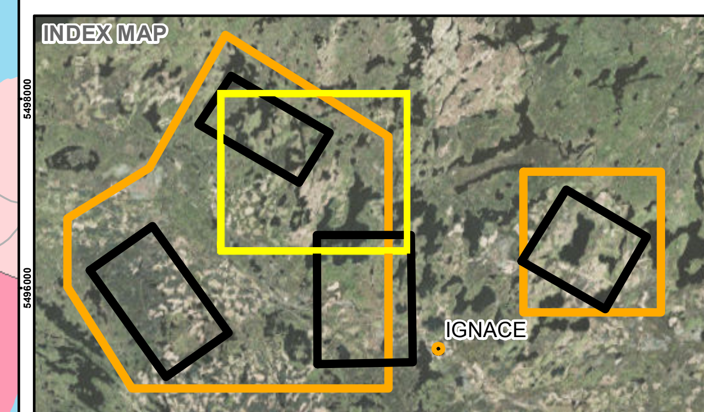


LEGEND

- Withdrawal Area
- Local Road
- Waterbody
- Outcrop (89)
- Overburden (23)
- Brittle-ductile shear zones - Dextral (1)
- Brittle-ductile shear zones - Sinistral (1)
- Brittle-ductile shear zones - Unknown Slip (1)
- Ductile shear zone - Sinistral (1)
- End moraine
- OGS Mapped Dyke

Bedrock Geology

- 15 Massive granodiorite to granite
- 12 Foliated tonalite suite
- 11 Gneissic tonalite suite
- 5 Mafic to intermediate metavolcanic rocks



0 3 6
1:80,000 KILOMETRES

REFERENCE(S)
1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015) AND DOMTAR (2015)

CLIENT
NWMO
IGNACE, ONTARIO

PROJECT
IGNACE DETAILED MAPPING REPORT

TITLE
BASKET LAKE - INDIAN LAKE WEST BATHOLITH AREA (NORTH) - DUCTILE AND BRITTLE-DUCTILE SHEAR ZONES

CONSULTANT

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

PROJECT NO. 1532407 CONTROL REV. FIGURE **5.2.10a**

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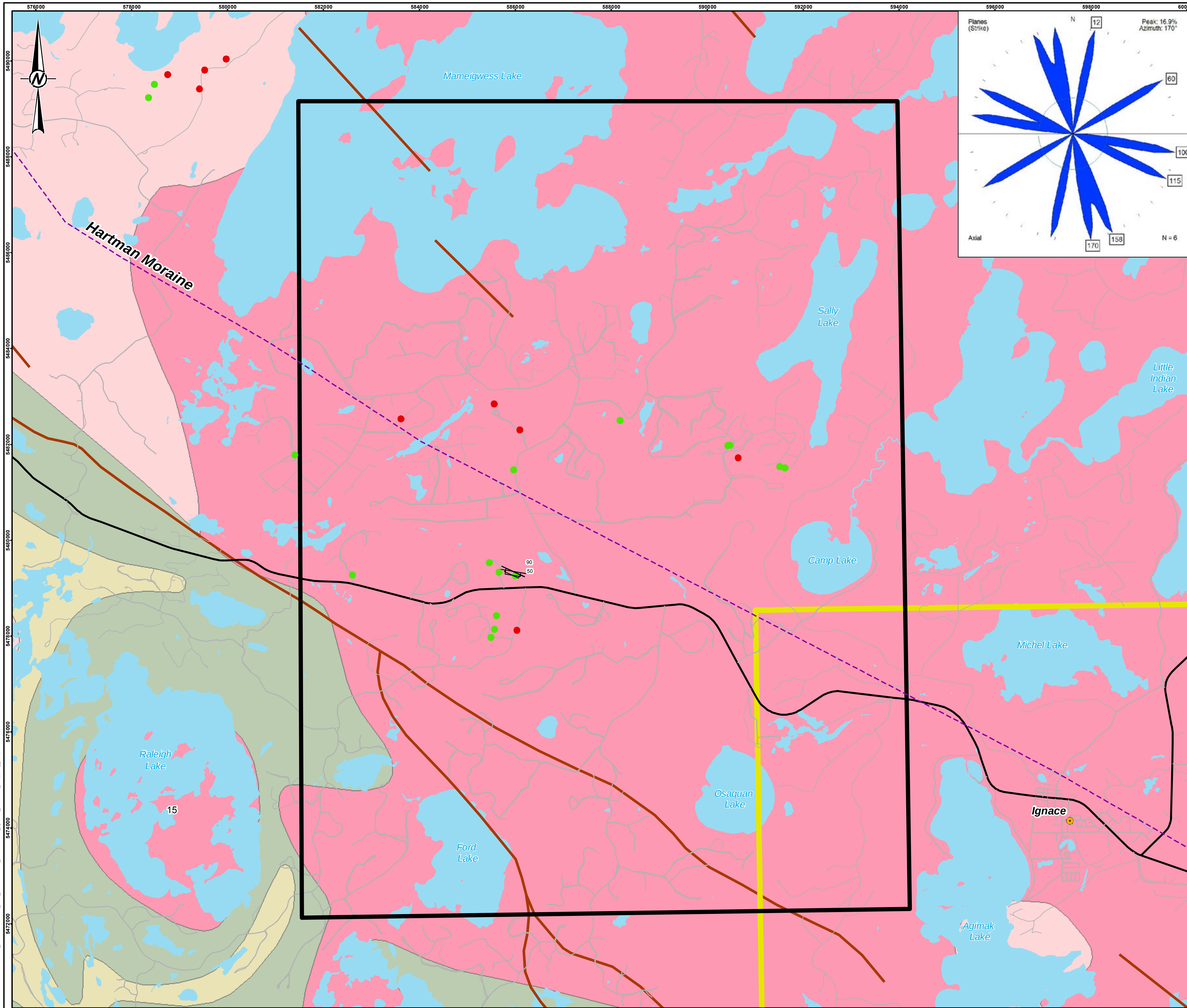
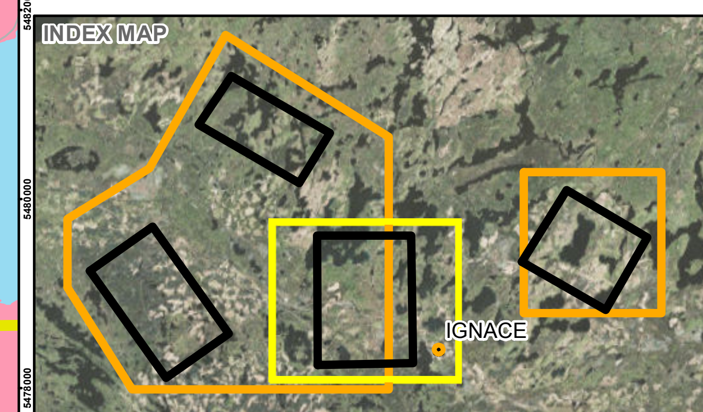


LEGEND

- Withdrawal Area
- Municipal Boundary (Township of Ignace)
- Community
- Main Road
- Local Road
- Waterbody
- Outcrop (16)
- Overburden (9)
- Ductile shear zone - Unknown Slip (2)
- End moraine
- OGS Mapped Dyke

Bedrock Geology

- 15 Massive granodiorite to granite
- 12 Foliated tonalite suite
- 6 Felsic to intermediate metavolcanic rocks
- 5 Mafic to intermediate metavolcanic rocks



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REFERENCE(S)
1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015) AND DOMTAR (2015)

CLIENT
NWMO
IGNACE, ONTARIO

PROJECT
IGNACE DETAILED MAPPING REPORT

TITLE
BASKET LAKE - INDIAN LAKE WEST BATHOLITH AREA (SOUTH) - DUCTILE AND BRITTLE-DUCTILE SHEAR ZONES

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1532407			5.2.10b

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

25mm

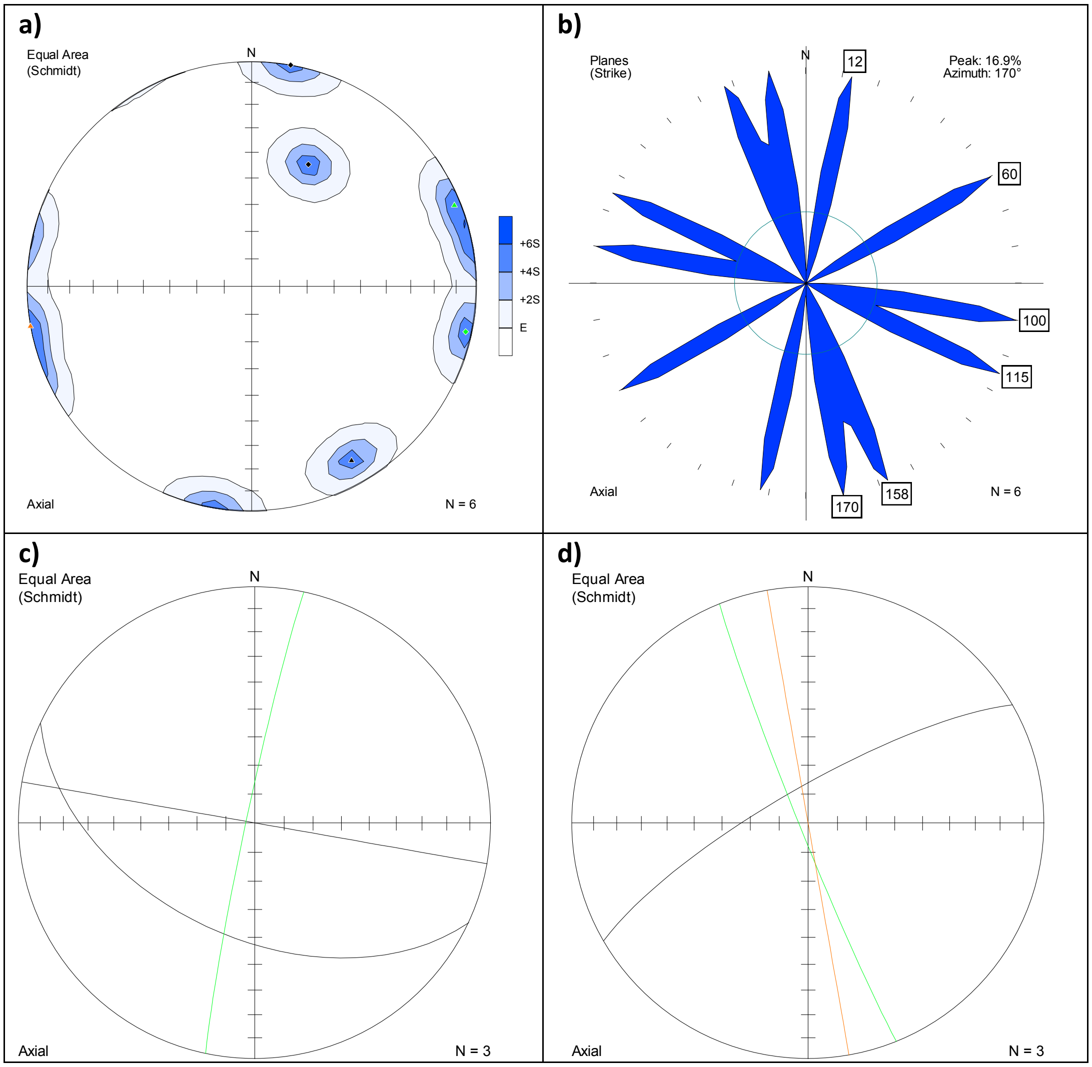


Figure 5.2.11: BASKET LAKE – INDIAN LAKE WEST BATHOLITH AREA - Ductile and Brittle-Ductile Shear Zone Orientation Data

a - All ductile and brittle-ductile shear zones displayed as equal area lower hemisphere stereonet plot of poles to shear planes. Sinistral ductile shear zones: green diamonds (N=1). Sinistral brittle-ductile shear zones: green triangles (N=1). Dextral brittle-ductile shear zones: orange triangles (N=1). Ductile shear zones with unknown slip: black diamonds (N=2). Brittle-ductile shear zones with unknown slip: black diamonds (N=1). Contours show multiples of the standard deviation S above the expectant count E calculated using Gaussian K-100.

b - All shear zone data displayed as rose diagram of trends of shear planes (N=73). Bins for rose diagrams are 10°.

c - Ductile shear zones displayed as equal area lower hemisphere stereonet plot of great circles (N=3). Sinistral structures: green lines (N=1). Structures with unknown slip sense: black (N=2). No lineation data available.

Figure 5.2.11 (Cont'd): BASKET LAKE – INDIAN LAKE WEST BATHOLITH AREA - Ductile and Brittle-Ductile Shear Zone Orientation Data

d - Brittle-ductile shear zones displayed as equal area lower hemisphere stereonet plot of great circles (N=3). Dextral structures: orange lines (N=1). Sinistral structures: green lines (N=1). Structures with unknown slip sense: black (N=1). No lineation data available.

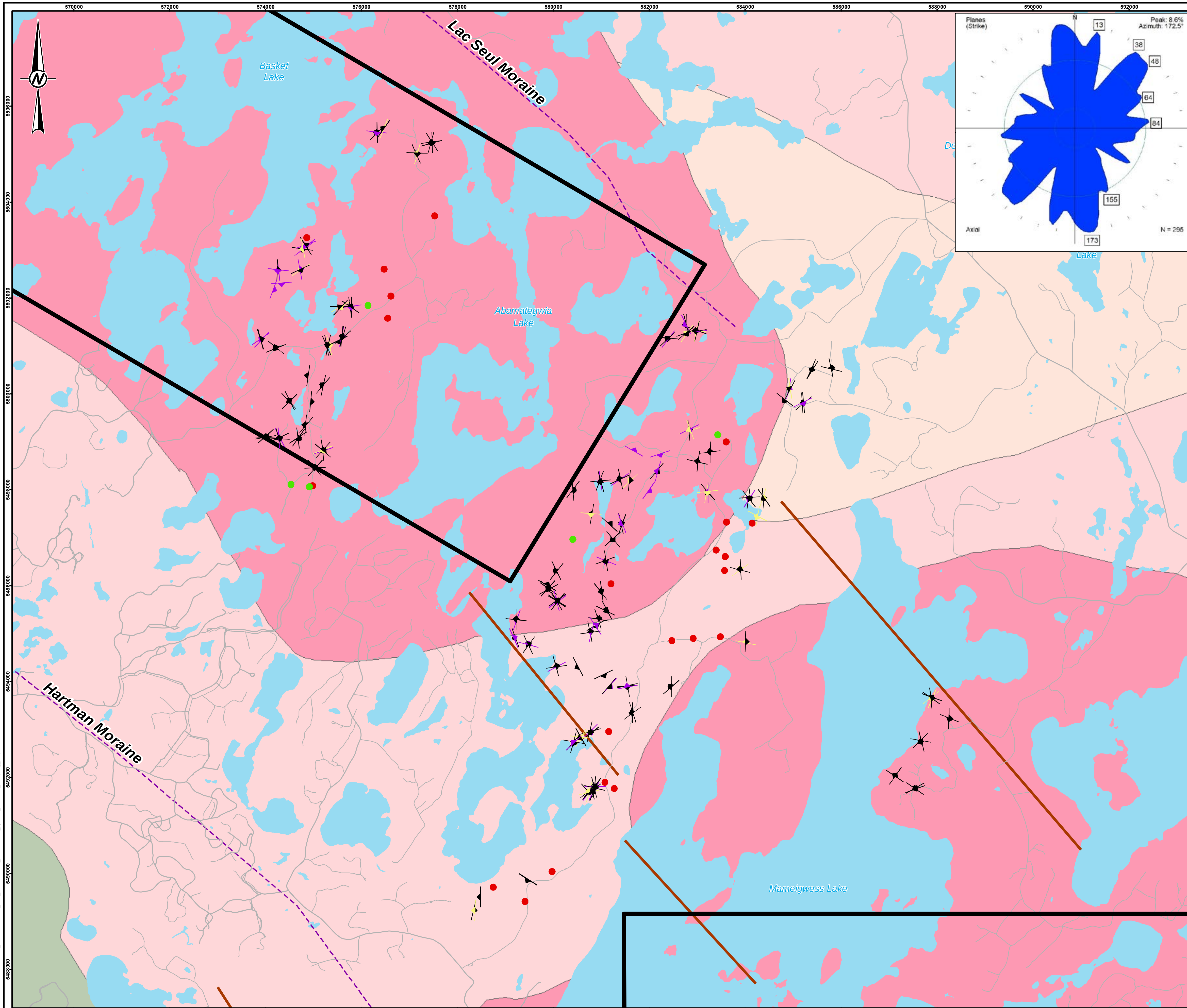
Figure 5.2.12: BASKET LAKE – INDIAN LAKE WEST BATHOLITH AREA – Field Examples of Ductile Structures

a - Igneous flow foliation, defined by the alignment of feldspar phenocrysts, aligned top to bottom in the photograph. View to the west, card for scale (Station 16TC2056).

b - Weakly developed tectonic foliation, defined by biotite, aligned approximately top to bottom in the photograph. View to the west, card for scale (Station 16IL1199).

c - Gneissic layering in tonalite gneiss xenoliths. View to the east, hammer for scale (Station 15TC2184).

d – Small-scale sinistral ductile shear zone to left of compass (192/87). View to the north, compass for scale (Station 16TC2184).

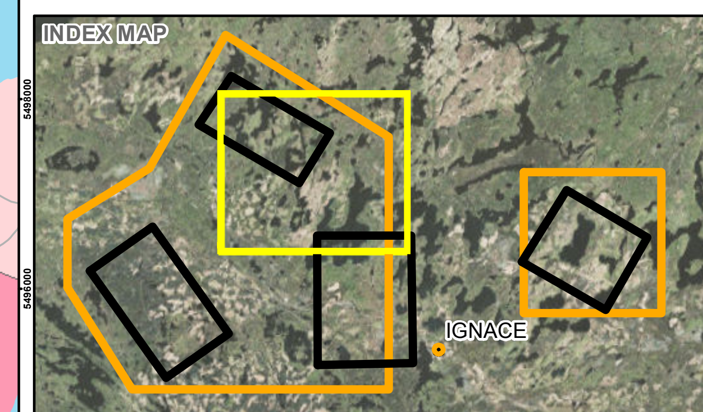


LEGEND

- Withdrawal Area
- Local Road
- Waterbody
- Outcrop (5)
- Overburden (22)
- Sub horizontal joint: 0° - 24° (48)
- Intermediate joint: 25° - 65° (33)
- Sub vertical joint: 66° - 90° (178)
- End moraine
- OGS Mapped Dyke

Bedrock Geology

- 15 Massive granodiorite to granite
- 12 Foliated tonalite suite
- 11 Gneissic tonalite suite
- 5 Mafic to intermediate metavolcanic rocks



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REFERENCE(S)
1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015) AND DOMTAR (2015)

CLIENT
NWMO
IGNACE, ONTARIO

PROJECT
IGNACE DETAILED MAPPING REPORT

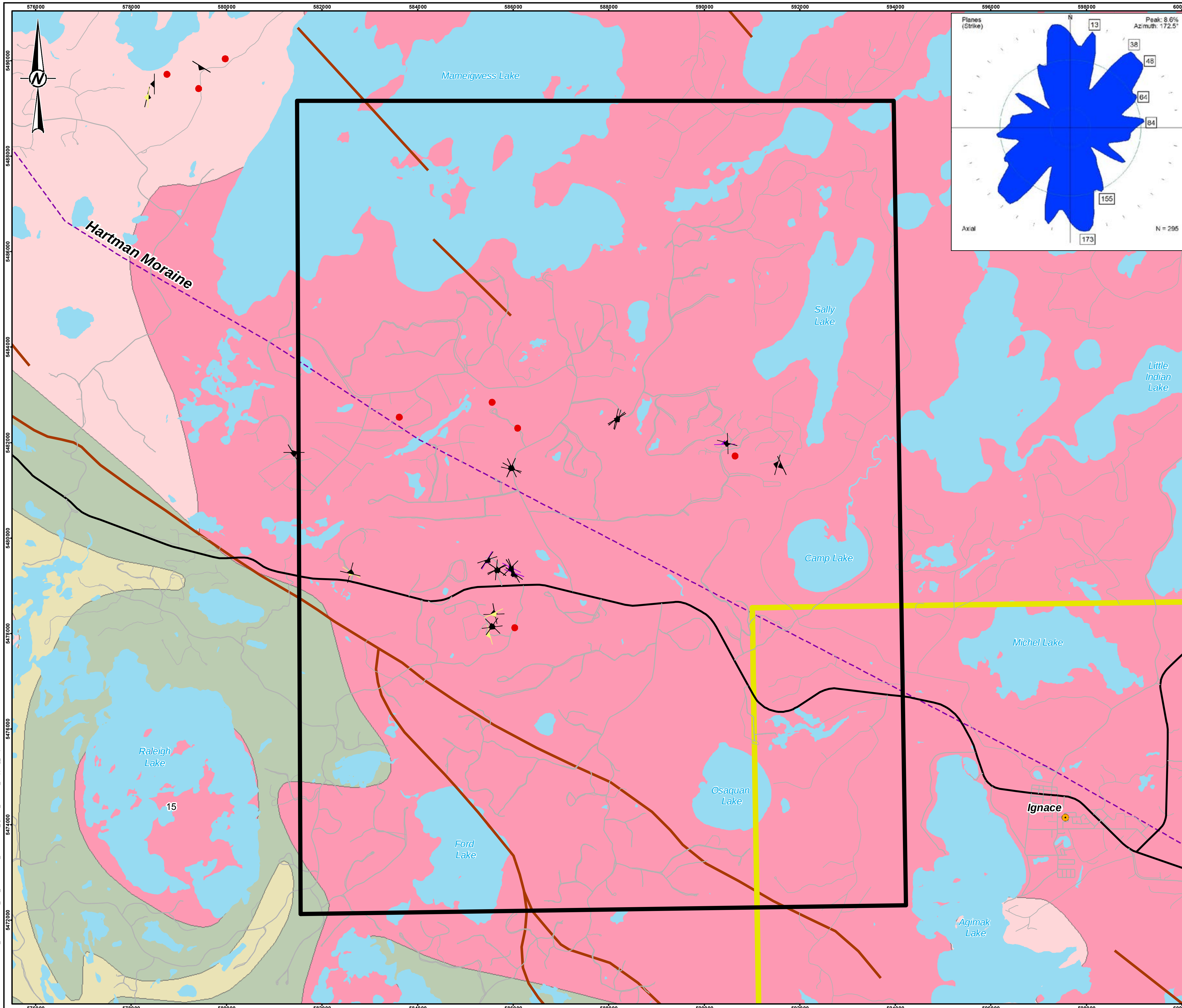
TITLE
BASKET LAKE - INDIAN LAKE WEST BATHOLITH AREA (NORTH) - JOINTS

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1532407			5.2.13a

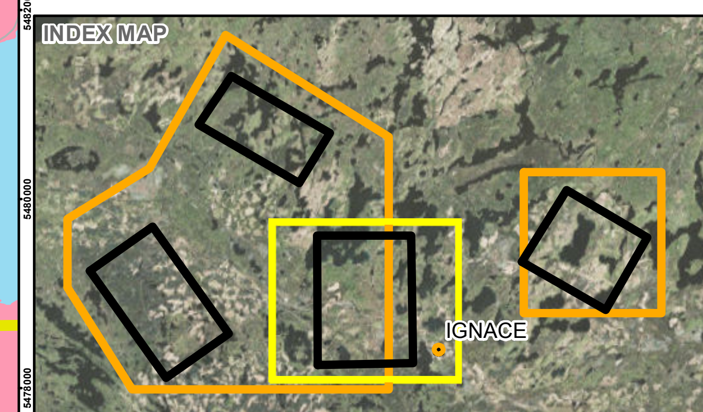


LEGEND

- Withdrawal Area
- Municipal Boundary (Township of Ignace)
- Community
- Main Road
- Local Road
- Waterbody
- Overburden (8)
- Sub horizontal joint: 0° - 24° (6)
- Intermediate joint: 25° - 65° (4)
- Sub vertical joint: 66° - 90° (37)
- End moraine
- OGS Mapped Dyke

Bedrock Geology

- 15 Massive granodiorite to granite
- 12 Foliated tonalite suite
- 6 Felsic to intermediate metavolcanic rocks
- 5 Mafic to intermediate metavolcanic rocks



0 3 6
1:80,000 KILOMETRES

REFERENCE(S)
1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015) AND DOMTAR (2015)

CLIENT
NWMO
IGNACE, ONTARIO

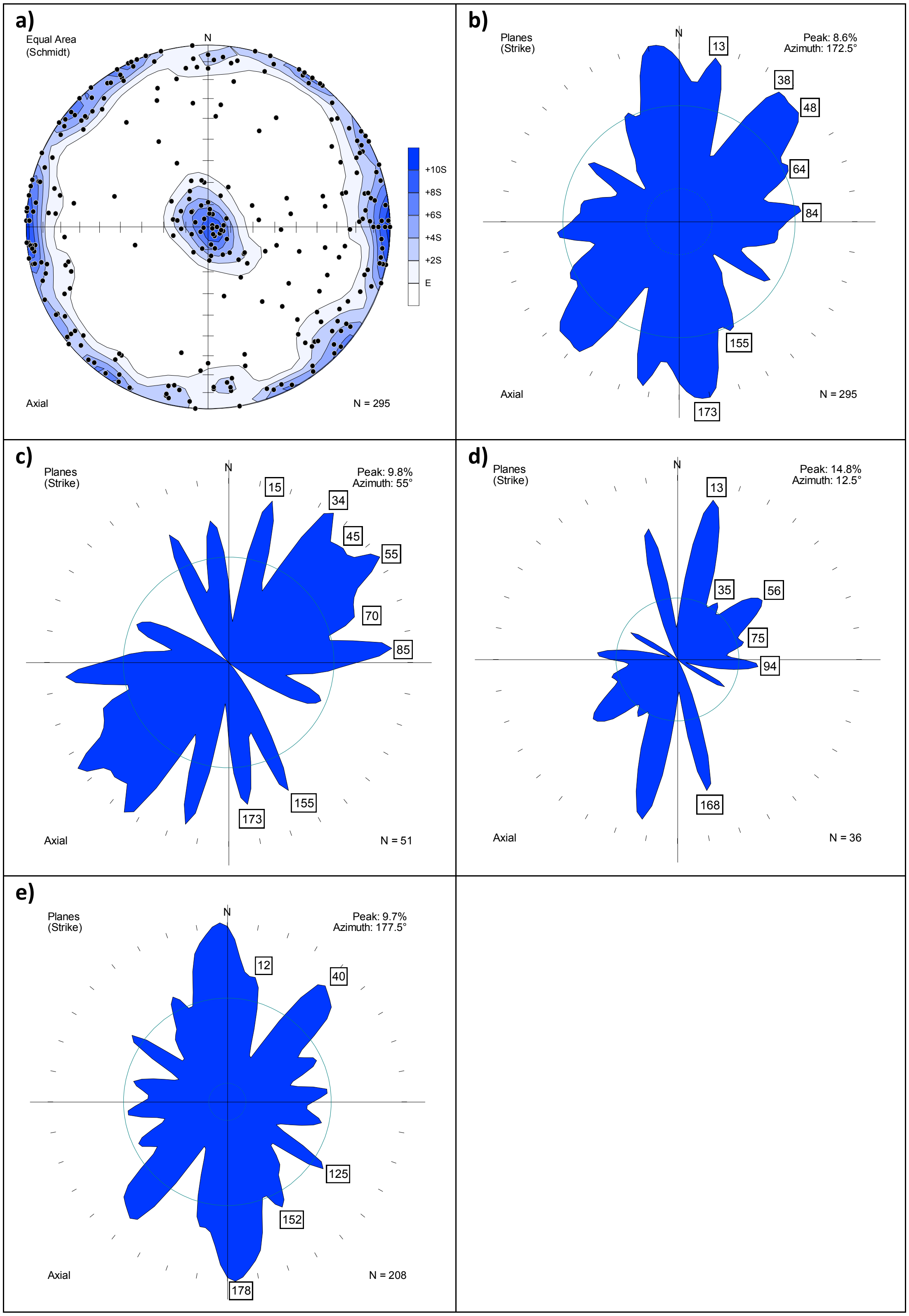
PROJECT
IGNACE DETAILED MAPPING REPORT

TITLE
BASKET LAKE - INDIAN LAKE WEST BATHOLITH AREA (SOUTH) - JOINTS

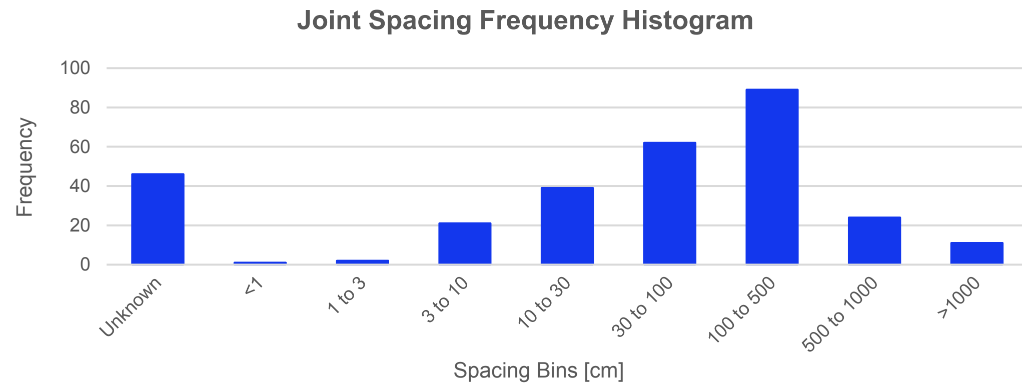
CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

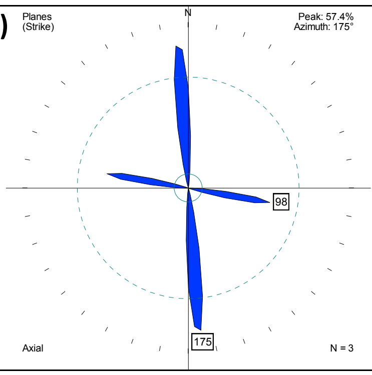
PROJECT NO.	CONTROL	REV.	FIGURE
1532407			5.2.13b


a)
Equal Area
(Schmidt)
N
+10S
+8S
+6S
+4S
+2S
E
Axial
N = 295
b)
Planes
(Strike)
N
Peak: 8.6%
Azimuth: 172.5°
13
38
48
64
84
155
173
Axial
N = 295
c)
Planes
(Strike)
N
Peak: 9.8%
Azimuth: 55°
15
34
45
55
70
85
155
173
Axial
N = 51
d)
Planes
(Strike)
N
Peak: 14.8%
Azimuth: 12.5°
13
35
56
75
94
168
Axial
N = 36
e)
Planes
(Strike)
N
Peak: 9.7%
Azimuth: 177.5°
12
40
125
152
178
Axial
N = 208

f)



g)



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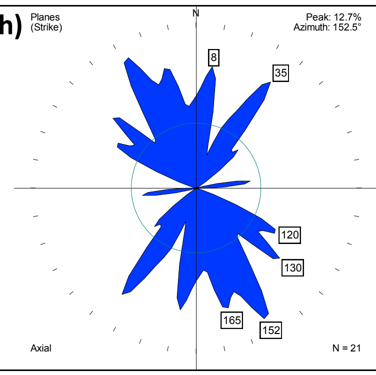
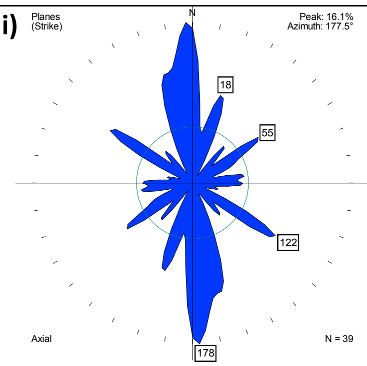


i)

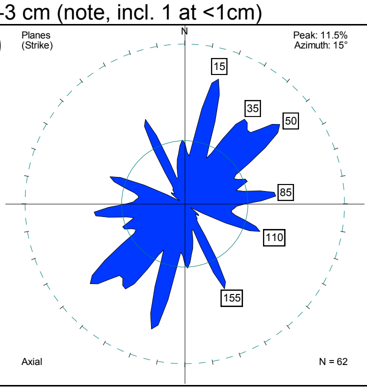


1-3 cm (note, incl. 1 at <1cm)

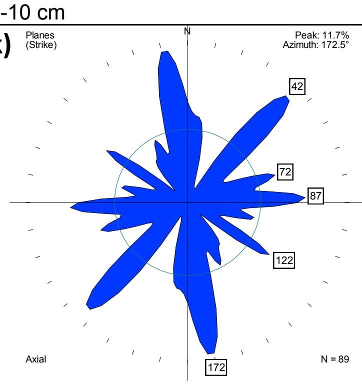
3-10 cm

10-30 cm

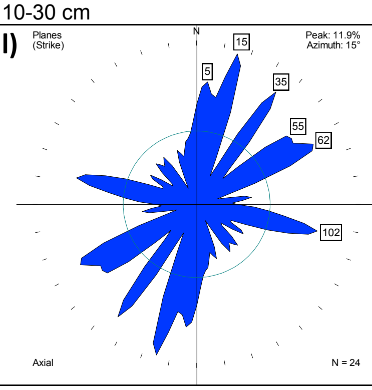
j)



k)



l)

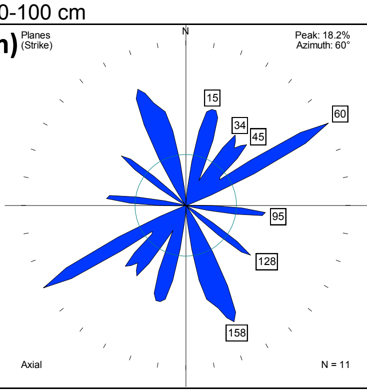


30-100 cm

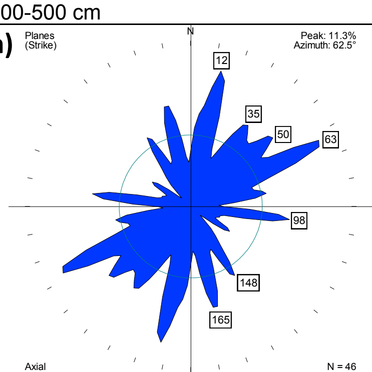
100-500 cm

500-1000

m)



n)



>1000

None/unknown

Figure 5.2.14: BASKET LAKE – INDIAN LAKE WEST BATHOLITH AREA - Joint Orientation Data and Joint Spacing Summary

a - All joint data displayed as equal area lower hemisphere stereonet plot of poles to joints (N=295). Contours show multiples of the standard deviation S above the expectant count E calculated using Gaussian K-100.

b - All joint data displayed as rose diagram of trends of joint planes (N=295). Bins for rose diagrams are 10°.

c - Shallow-dipping joints (<25° dip) displayed as rose diagram of trends of joint planes (N=51). Bins for rose diagrams are 10°.

d – Moderately-dipping joints (25° – 65° dip) displayed as rose diagram of trends of joint planes (N=36). Bins for rose diagrams are 10°.

e - Steep joints (>65° dip) displayed as rose diagram of trends of joint planes (N=208). Bins for rose diagrams are 10°.

f - Joint spacing histograms showing frequency distribution of all joint spacing classes.

g - Joint data with spacing <1 cm and 1-3 cm displayed as rose diagram of trends of joint planes (N=3). Bins for rose diagrams are 10°.

h - Joint data with spacing 3-10 cm displayed as rose diagram of trends of joint planes (N=21). Bins for rose diagrams are 10°.

i - Joint data with spacing 10-30 cm displayed as rose diagram of trends of joint planes (N=39). Bins for rose diagrams are 10°.

j - Joint data with spacing 30-100 cm displayed as rose diagram of trends of joint planes (N=62). Bins for rose diagrams are 10°.

k - Joint data with spacing 100-500 cm displayed as rose diagram of trends of joint planes (N=89). Bins for rose diagrams are 10°.

l - Joint data with spacing 500-1000 cm displayed as rose diagram of trends of joint planes (N=24). Bins for rose diagrams are 10°.

m - Joint data with spacing >1000 cm displayed as rose diagram of trends of joint planes (N=11). Bins for rose diagrams are 10°.

n - Joint data with unknown spacing displayed as rose diagram of trends of joint planes (N=46). Bins for rose diagrams are 10°.

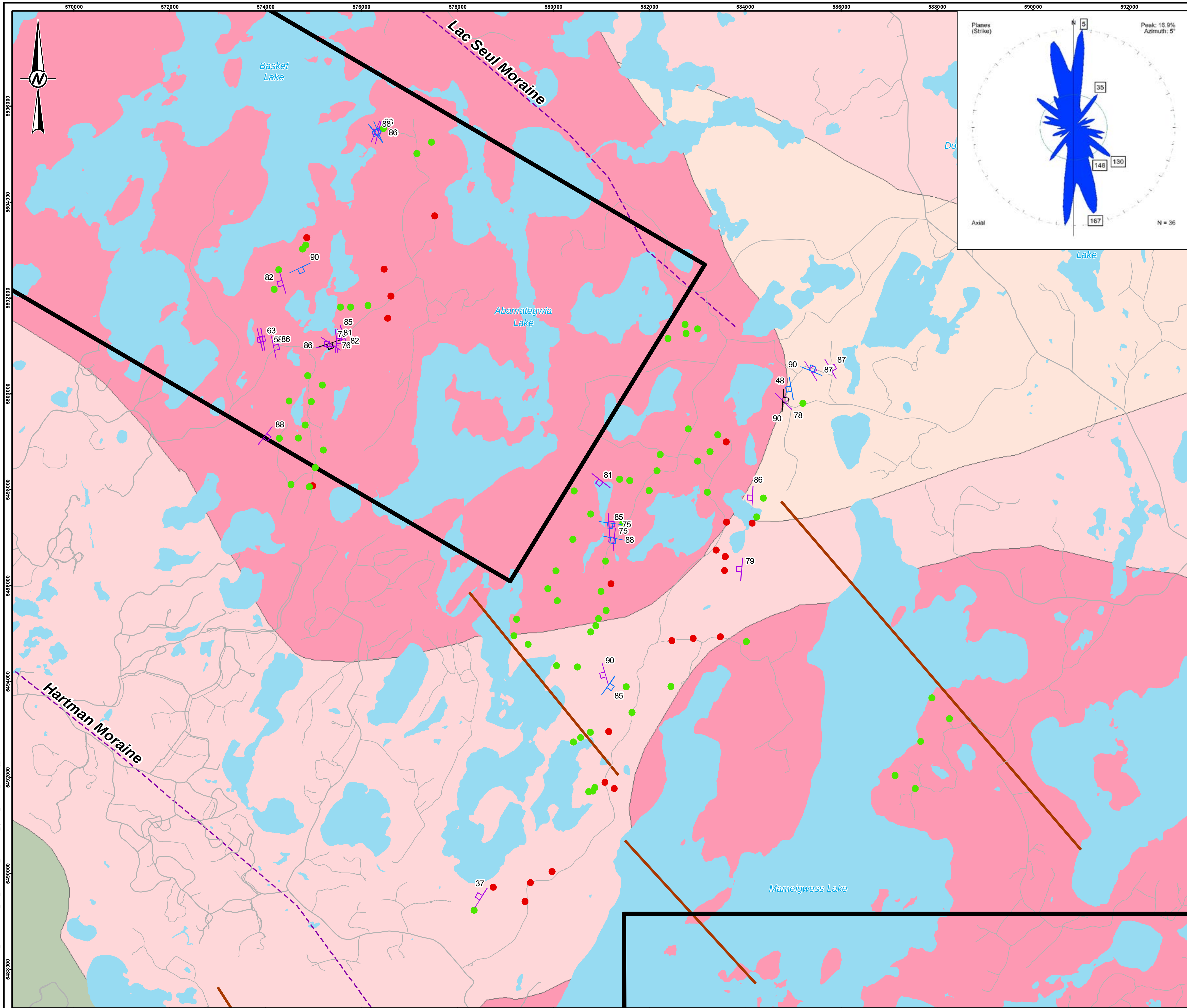
Figure 5.2.15: BASKET LAKE – INDIAN LAKE WEST BATHOLITH AREA – Field Examples of Joints

a - Example of subhorizontal joints forming metre scale steps in the outcrop. View to the east, person and hammer for scale (Station 16IL1178).

b - Example of >1000 cm joint spacing. No joints observed over several metres of outcrop. View to the west, hammer for scale (Station 16TC2170).

c - Example of 3-10 cm joint spacing. Centimetre-scale joint spacing parallel to and near mafic dyke margin. View to the west, hammer for scale (Station 16IL1173).

d - Example of multiple mutually cross-cutting joint sets. View to the southeast, compass for scale (Station 16FB3147).

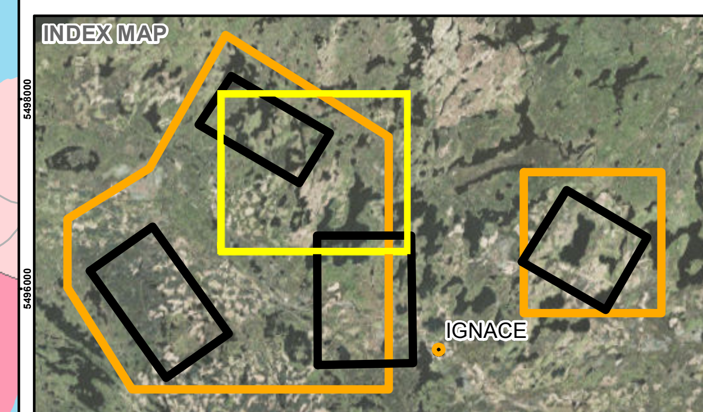


LEGEND

- Withdrawal Area
- Local Road
- Waterbody
- Outcrop (72)
- Overburden (23)
- Fault - Dextral (22)
- Fault - Sinistral (8)
- Fault - Other slip (2)
- End moraine
- OGS Mapped Dyke

Bedrock Geology

- 15 Massive granodiorite to granite
- 12 Foliated tonalite suite
- 11 Gneissic tonalite suite
- 5 Mafic to intermediate metavolcanic rocks



0 3 6

1:80,000 KILOMETRES

REFERENCE(S)
1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015) AND DOMTAR (2015)

CLIENT
NWMO
IGNACE, ONTARIO

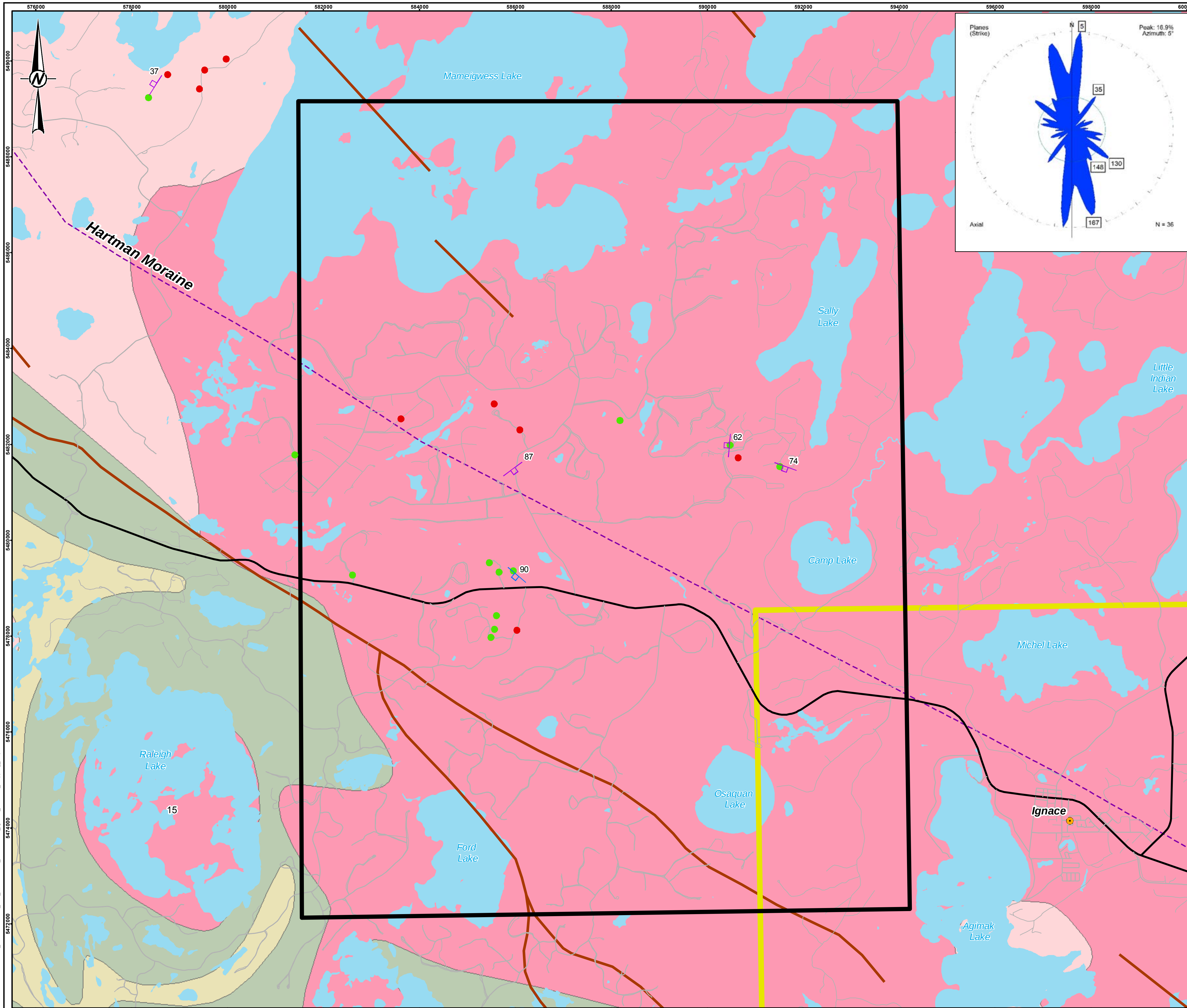
PROJECT
IGNACE DETAILED MAPPING REPORT

TITLE
BASKET LAKE - INDIAN LAKE WEST BATHOLITH AREA (NORTH) - FAULTS

CONSULTANT

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1532407			5.2.16a

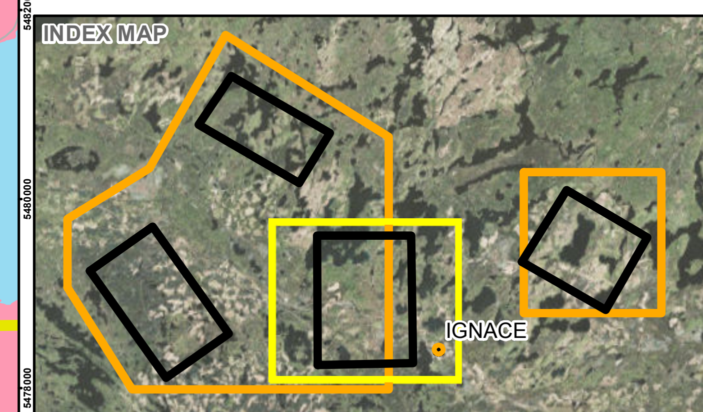


LEGEND

- Withdrawal Area
- Municipal Boundary (Township of Ignace)
- Community
- Main Road
- Local Road
- Waterbody
- Outcrop (12)
- Overburden (9)
- Fault - Dextral (3)
- Fault - Sinistral (1)
- End moraine
- OGS Mapped Dyke

Bedrock Geology

- 15 Massive granodiorite to granite
- 12 Foliated tonalite suite
- 6 Felsic to intermediate metavolcanic rocks
- 5 Mafic to intermediate metavolcanic rocks



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1:80,000 KILOMETRES

REFERENCE(S)
1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015) AND DOMTAR (2015)

CLIENT
NWMO
IGNACE, ONTARIO

PROJECT
IGNACE DETAILED MAPPING REPORT

TITLE
BASKET LAKE - INDIAN LAKE WEST BATHOLITH AREA (SOUTH) - FAULTS

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1532407			5.2.16b

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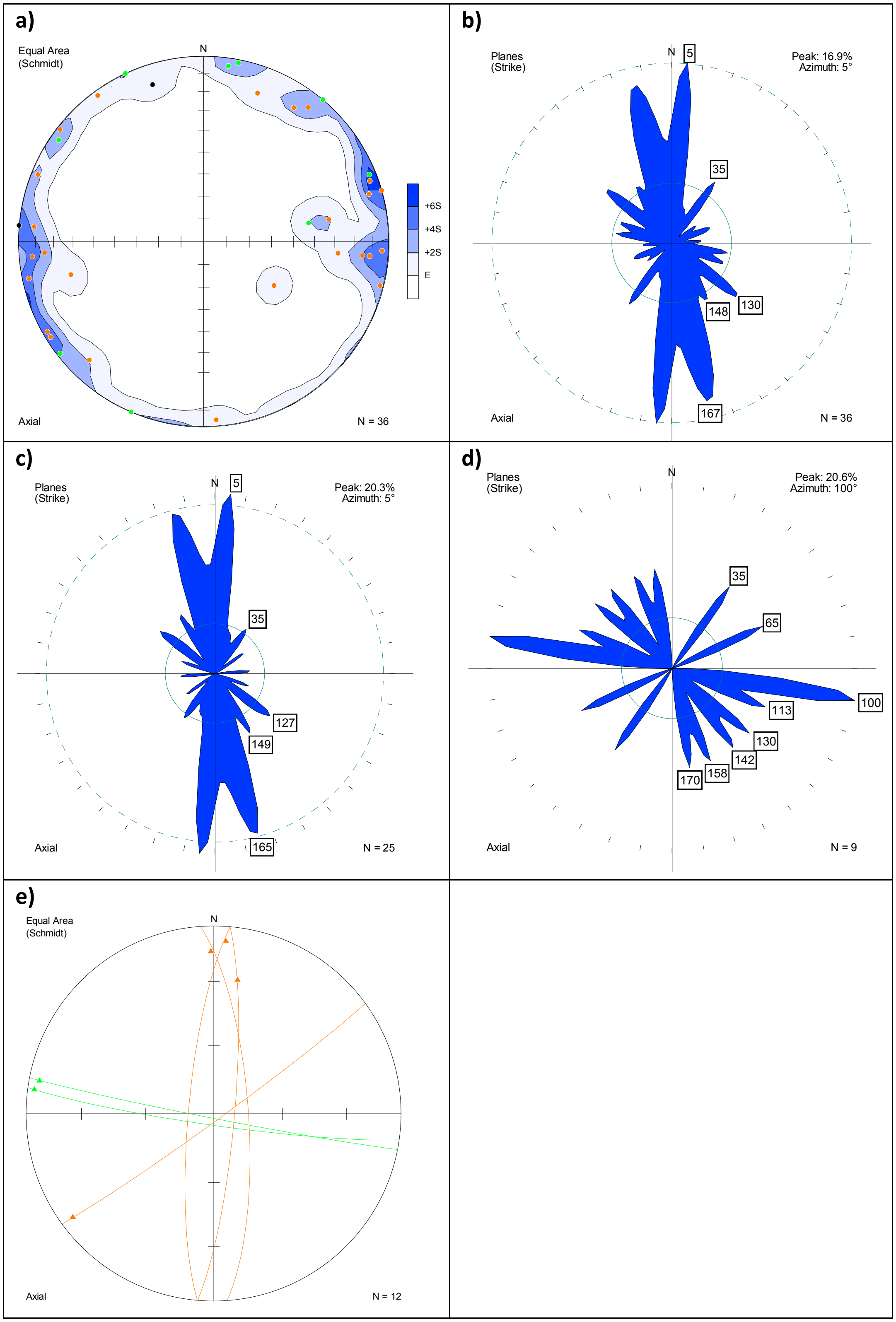

a)
Equal Area
(Schmidt)
N
+6S
+4S
+2S
E
Axial
N = 36
b)
Planes
(Strike)
N
5
Peak: 16.9%
Azimuth: 5°
35
130
148
167
Axial
N = 36
c)
Planes
(Strike)
N
5
Peak: 20.3%
Azimuth: 5°
35
127
149
165
Axial
N = 25
d)
Planes
(Strike)
N
Peak: 20.6%
Azimuth: 100°
35
65
100
113
130
142
158
170
Axial
N = 9
e)
Equal Area
(Schmidt)
N
Axial
N = 12

Figure 5.2.17: BASKET LAKE – INDIAN LAKE WEST BATHOLITH AREA - Fault Orientation Data

a - All fault data displayed as equal area lower hemisphere stereonet plot of poles to fault planes. Dextral faults: orange circles (N=25). Sinistral faults: green circles (N=9). Faults with unknown slip: black circles (N=2). Contours show multiples of the standard deviation S above the expectant count E calculated using Gaussian K-100.

b - All fault data displayed as rose diagram of trends of fault planes (N=36). Bins for rose diagrams are 10°.

c - Dextral fault data displayed as rose diagram of trends of fault planes (N=25). Bins for rose diagrams are 10°.

d - Sinistral fault data displayed as rose diagram of trends of fault planes (N=9). Bins for rose diagrams are 10°.

e - Faults with slickenline lineation displayed as equal area lower hemisphere stereonet plot of great circles (N=6) and associated lineations (N=6). Dextral faults: orange lines (N=4). Sinistral faults: green lines (N=2). Slickenlines projected on to fault planes.

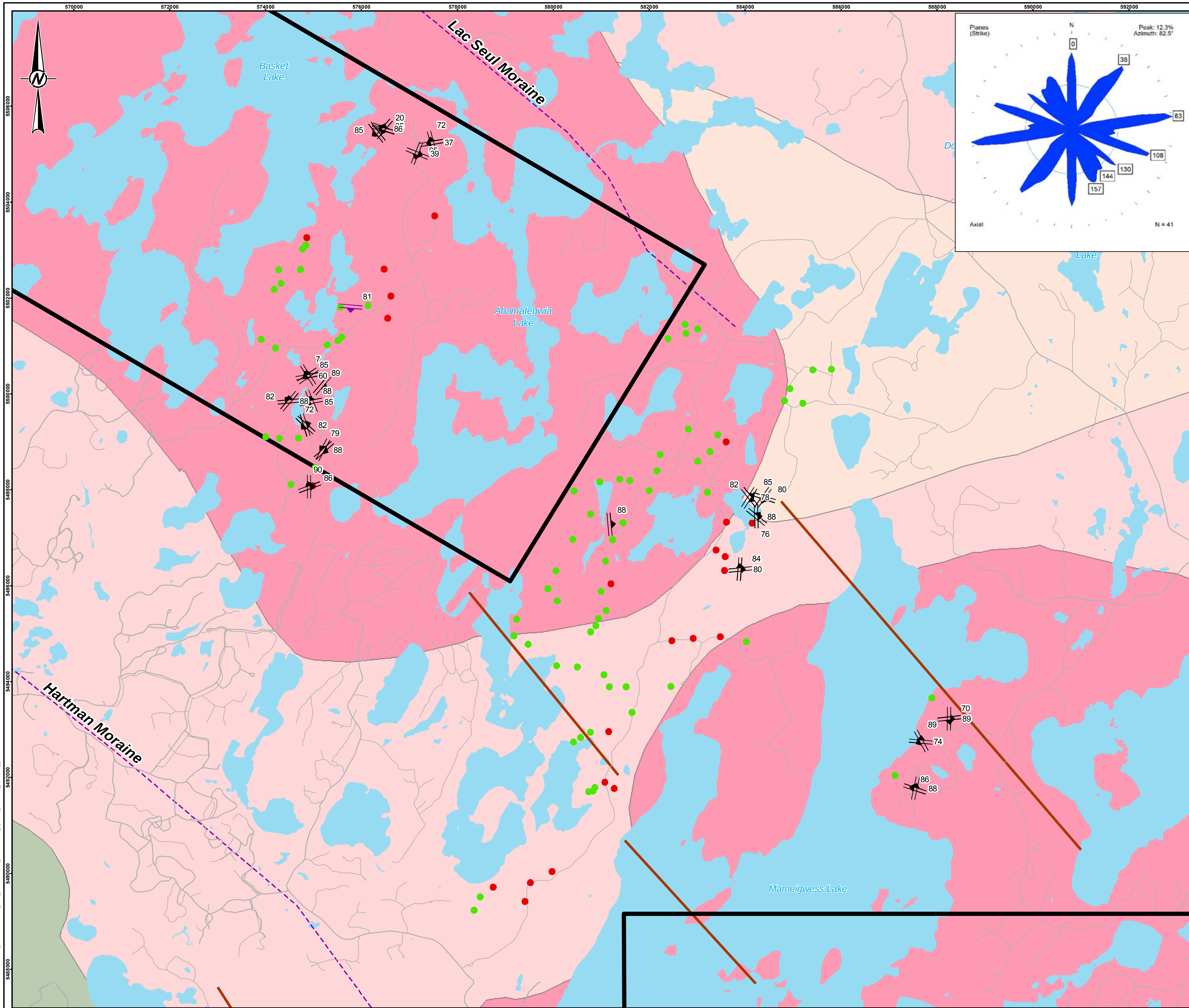
Figure 5.2.18: BASKET LAKE – INDIAN LAKE WEST BATHOLITH AREA – Field Examples of Faults

a - Fault (158/86) associated with quartz vein and breccia infill in fault. View to the northwest, pencil for scale (Station 16IL1196).

b - Dextral offset of pegmatite vein on north-striking subvertical fault with quartz infill. View to the northeast, compass for scale (Station 16IL1196).

c - Crush zone in fault core (055/86). View to the southeast, pencil for scale (Station 16IL1181).

d - Dextral fault surface, with subhorizontal slickenlines, spatially correlated with a NNW-striking lineament. View to the west, pencil for scale (Station 16IL1162).



LEGEND

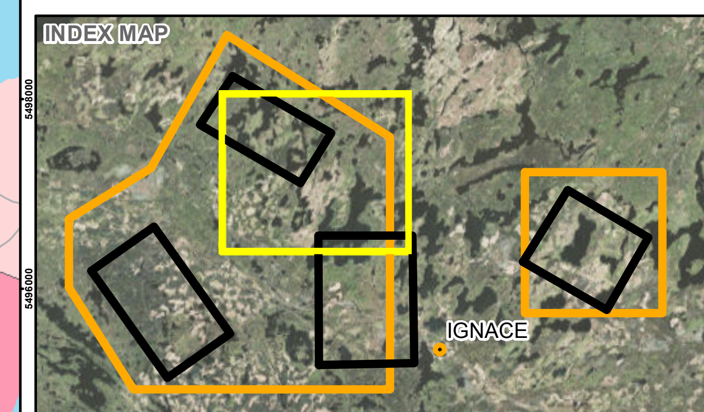
- Withdrawal Area
- Local Road
- Waterbody
- Outcrop (73)
- Overburden (23)

Vein

- Extension (37)
- Other (1)
- End moraine
- OGS Mapped Dyke

Bedrock Geology

- 15 Massive granodiorite to granite
- 12 Foliated tonalite suite
- 11 Gneissic tonalite suite
- 5 Mafic to intermediate metavolcanic rocks



0 3 6

1:80,000 KILOMETRES

REFERENCE(S)

1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015) AND DOMTAR (2015)

CLIENT

NWMO

IGNACE, ONTARIO

PROJECT

IGNACE DETAILED MAPPING REPORT

TITLE

BASKET LAKE - INDIAN LAKE WEST BATHOLITH AREA (NORTH) - VEINS

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1532407			5.2.19a

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

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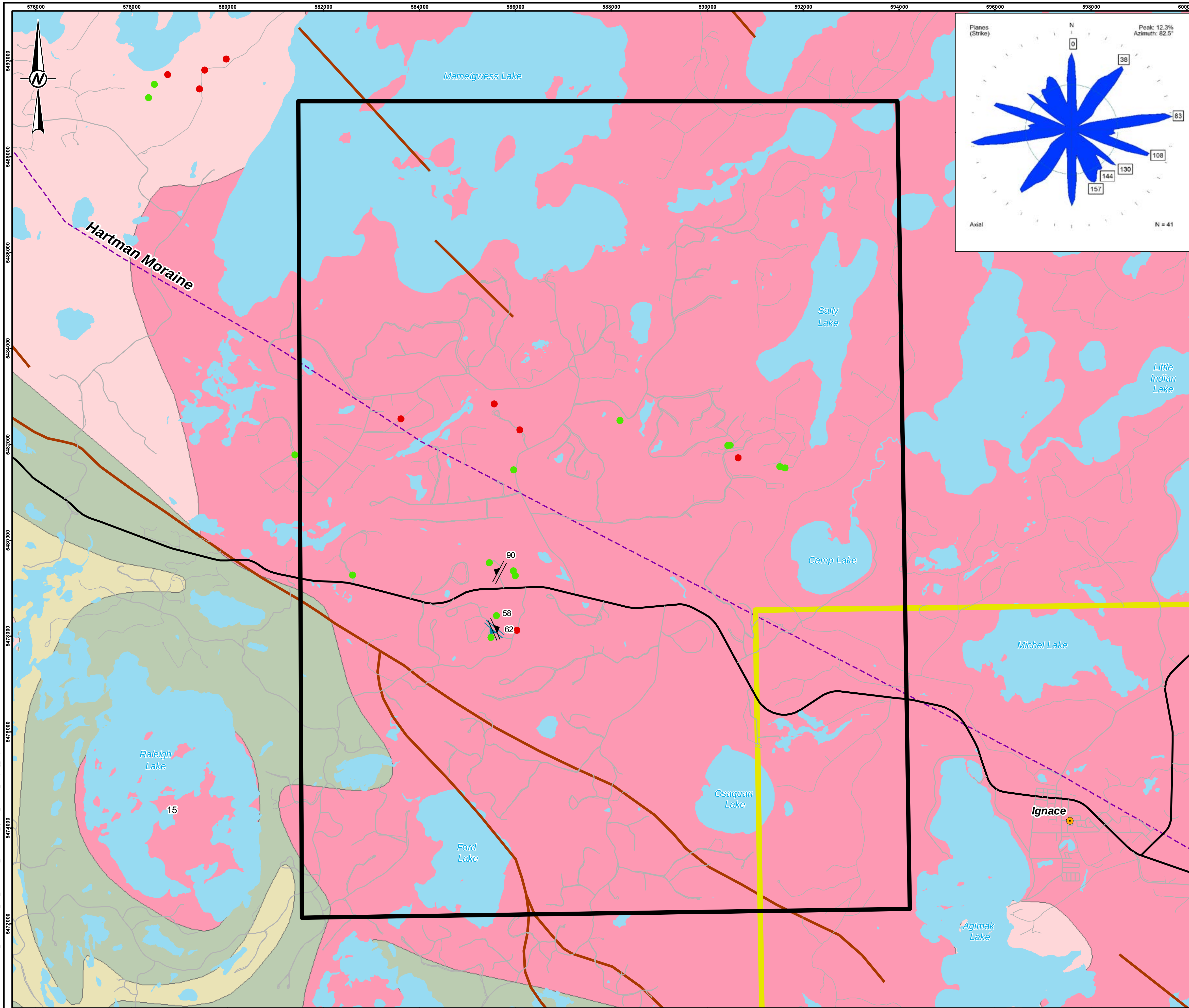


LEGEND

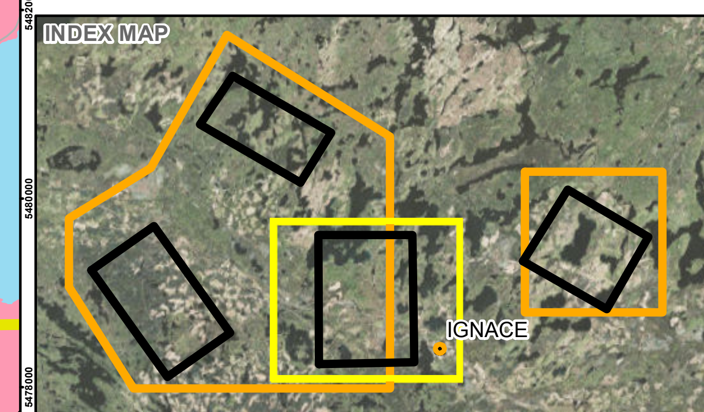
- Withdrawal Area
- Municipal Boundary (Township of Ignace)
- Community
- Main Road
- Local Road
- Waterbody
- Outcrop (15)
- Overburden (9)

Vein

- Extension (2)
- Shear (1)
- End moraine
- OGS Mapped Dyke

Bedrock Geology

- 15 Massive granodiorite to granite
- 12 Foliated tonalite suite
- 6 Felsic to intermediate metavolcanic rocks
- 5 Mafic to intermediate metavolcanic rocks



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REFERENCE(S)

1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015) AND DOMTAR (2015)

CLIENT
NWMO
IGNACE, ONTARIO

PROJECT
IGNACE DETAILED MAPPING REPORT

TITLE
BASKET LAKE - INDIAN LAKE WEST BATHOLITH AREA (SOUTH) - VEINS

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1532407			5.2.19b

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

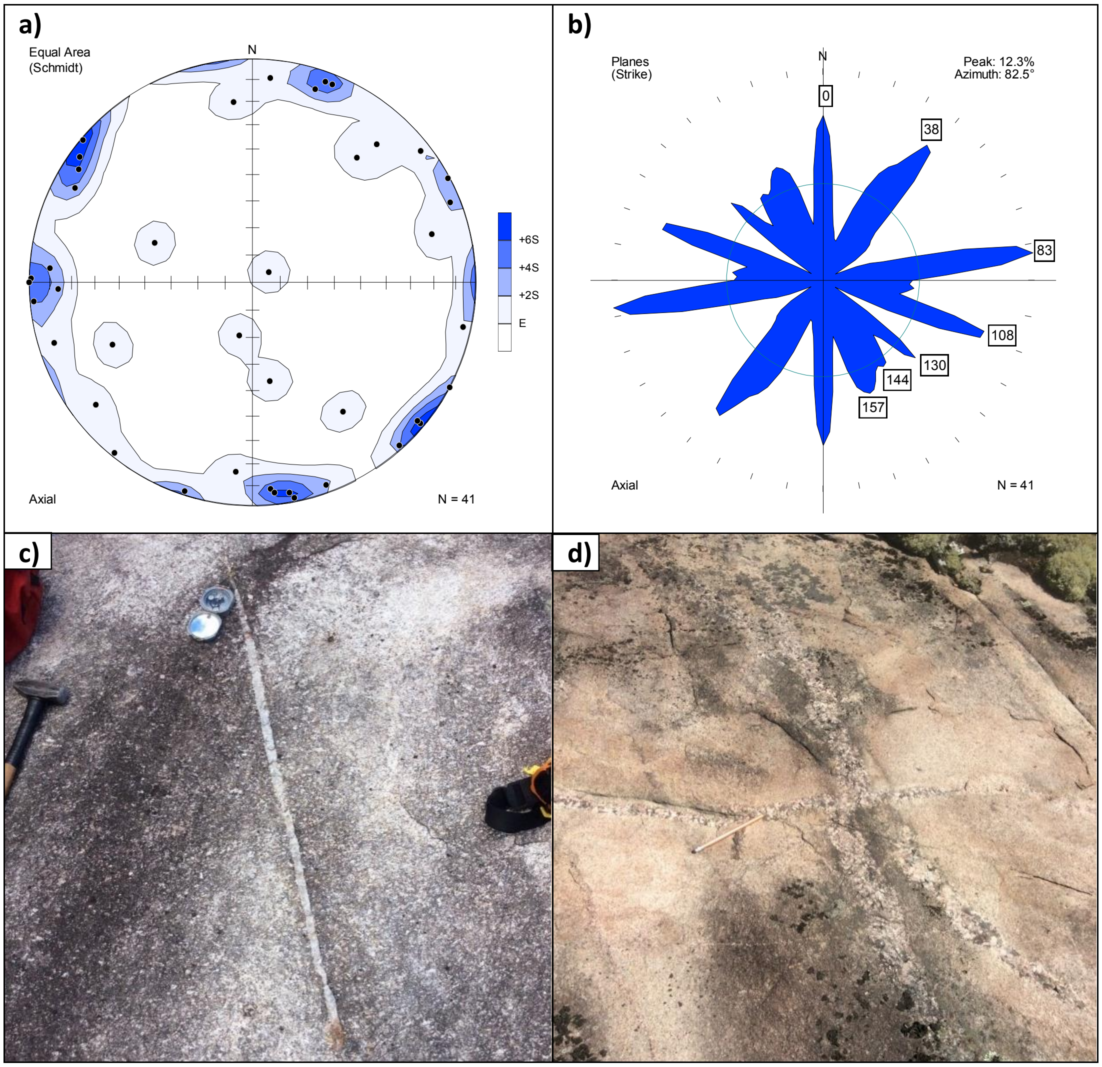


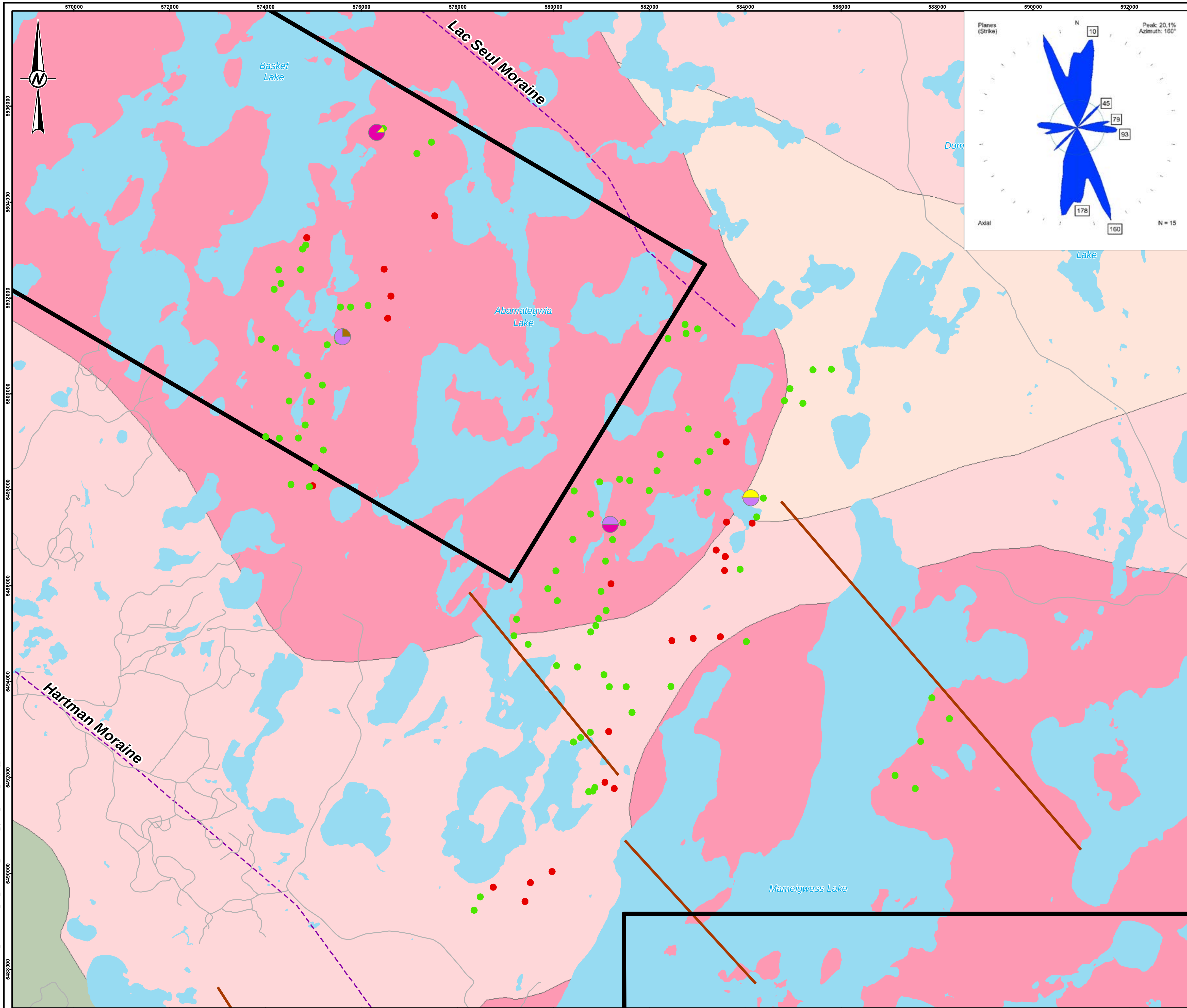
Figure 5.2.20: BASKET LAKE – INDIAN LAKE WEST BATHOLITH AREA - Vein Orientation Data and Field Examples

a - All vein data displayed as equal area lower hemisphere stereonet plot of poles to veins (N=41). Contours show multiples of the standard deviation S above the expectant count E calculated using Gaussian K-100.

b - All vein data displayed as rose diagram of trends of veins (N=38). Bins for rose diagrams are 10°.

c - Extensional quartz-filled vein. View to the northwest, compass for scale (Station 16TC2056).

d - Multiple intersecting pegmatite veins. View to the southeast, pencil for scale (Station 16IL1199).

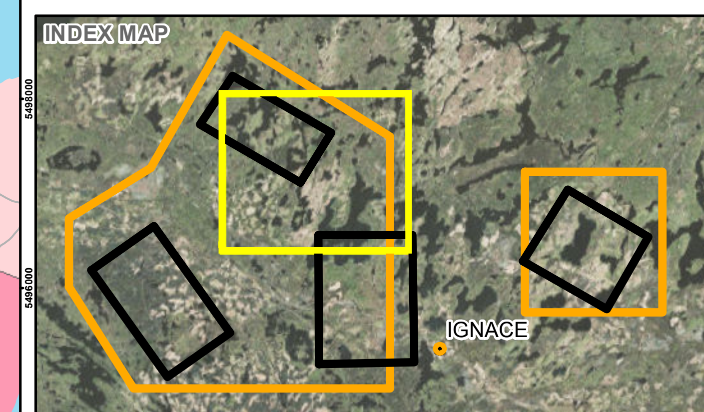


LEGEND

- Withdrawal Area
- Local Road
- Waterbody
- Outcrop
- Overburden
- End moraine
- OGS Mapped Dyke
- Secondary Minerals and Alteration
- Alkali Feldspar (0)
- Biotite (0)
- Chlorite (1)
- Epidote (2)
- Hematite (3)
- Plagioclase (0)
- Pyrite (0)
- Quartz (2)

Bedrock Geology

- 15 Massive granodiorite to granite
- 12 Foliated tonalite suite
- 11 Gneissic tonalite suite
- 5 Mafic to intermediate metavolcanic rocks



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REFERENCE(S)
1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015) AND DOMTAR (2015)

CLIENT
NWMO
IGNACE, ONTARIO

PROJECT
IGNACE DETAILED MAPPING REPORT

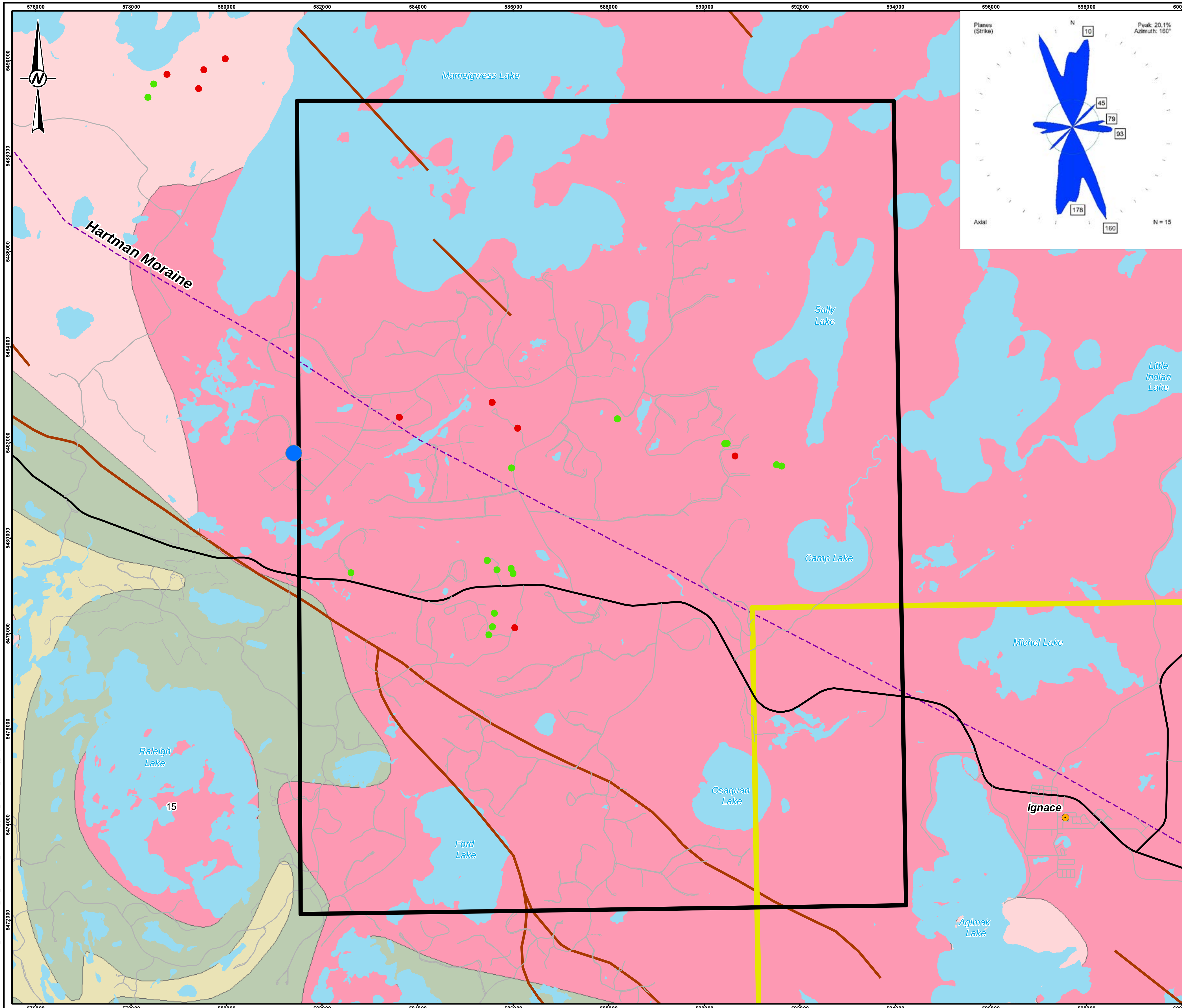
TITLE
BASKET LAKE - INDIAN LAKE WEST BATHOLITH AREA (NORTH) - SECONDARY MINERAL INFILL AND ALTERATION

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1532407			5.2.21a

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

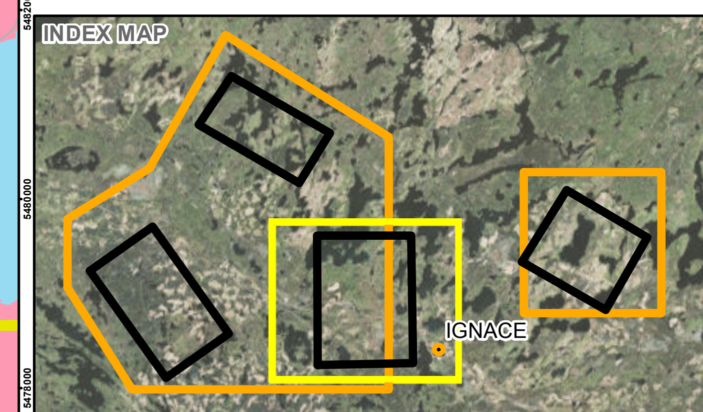


LEGEND

- Withdrawal Area
- Municipal Boundary (Township of Ignace)
- Community
- Main Road
- Local Road
- Waterbody
- Outcrop
- Overburden
- End moraine
- OGS Mapped Dyke
- Secondary Minerals and Alteration
- Alkali Feldspar (1)
- Biotite (0)
- Chlorite (0)
- Epidote (0)
- Hematite (0)
- Plagioclase (0)
- Pyrite (0)
- Quartz (0)

Bedrock Geology

- 15 Massive granodiorite to granite
- 12 Foliated tonalite suite
- 6 Felsic to intermediate metavolcanic rocks
- 5 Mafic to intermediate metavolcanic rocks



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1:80,000 KILOMETRES

REFERENCE(S)
1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
3. LOGGING ROAD DATA PROVIDED BY DOMTAR (2015).

CLIENT
NWMO
IGNACE, ONTARIO

PROJECT
IGNACE DETAILED MAPPING REPORT

TITLE
BASKET LAKE - INDIAN LAKE WEST BATHOLITH AREA (SOUTH) - SECONDARY MINERAL INFILL AND ALTERATION

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1532407			**5.2.21b**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:
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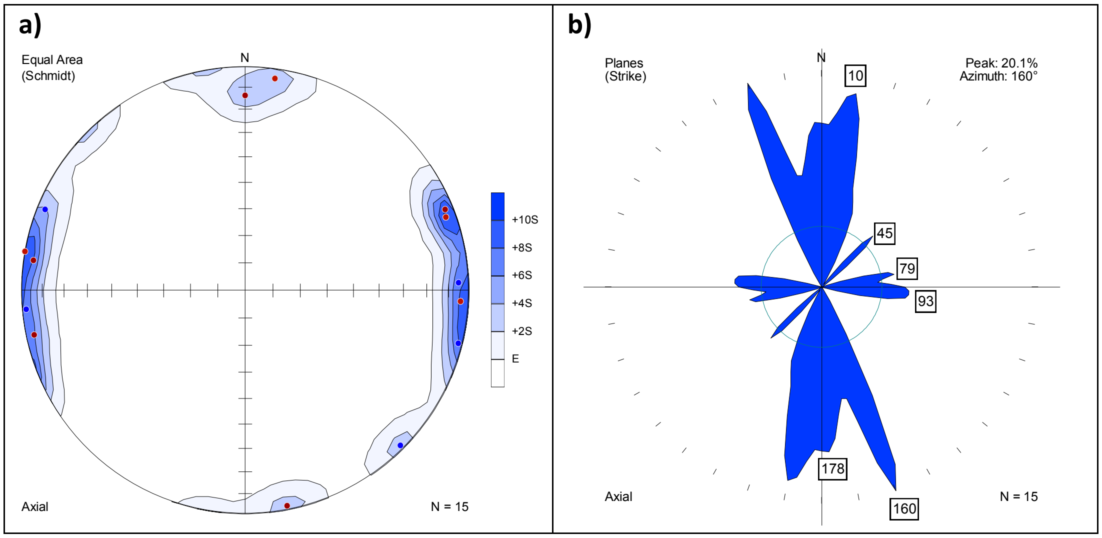


Figure 5.2.22: BASKET LAKE – INDIAN LAKE WEST BATHOLITH AREA – Secondary Minerals and Alteration Orientation Data

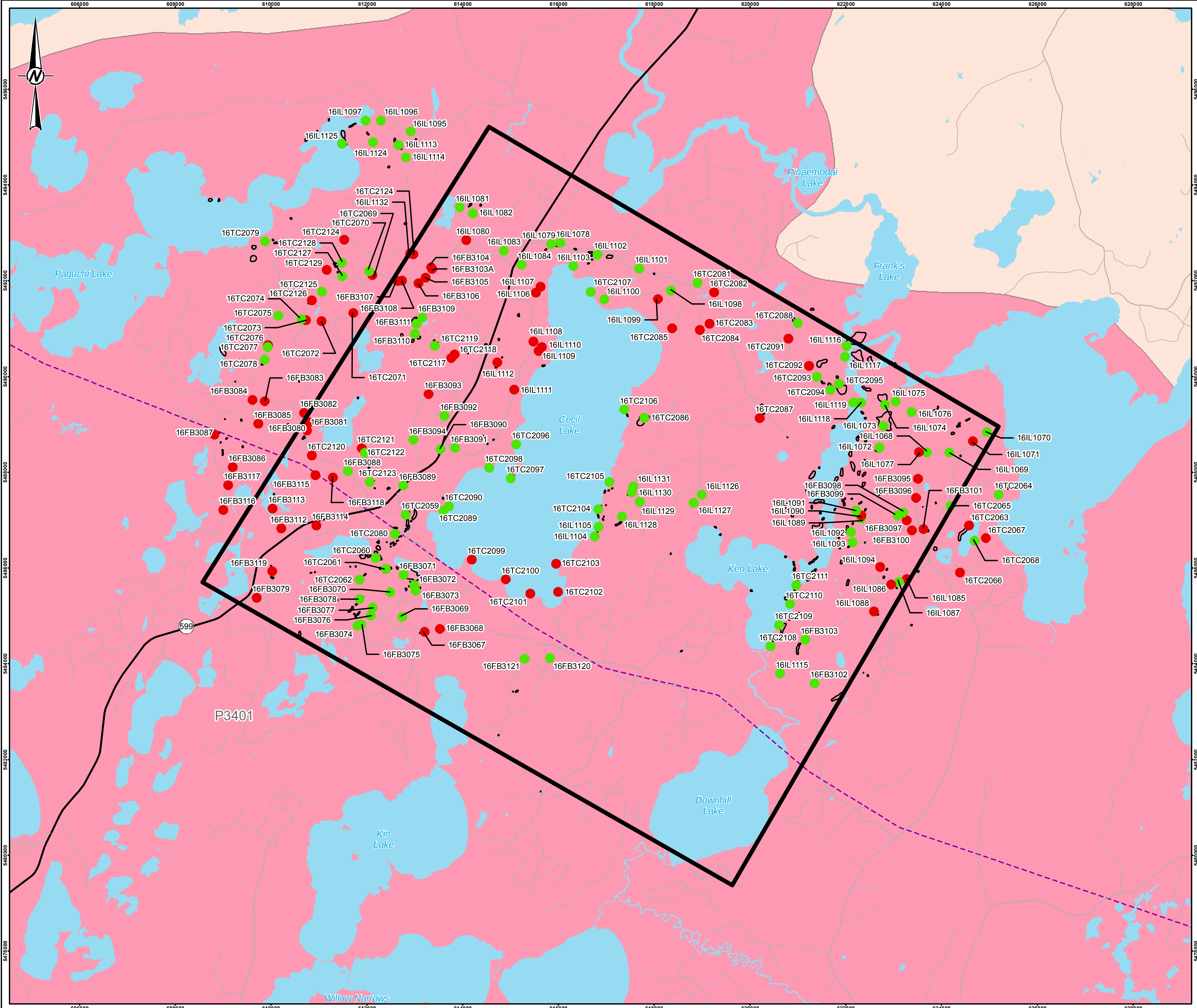
a - All mineral infill data displayed as equal area lower hemisphere stereonet plot of poles to joints, faults, or veins (N=164). Quartz infill: blue (N=5). Hematite infill: red (N=4). Other infill (breccia, epidote, feldspar, chlorite, bleaching): black (N=6). Contours show multiples of the standard deviation S above the expectant count E calculated using Gaussian K-100.

b - All mineral infill data displayed as rose diagram of trends of joints, faults, or veins (N=15). Bins for rose diagrams are 10°.

Figure 5.2.23: BASKET LAKE – INDIAN LAKE WEST BATHOLITH AREA - Field Examples of Secondary Minerals and Alteration

a - Chlorite and hematite coating several parallel brittle dextral fault planes (160/85). View to the west, compass for scale (Station 16FB3162).

b - Hematite stain on a fault plane (185/79). View to the west, pencil for scale (Station 16IL1208).

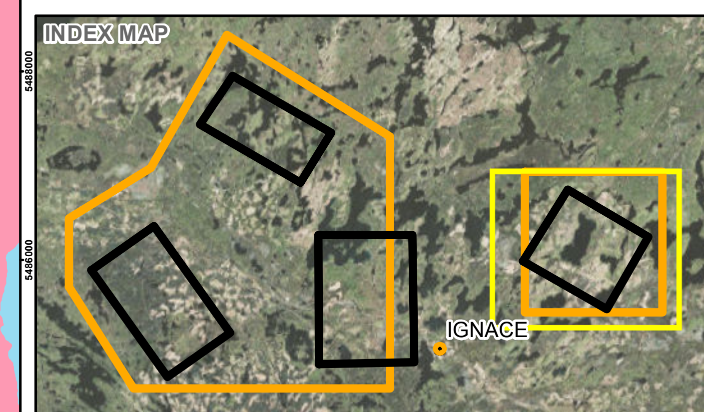


LEGEND

- Withdrawal Area
- Main Road
- Local Road
- Waterbody
- Outcrop (108)
- Overburden (76)
- End moraine
- Predicted Outcrop

Bedrock Geology

- 15 Massive granodiorite to granite
- 12 Foliated tonalite suite
- 11 Gneissic tonalite suite



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REFERENCE(S)
1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015)

CLIENT
NWMO
IGNACE, ONTARIO

PROJECT
IGNACE DETAILED MAPPING REPORT

TITLE
INDIAN LAKE EAST BATHOLITH AREA - MAPPING OBSERVATION LOCATIONS

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1532407			5.3.1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

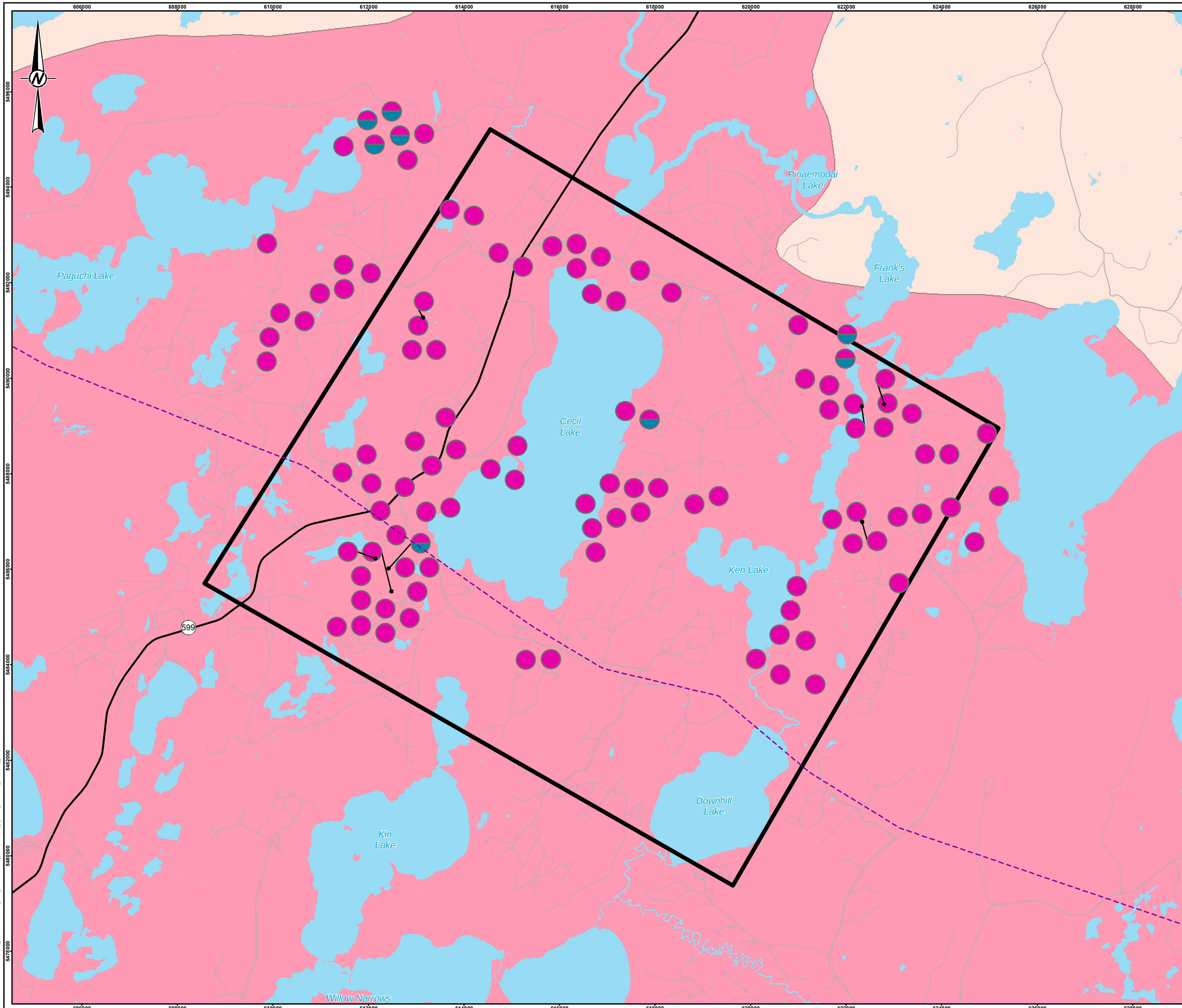
Figure 5.3.2: INDIAN LAKE EAST BATHOLITH AREA – Field Examples of Accessibility and Bedrock Exposure

a - Typical well-maintained secondary forestry road used for access. View to the east, trucks for scale (Station 16TC2120).

b - A portion of well-exposed bedrock on the Cecil lake shoreline. The lake is a major geographical feature of the Indian Lake East area. View to the north, person for scale (Station 16TC2106).

c - Typical bedrock exposure in forested area showing moss and lichen cover on bedrock. View to the northeast, person for scale (Station 16FB3111).

d - Overburden cover showing an example of a large sand plain located to the west of Cecil Lake. View to the east, person for scale (Station 16IL1109).



LEGEND

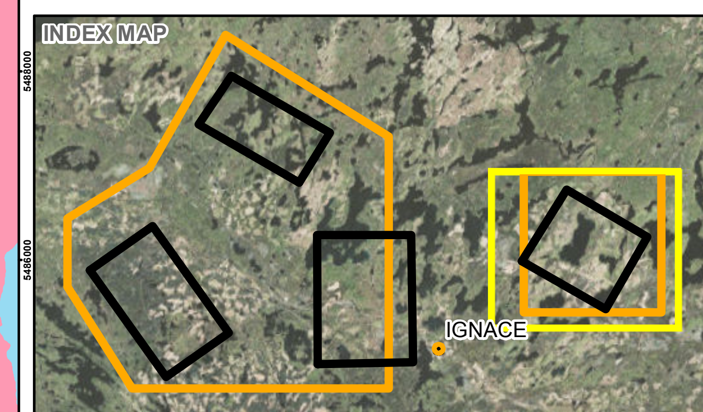
- Withdrawal Area
- Main Road
- Local Road
- Waterbody

Major Lithology

- Granite (106)
- Tonalite (8)
- End moraine

Bedrock Geology

- 15 Massive granodiorite to granite
- 12 Foliated tonalite suite
- 11 Gneissic tonalite suite



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REFERENCE(S)
1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
2A. STONE, HELLEBRANDT & LANGE 2011 (P3623)
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015)

CLIENT
NWMO
IGNACE, ONTARIO

PROJECT
IGNACE DETAILED MAPPING REPORT

TITLE
INDIAN LAKE EAST BATHOLITH AREA - MAIN LITHOLOGICAL UNITS

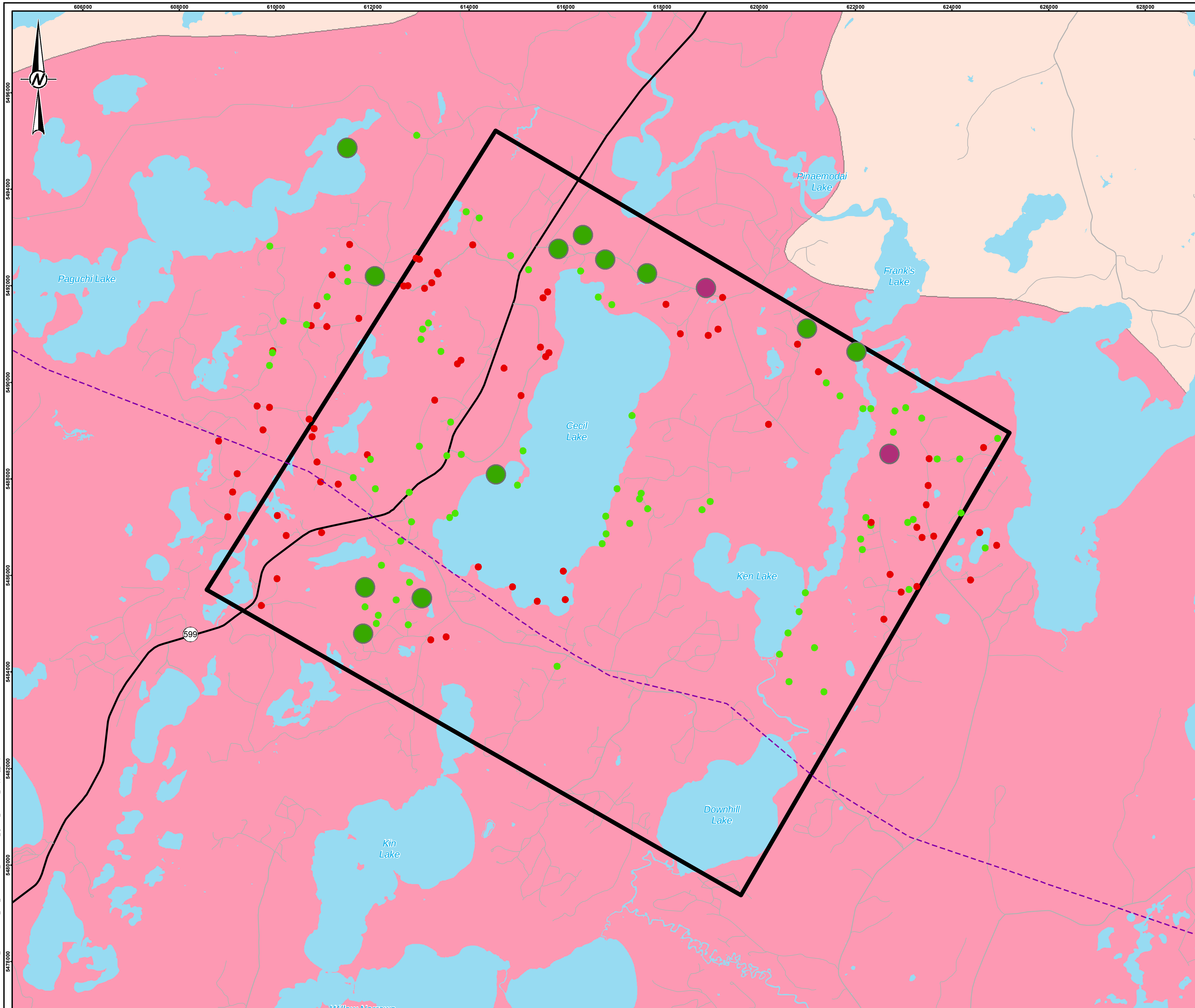
CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1532407			5.3.3

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm



LEGEND

- Withdrawal Area
- Main Road
- Local Road
- Waterbody
- Outcrop (84)
- Overburden (76)
- End moraine

Bedrock Geology

- 15 Massive granodiorite to granite
- 12 Foliated tonalite suite
- 11 Gneissic tonalite suite

Minor Lithology

- Diorite / Quartz Diorite (0)
- Granodiorite (2)
- Mafic Metavolcanic Rocks (12)
- Schist (0)

INDEX MAP

IGNACE

0 3 6

1:80,000 KILOMETRES

REFERENCE(S)

1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
2A. STONE, HELLEBRANDT & LANGE 2011 (P3623)
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015)

CLIENT
NWMO
IGNACE, ONTARIO

PROJECT
IGNACE DETAILED MAPPING REPORT

TITLE
INDIAN LAKE EAST BATHOLITH AREA - MINOR LITHOLOGICAL UNITS

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1532407			5.3.4

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

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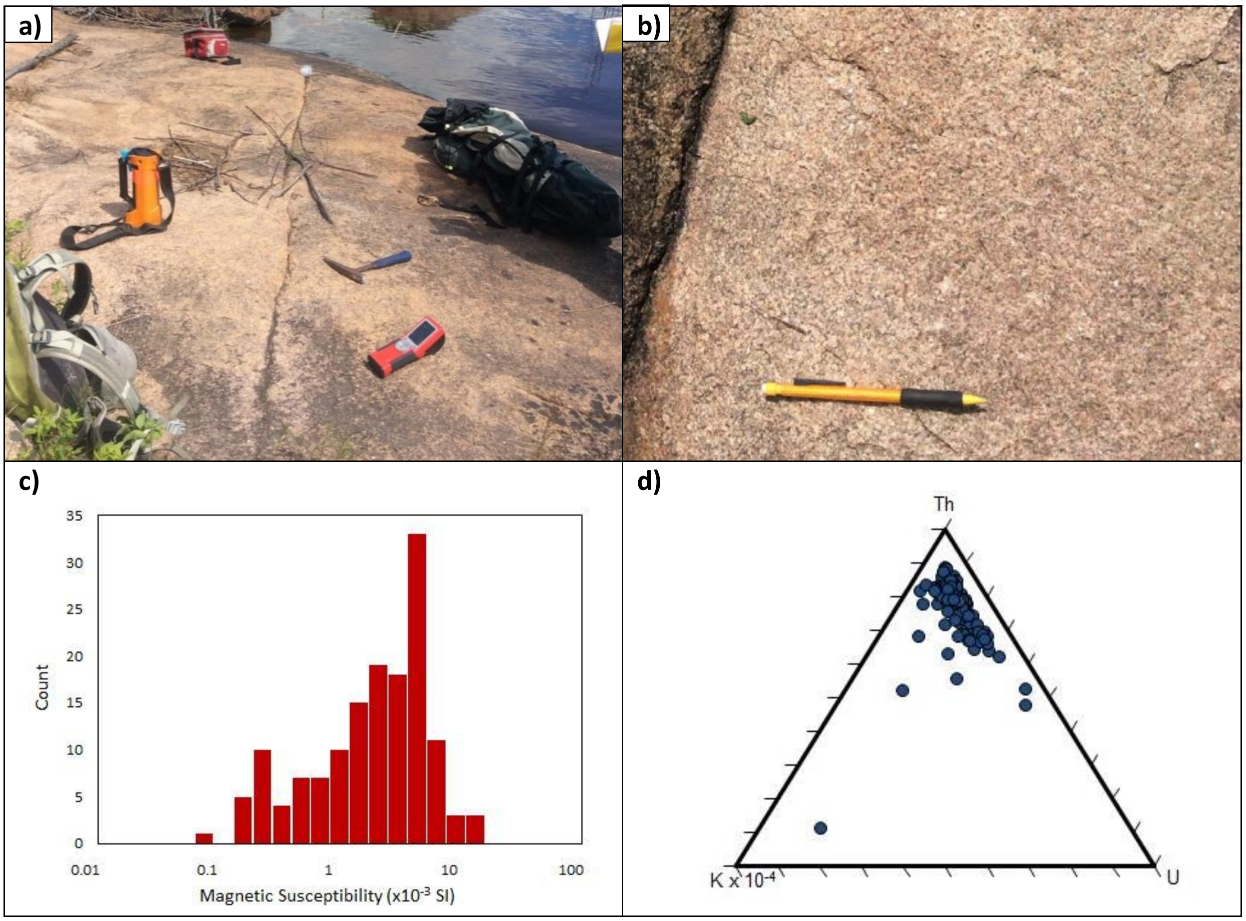


Figure 5.3.5: INDIAN LAKE EAST BATHOLITH AREA – Field Examples of Main Lithology - Granite

a - Field example of granite at outcrop scale. View to the east, hammer for scale (Station 16IL1119).

b - Close-up photo of granite showing mineral composition and texture. View to the east, pencil for scale (Station 16IL1119).

c - Logarithmic plot of magnetic susceptibility for granite (N=146).

d - Ternary plot of gamma ray spectrometer data for granite (N=118).

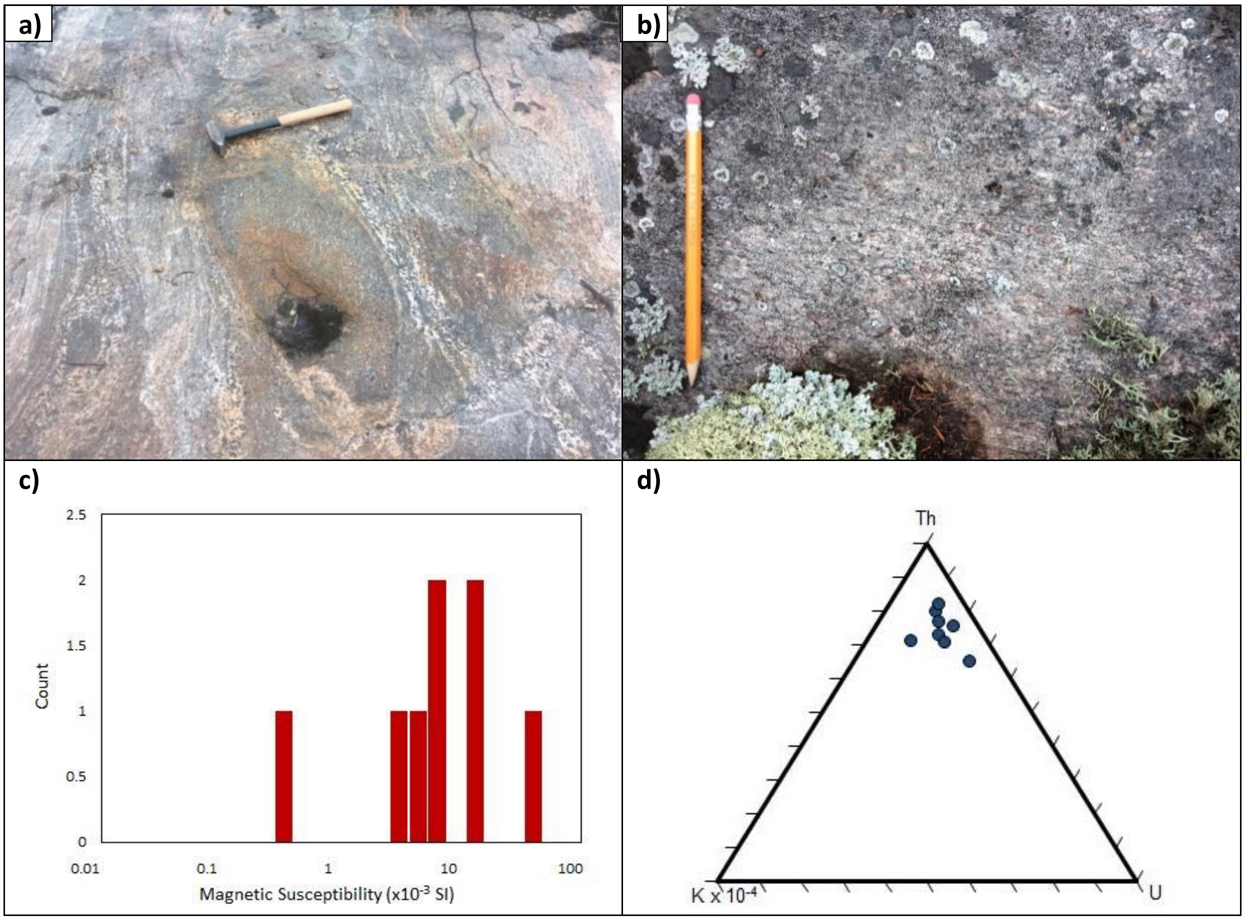


Figure 5.3.6: INDIAN LAKE EAST BATHOLITH AREA – Field Examples of Main Lithology - Tonalite Gneiss

a - Field example of tonalite gneiss at outcrop scale. View to the east, hammer for scale (Station 16TC2062).

b - Close-up photo of tonalite gneiss showing mineral composition and texture. View to the north, pencil for scale (Station 16IL1113).

c - Logarithmic plot of magnetic susceptibility for tonalite gneiss (N=-8).

d - Ternary plot of gamma ray spectrometer data for tonalite gneiss (N=8).

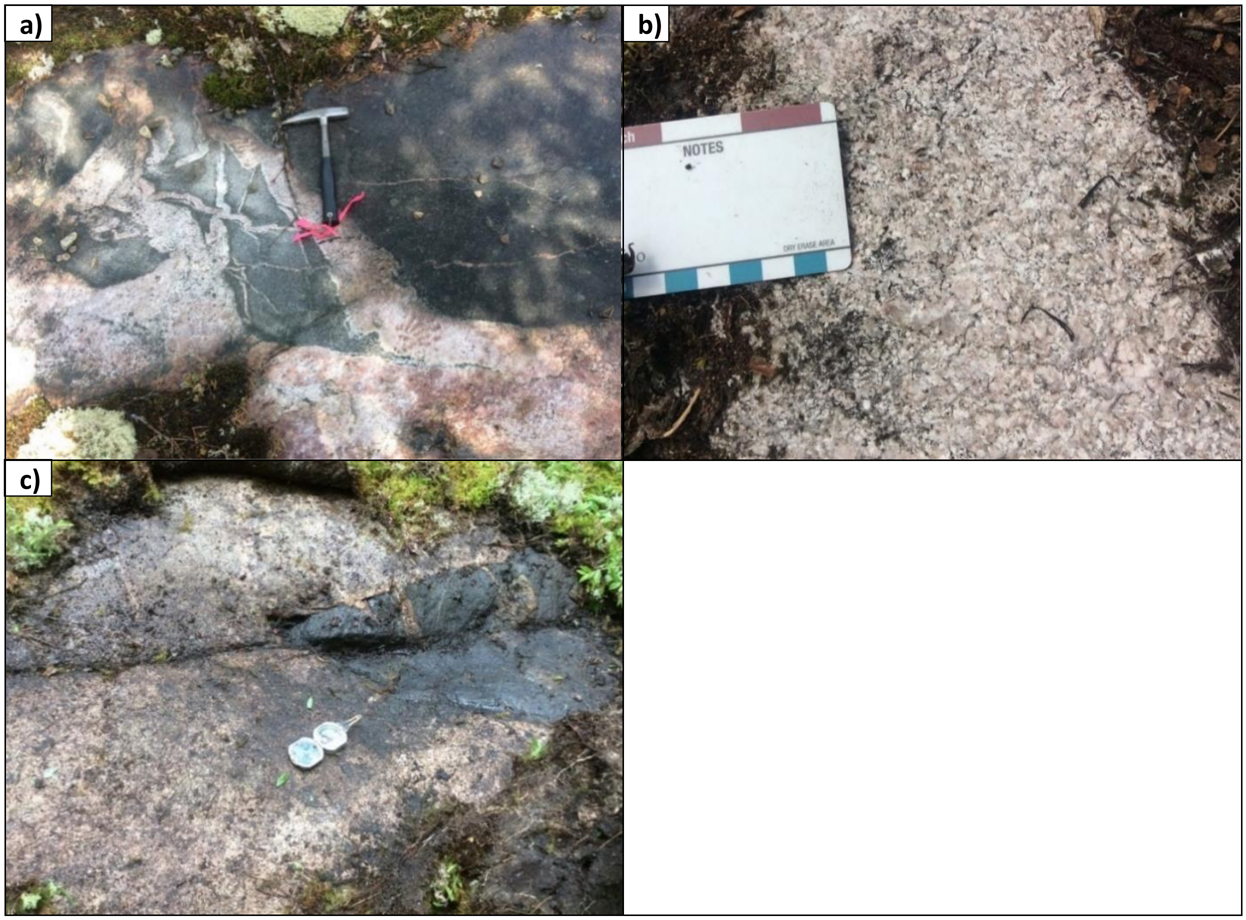
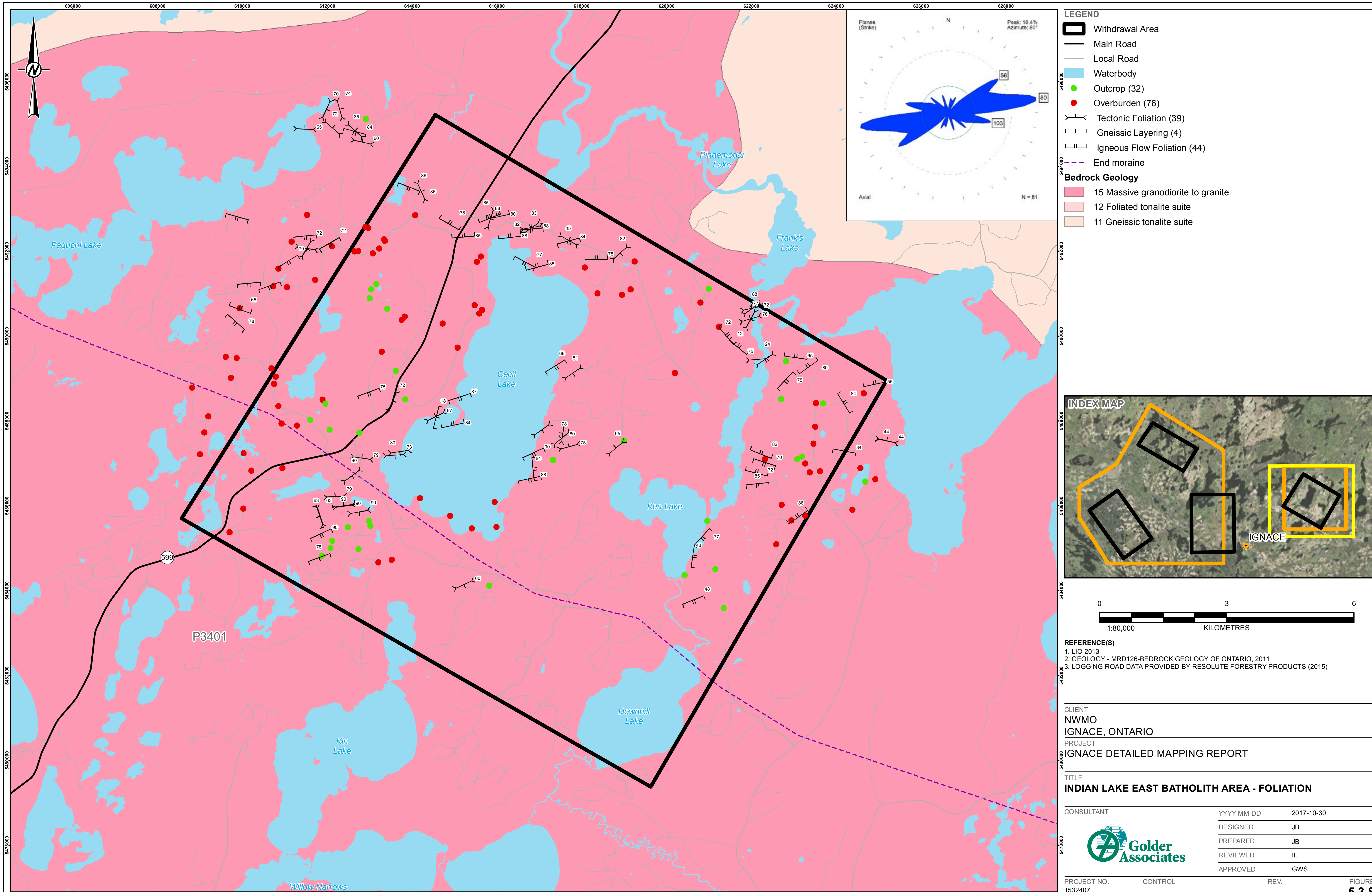


Figure 5.3.7: INDIAN LAKE EAST BATHOLITH AREA – Field Examples of Minor Lithological Units

a - Photo of mafic metavolcanic rock xenolith within granite. View to the north, hammer for scale, (Station 16IL1079).

b - Photo of granodiorite. Unoriented photo, card for scale (Station 16IL1129).

c - Photo of basalt xenolith within granite. View to the northwest, compass for scale (Station 16TC2070).



LEGEND
Withdrawal Area
Main Road
Local Road
Waterbody
Outcrop (32)
Overburden (76)
Tectonic Foliation (39)
Gneissic Layering (4)
Igneous Flow Foliation (44)
End moraine
Bedrock Geology
15 Massive granodiorite to granite
12 Foliated tonalite suite
11 Gneissic tonalite suite
Planes (Strike)
N
Peak: 18.4%
Azimuth: 80°
Axial
N = 81
INDEX MAP
IGNACE
Paguchi Lake
Pinaemodal Lake
Frank's Lake
Cecil Lake
Ken Lake
Downhill Lake
Kin Lake
Willow Narrows
P3401
599
0
3
6
1:80,000
KILOMETRES
REFERENCE(S)
1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015)
CLIENT
NWMO
IGNACE, ONTARIO
PROJECT
IGNACE DETAILED MAPPING REPORT
TITLE
INDIAN LAKE EAST BATHOLITH AREA - FOLIATION
CONSULTANT
Golder Associates
YYYY-MM-DD 2017-10-30
DESIGNED JB
PREPARED JB
REVIEWED IL
APPROVED GWS
PROJECT NO. 1532407
CONTROL
REV.
FIGURE 5.3.8

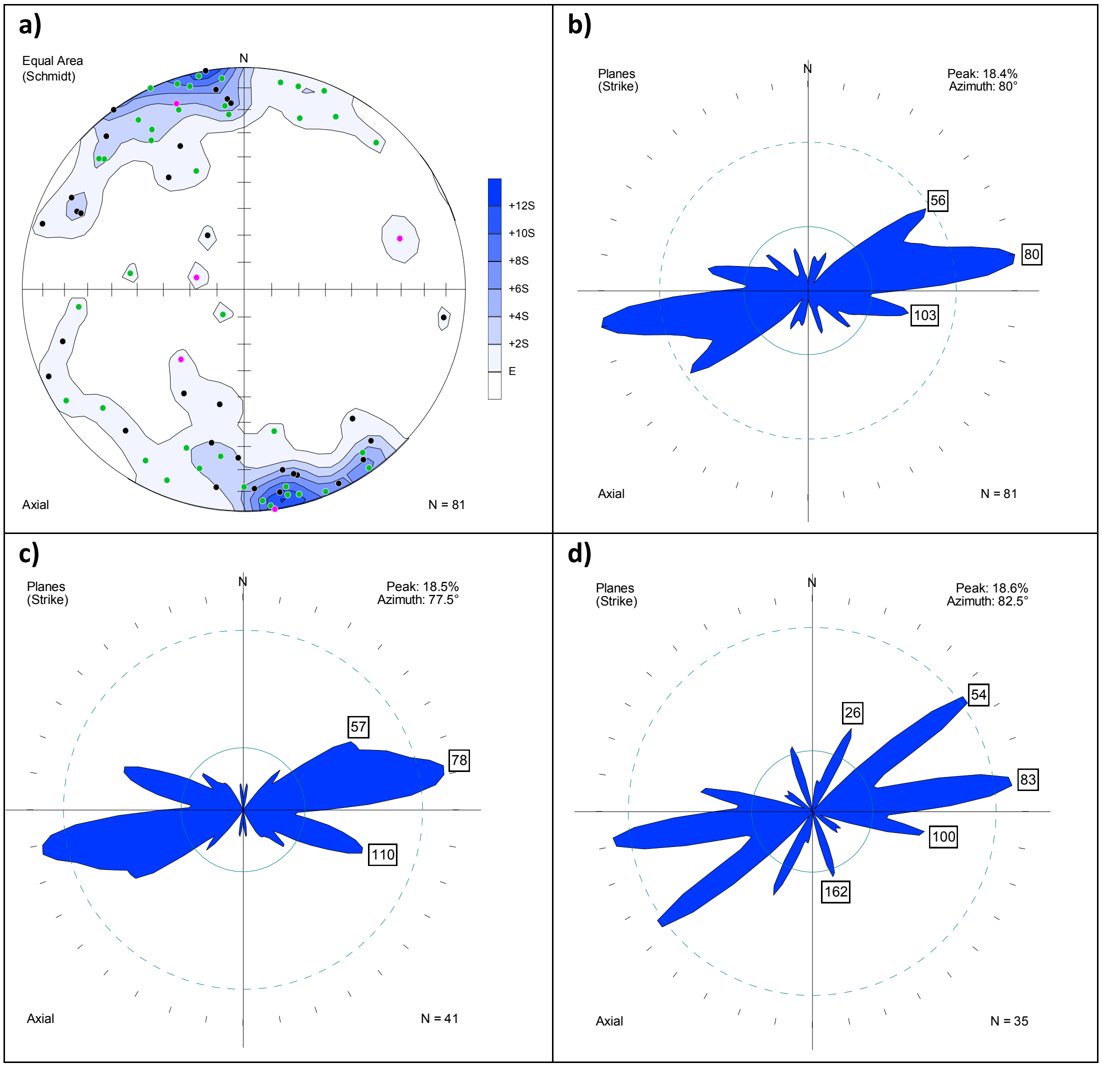


Figure 5.3.9: INDIAN LAKE EAST BATHOLITH AREA - Foliation Orientation Data

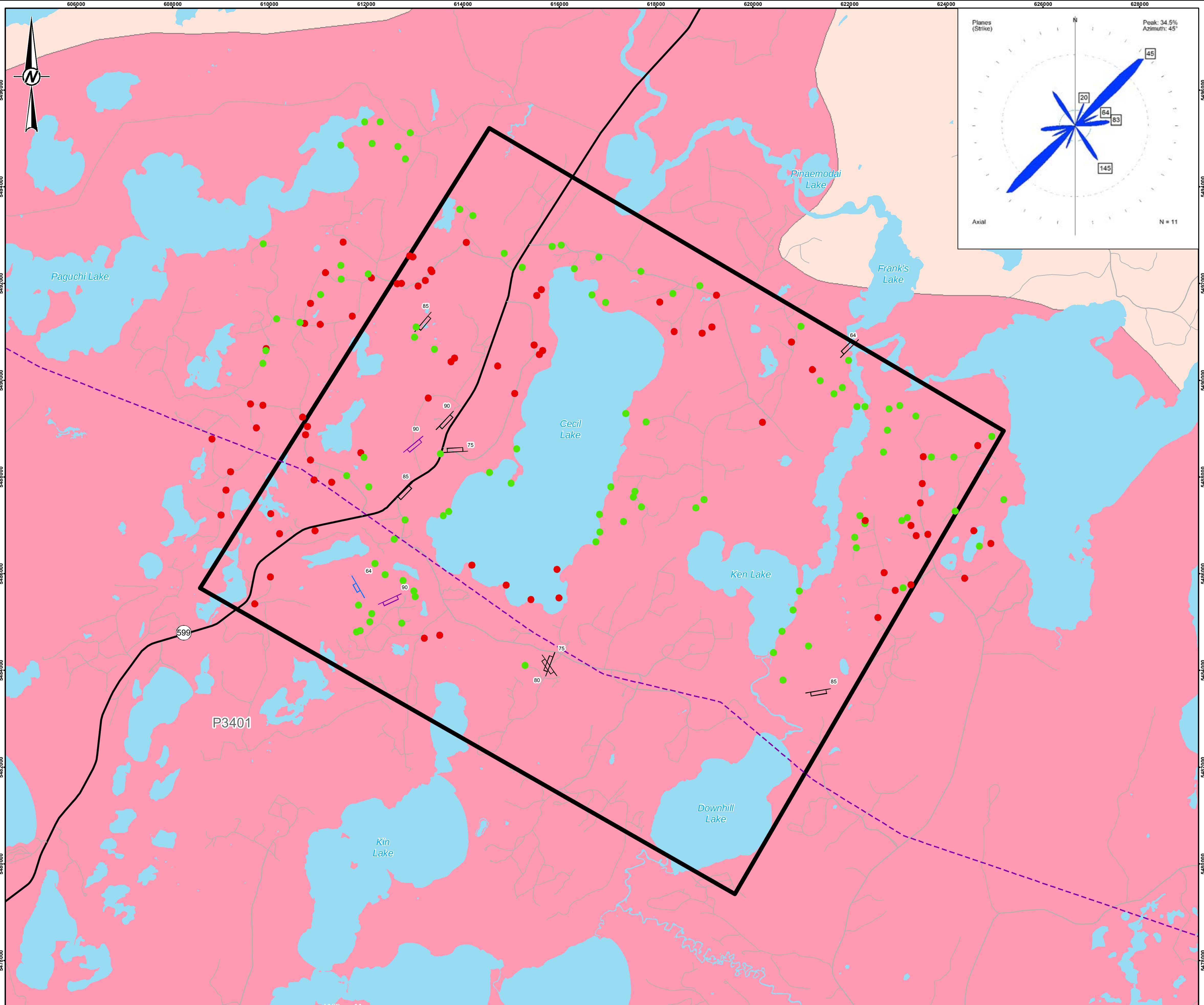
a - All foliation data displayed as equal area lower hemisphere stereonet plot of poles to foliation planes. Tectonic foliation: black circles (N=35). Igneous flow foliation: green circles (N=41). Gneissic layering: pink circles (N=5).

Contours show multiples of the standard deviation S above the expectant count E calculated using Gaussian K-100.

b - All foliation data displayed as rose diagram of trends of foliation planes (N=81). Bins for rose diagrams are 10°.

c - Igneous flow foliation data displayed as rose diagram of trends of foliation planes (N=41). Bins for rose diagrams are 10°.

d - Tectonic foliation data displayed as rose diagram of trends of foliation planes (N=35). Bins for rose diagrams are 10°.

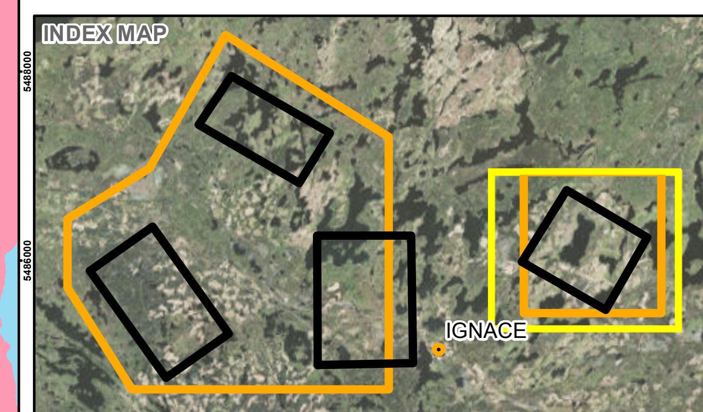


LEGEND

- Withdrawal Area
- Main Road
- Local Road
- Waterbody
- Brittle-ductile shear zone - Sinistral (1)
- Ductile shear zone - Dextral (2)
- Ductile shear zone - Unknown Slip (8)
- End moraine

Bedrock Geology

- 15 Massive granodiorite to granite
- 12 Foliated tonalite suite
- 11 Gneissic tonalite suite



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REFERENCE(S)

1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015)

CLIENT

NWMO

IGNACE, ONTARIO

PROJECT

IGNACE DETAILED MAPPING REPORT

TITLE

INDIAN LAKE EAST BATHOLITH AREA - DUCTILE AND BRITTLE-DUCTILE SHEAR ZONES

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	AM
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1532407			5.3.10

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

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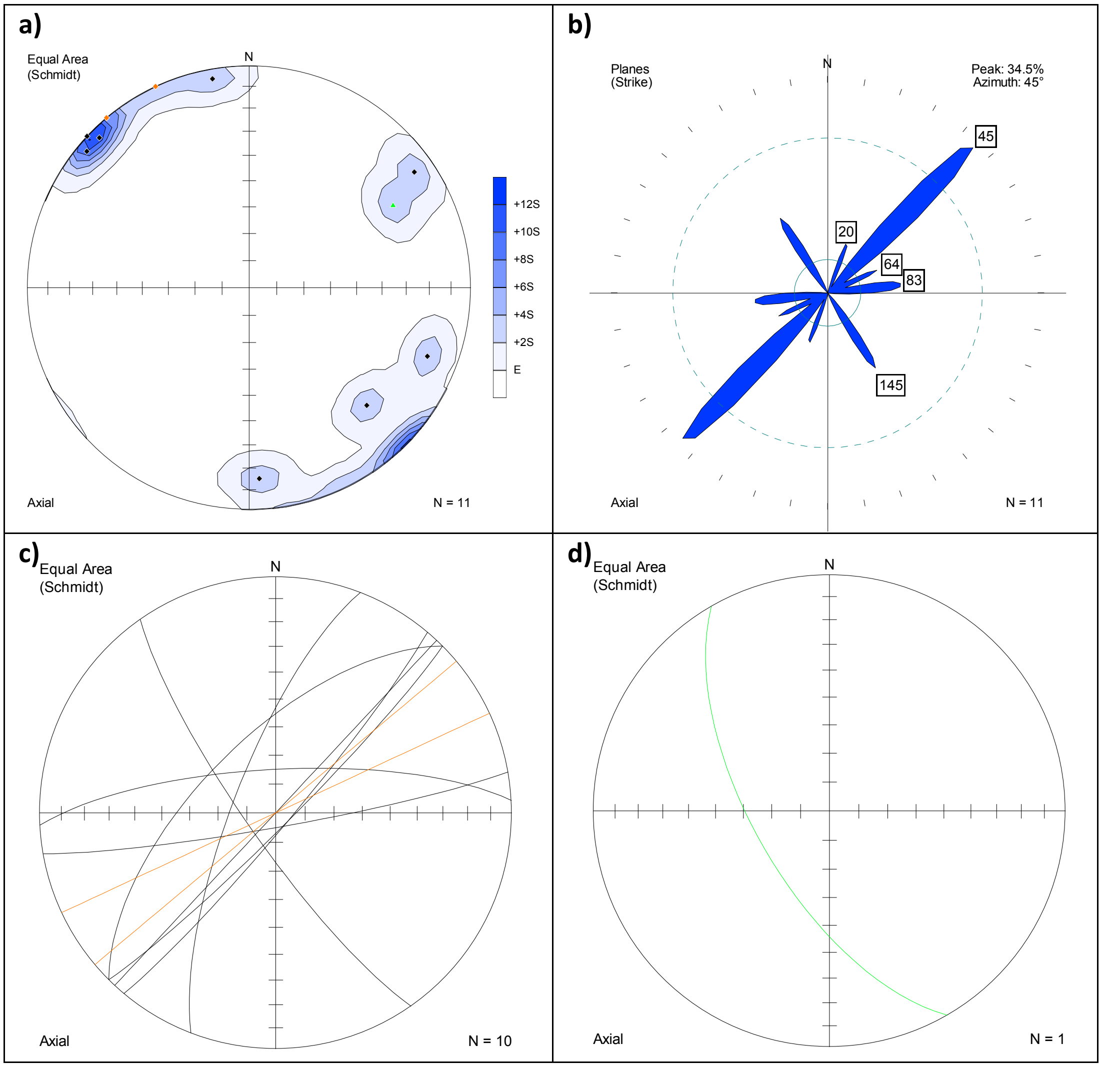


Figure 5.3.11: INDIAN LAKE EAST BATHOLITH AREA - Ductile and Brittle-Ductile Shear Zone Orientation Data

a - All shear zones displayed as equal area lower hemisphere stereonet plot of poles to shear planes. Dextral ductile shear zones: orange diamonds (N=2). Sinistral brittle-ductile shear zone: green triangle (N=1). Shear zones with unknown slip: black diamonds (N=8). Contours show multiples of the standard deviation S above the expectant count E calculated using Gaussian K-100.

b - All shear zone data displayed as rose diagram of trends of shear planes (N=11). Bins for rose diagrams are 10°.

c - Ductile shear zones displayed as equal area lower hemisphere stereonet plot of great circles (N=10). Dextral structures: orange lines (N=2). Structures with unknown slip sense: black (N=8). No lineation data available.

d - Brittle-ductile shear zones displayed as equal area lower hemisphere stereonet plot of great circles (N=1). Sinistral structures: green lines (N=1). No lineation data available.

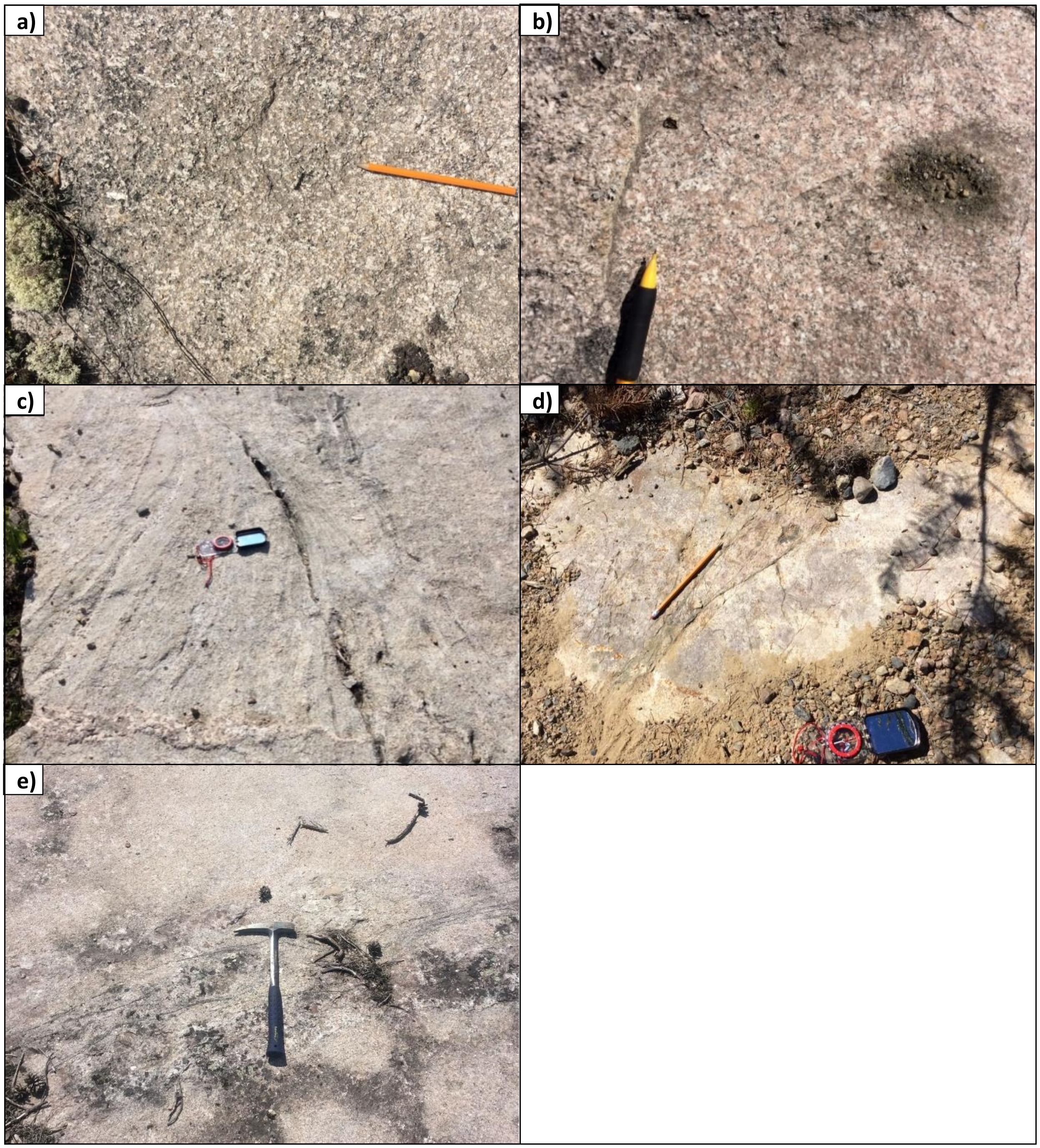


Figure 5.3.12: INDIAN LAKE EAST BATHOLITH AREA – Field Examples of Ductile Structures

a - Photo of igneous flow foliation in granite. View to the north, pencil for scale (Station 16IL1131).

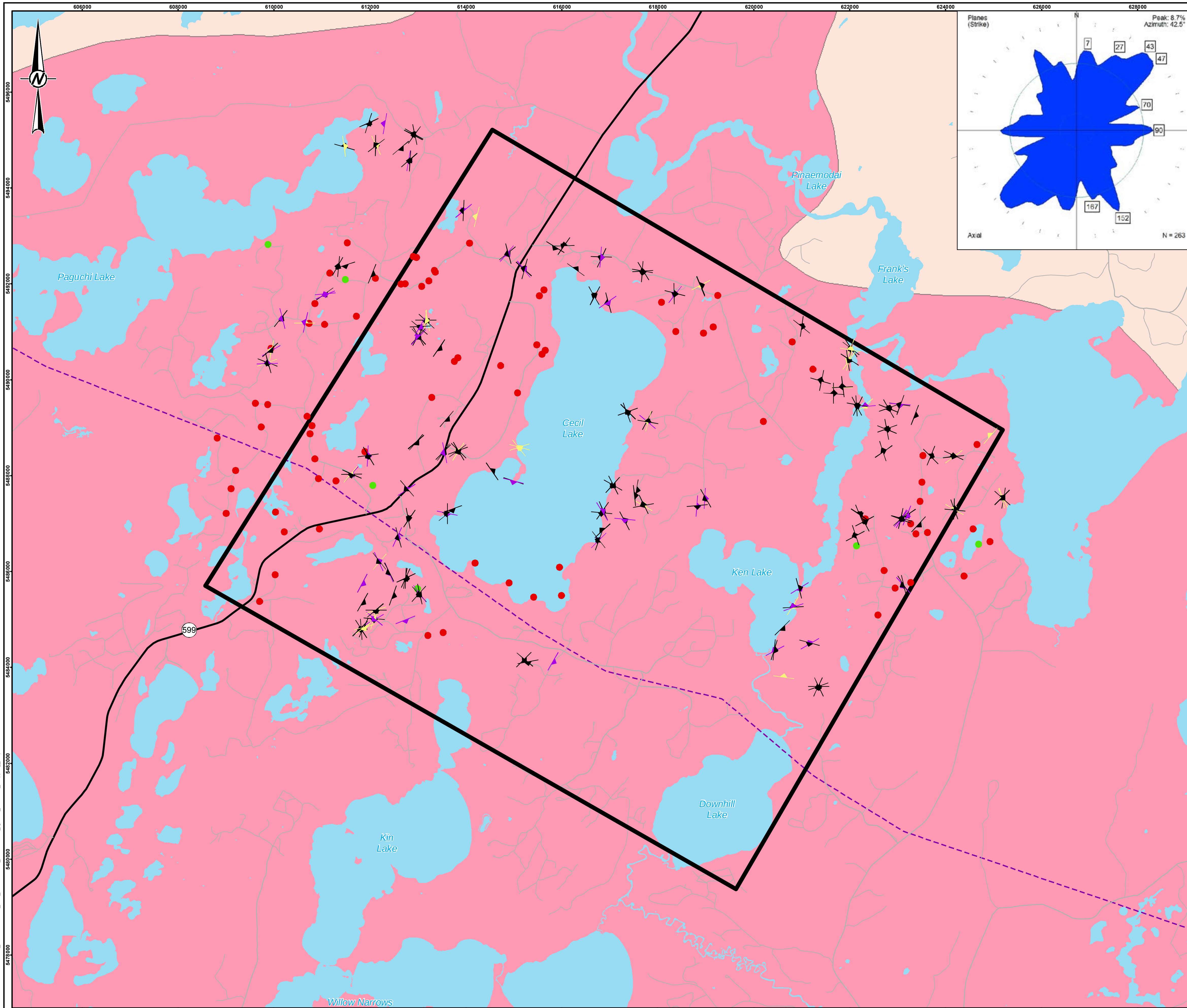
b - Photo of tectonic foliation, weakly defined by biotite, in granite. View to the east, pencil for scale (Station 16IL1102).

c - Photo of gneissic layering in tonalite gneiss. View to the east, compass for scale (Station 16TC2062).

d - Photo of chlorite-hematite ductile shear zone (145/80). View to the northwest, pencil for scale (Station 16FB3120).

Figure 5.3.12 (Cont'd): INDIAN LAKE EAST BATHOLITH AREA – Field Examples of Ductile Structures

e - Photo of ductile shear zone (065/90) crosscutting igneous layering. View to the north, hammer for scale (Station 16FB3070).

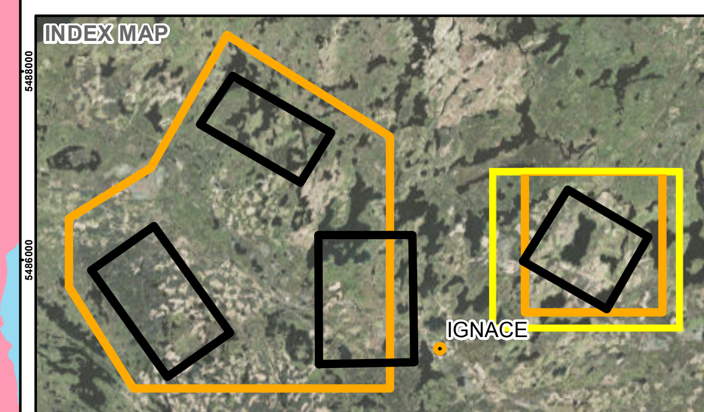


LEGEND

- Withdrawal Area
- Main Road
- Local Road
- Waterbody
- Outcrop (6)
- Overburden (76)
- Sub horizontal joint: 0° - 24° (45)
- Intermediate joint: 25° - 65° (40)
- Sub vertical joint: 66° - 90° (178)
- End moraine

Bedrock Geology

- 15 Massive granodiorite to granite
- 12 Foliated tonalite suite
- 11 Gneissic tonalite suite



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REFERENCE(S)
1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015)

CLIENT
NWMO
IGNACE, ONTARIO

PROJECT
IGNACE DETAILED MAPPING REPORT

TITLE
INDIAN LAKE EAST BATHOLITH AREA - JOINTS

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1532407			5.3.13

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

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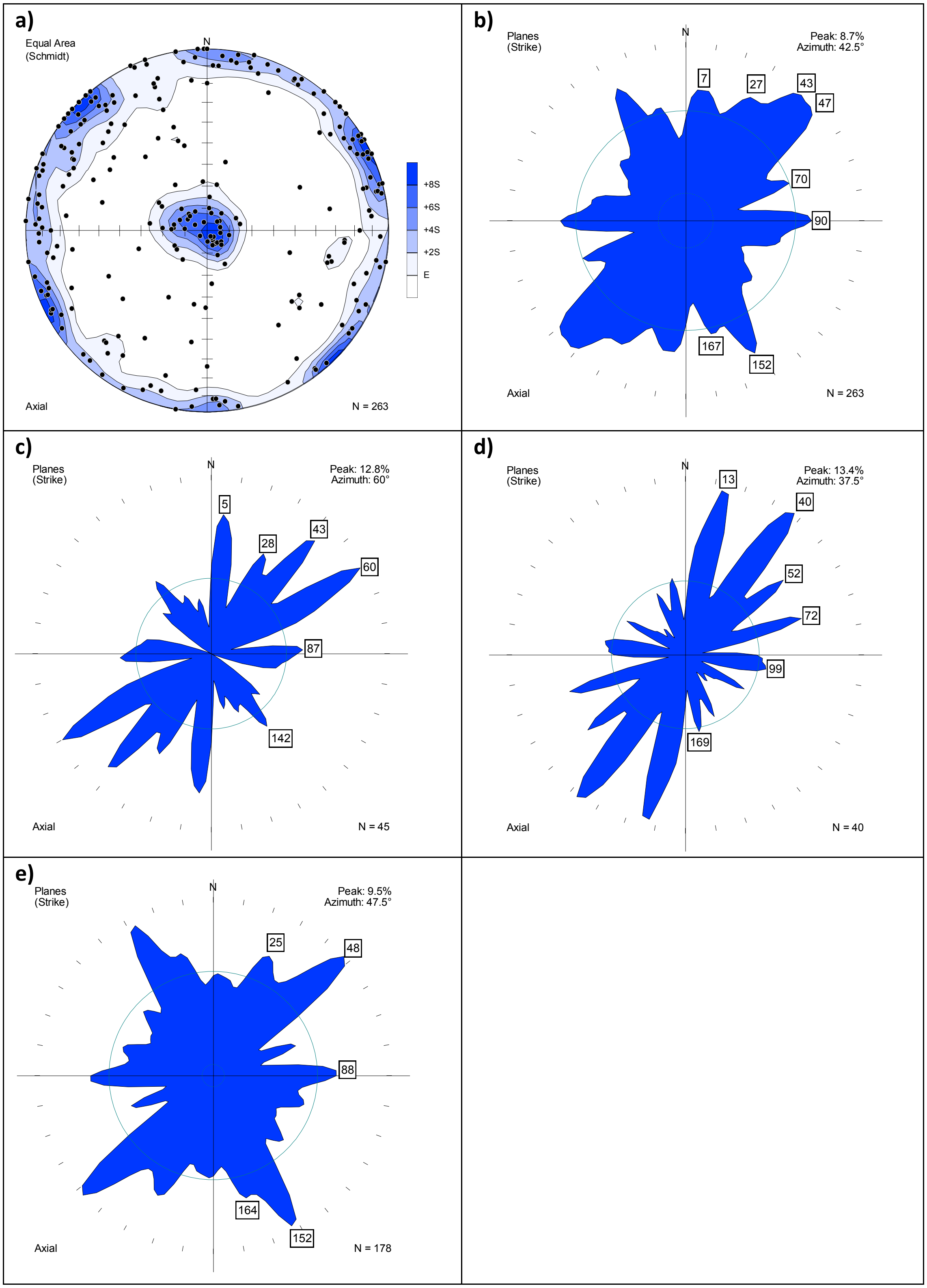
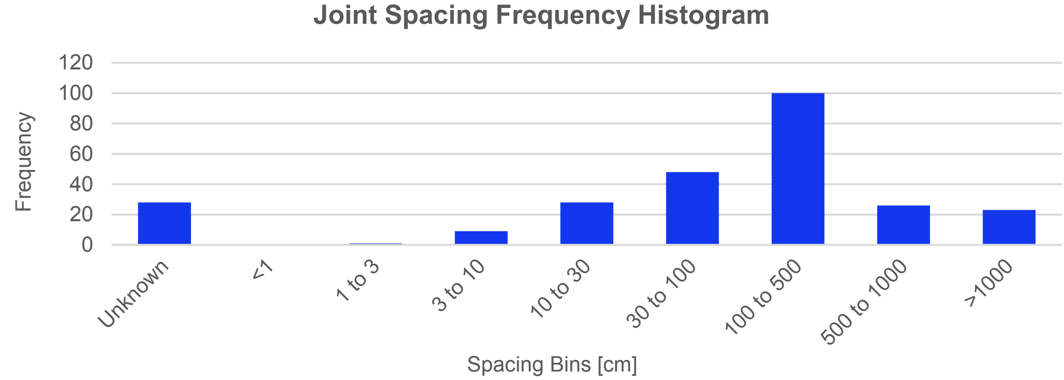
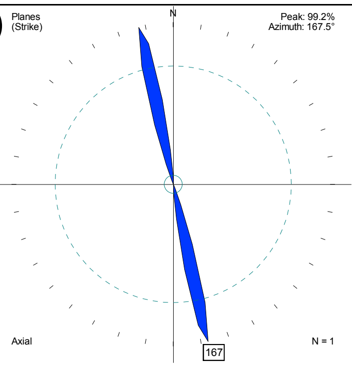

a)
Equal Area
(Schmidt)
N
+8S
+6S
+4S
+2S
E
Axial
N = 263
b)
Planes
(Strike)
N
Peak: 8.7%
Azimuth: 42.5°
7
27
43
47
70
90
167
152
Axial
N = 263
c)
Planes
(Strike)
N
Peak: 12.8%
Azimuth: 60°
5
28
43
60
87
142
Axial
N = 45
d)
Planes
(Strike)
N
Peak: 13.4%
Azimuth: 37.5°
13
40
52
72
99
169
Axial
N = 40
e)
Planes
(Strike)
N
Peak: 9.5%
Azimuth: 47.5°
25
48
88
164
152
Axial
N = 178

f)

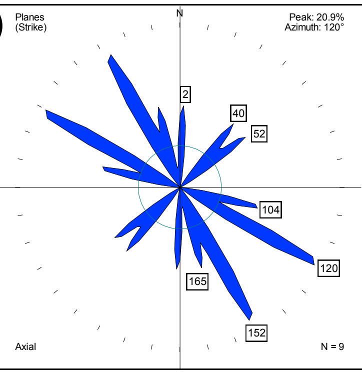


g)



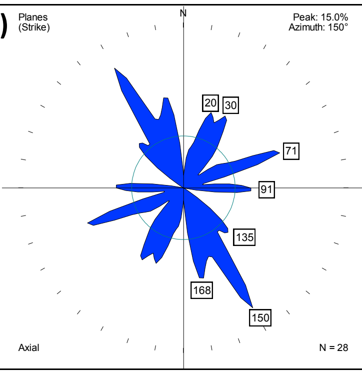
1-3 cm

h)



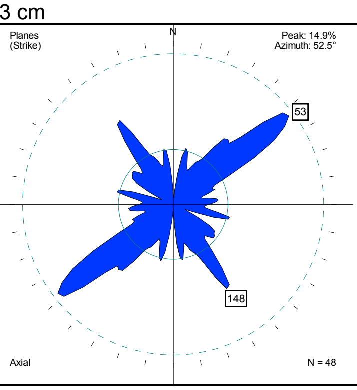
3-10 cm

i)



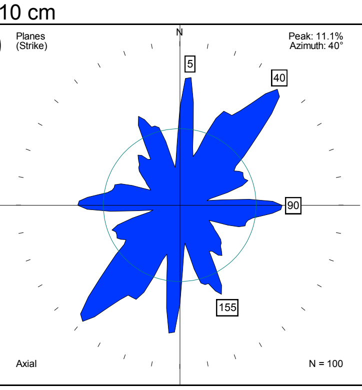
10-30 cm

j)



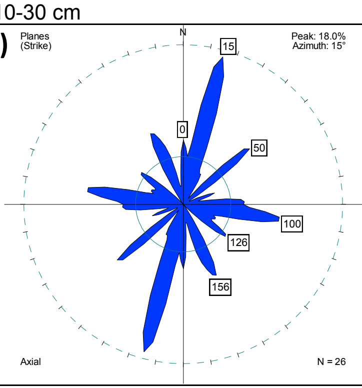
30-100 cm

k)



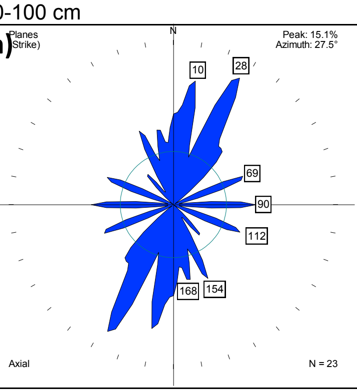
100-500 cm

l)



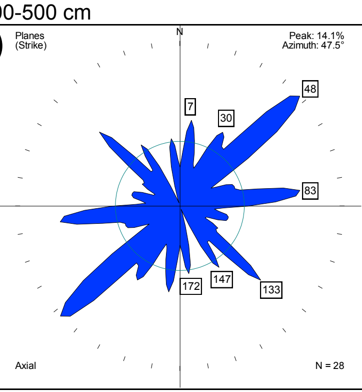
500-1000

m)



>1000

n)



None/unknown

Figure 5.3.14: INDIAN LAKE EAST BATHOLITH AREA - Joint Orientation Data and Joint Spacing Summary

a - All joint data displayed as equal area lower hemisphere stereonet plot of poles to joints (N=263). Contours show multiples of the standard deviation S above the expectant count E calculated using Gaussian K-100.

b - All joint data displayed as rose diagram of trends of joint planes (N=263). Bins for rose diagrams are 10°.

c - Shallow-dipping joints (<25° dip) displayed as rose diagram of trends of joint planes (N=45). Bins for rose diagrams are 10°.

d – Moderately-dipping joints (25-65° dip) displayed as rose diagram of trends of joint planes (N=40). Bins for rose diagrams are 10°.

e - Steep joints (>65° dip) displayed as rose diagram of trends of joint planes (N=178). Bins for rose diagrams are 10°.

f – Joint spacing histograms showing frequency distribution of all joint spacing classes.

g – Joint data with spacing 1-3 cm displayed as rose diagram of trends of joint planes (N=1). Bins for rose diagrams are 10°. No joints spaced <1 cm in the Indian Lake East area.

h – Joint data with spacing 3-10 cm displayed as rose diagram of trends of joint planes (N=9). Bins for rose diagrams are 10°.

i- Joint data with spacing 10-30 cm displayed as rose diagram of trends of joint planes (N=28). Bins for rose diagrams are 10°.

j – Joint data with spacing 30-100 cm displayed as rose diagram of trends of joint planes (N=48). Bins for rose diagrams are 10°.

k – Joint data with spacing 100-500 cm displayed as rose diagram of trends of joint planes (N=100). Bins for rose diagrams are 10°.

l – Joint data with spacing 500-1000 cm displayed as rose diagram of trends of joint planes (N=26). Bins for rose diagrams are 10°.

m – Joint data with spacing >1000 cm displayed as rose diagram of trends of joint planes (N=23). Bins for rose diagrams are 10°.

n – Joint data with unknown spacing displayed as rose diagram of trends of joint planes (N=28). Bins for rose diagrams are 10°.

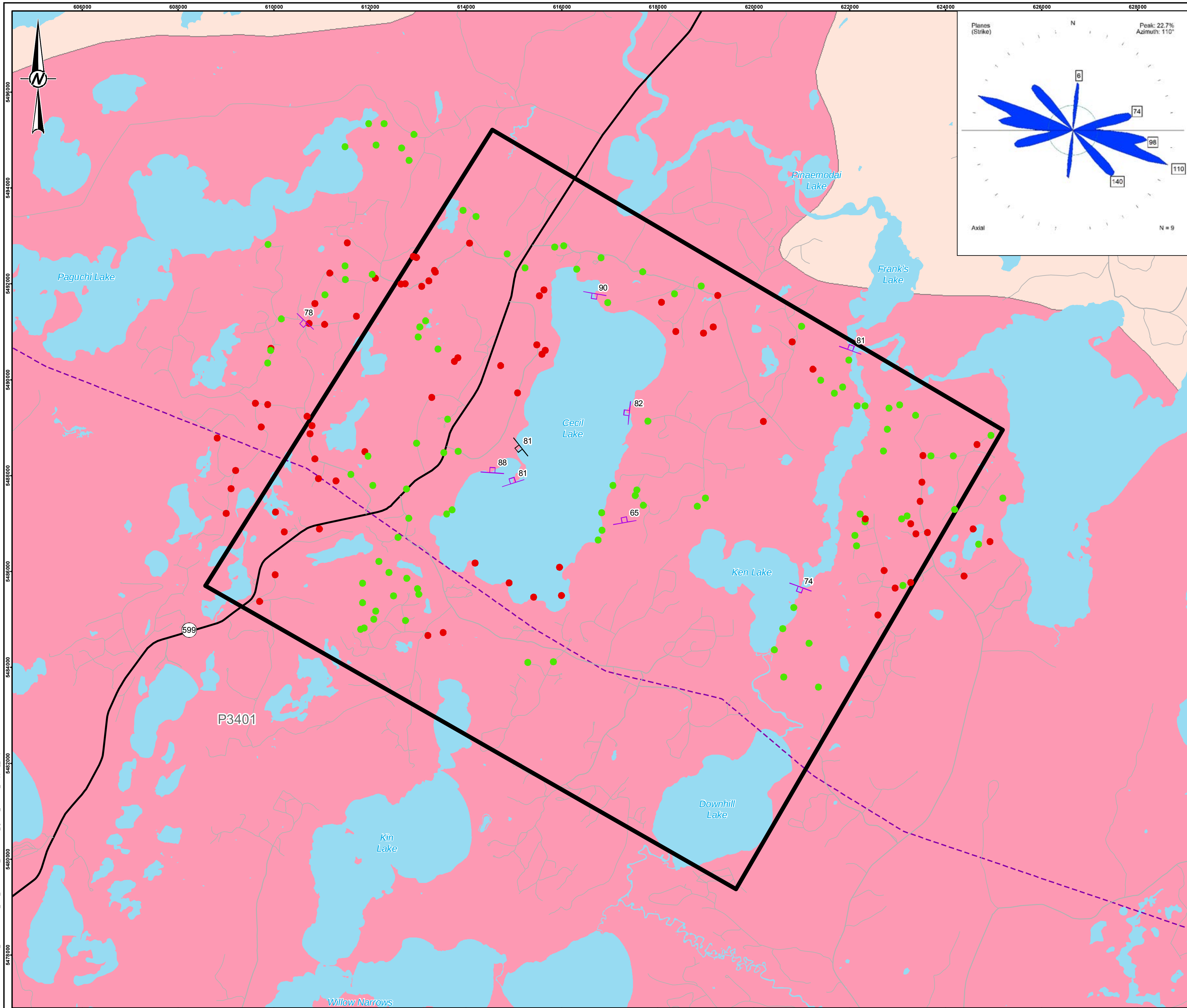
Figure 5.3.15: INDIAN LAKE EAST BATHOLITH AREA – Field Examples of Joints

a – Example of subhorizontal joints in granite. View to the southwest, no scale (Station 16IL1128).

b - Example of 500-1000 cm joint spacing in granite. View to the north, person for scale (Station 16TC2106).

c - Example of 3-10 cm joint spacing in granite. View to the north, hammer for scale (Station 16TC2111).

d - Example of multiple joint sets in a mafic metavolcanic rock xenolith. View to the southwest, compass for scale (Station 16IL1095).

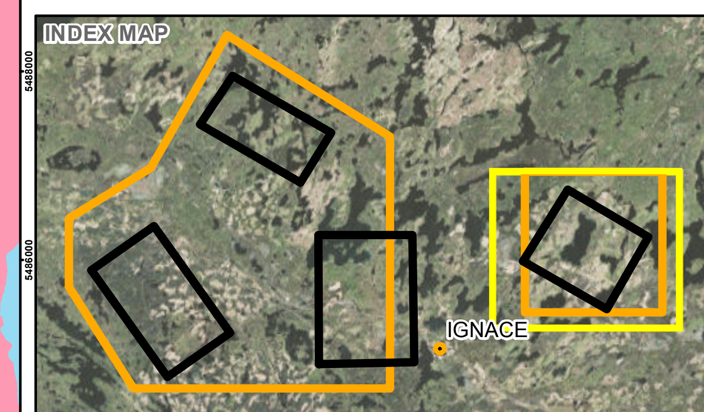


LEGEND

- Withdrawal Area
- Main Road
- Local Road
- Waterbody
- Outcrop (99)
- Overburden (76)
- Fault - Dextral (8)
- Fault - Other slip (1)
- End moraine

Bedrock Geology

- 15 Massive granodiorite to granite
- 12 Foliated tonalite suite
- 11 Gneissic tonalite suite



0 3 6

1:80,000 KILOMETRES

REFERENCE(S)
1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015)

CLIENT
NWMO
IGNACE, ONTARIO

PROJECT
IGNACE DETAILED MAPPING REPORT

TITLE
INDIAN LAKE EAST BATHOLITH AREA - FAULTS

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1532407			5.3.16

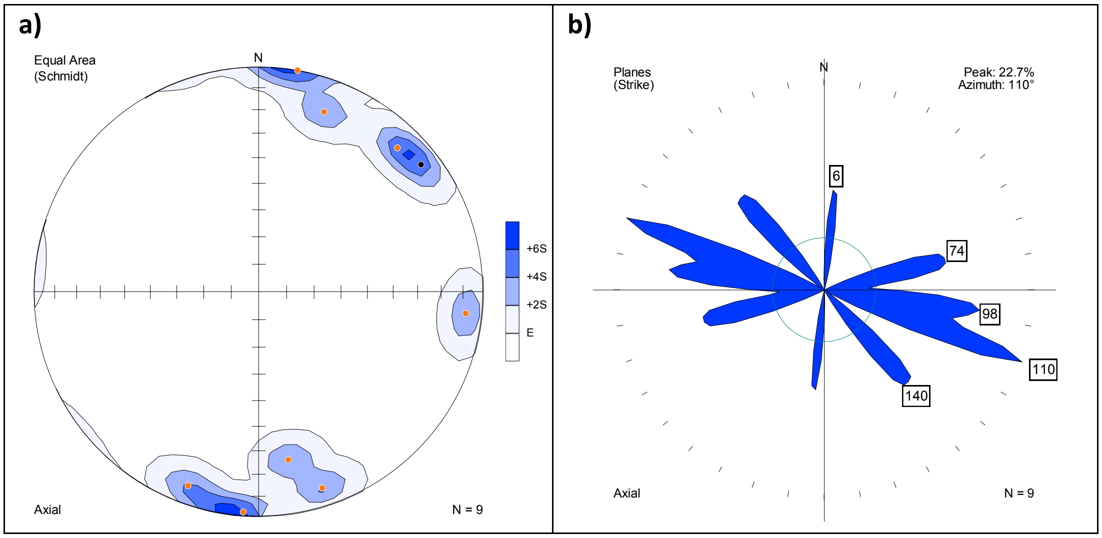


Figure 5.3.17: INDIAN LAKE EAST BATHOLITH AREA - Fault Orientation Data

a - All fault data displayed as equal area lower hemisphere stereonet plot of poles to fault planes. Dextral faults: orange circles (N=8). Faults with unknown slip: black circle (N=1).

b - All fault data displayed as rose diagram of trends of fault planes (N=9). Bins for rose diagrams are 10°.

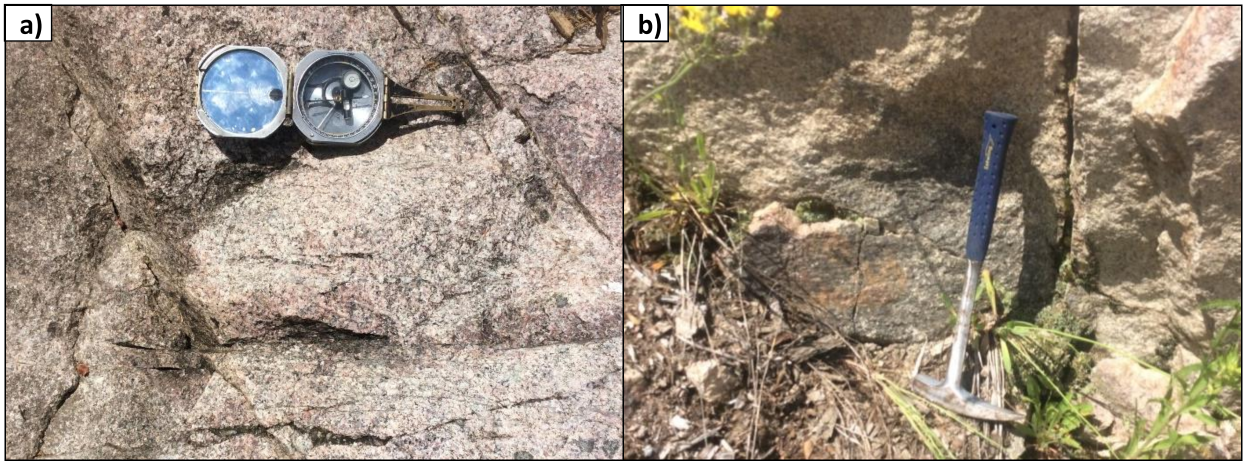
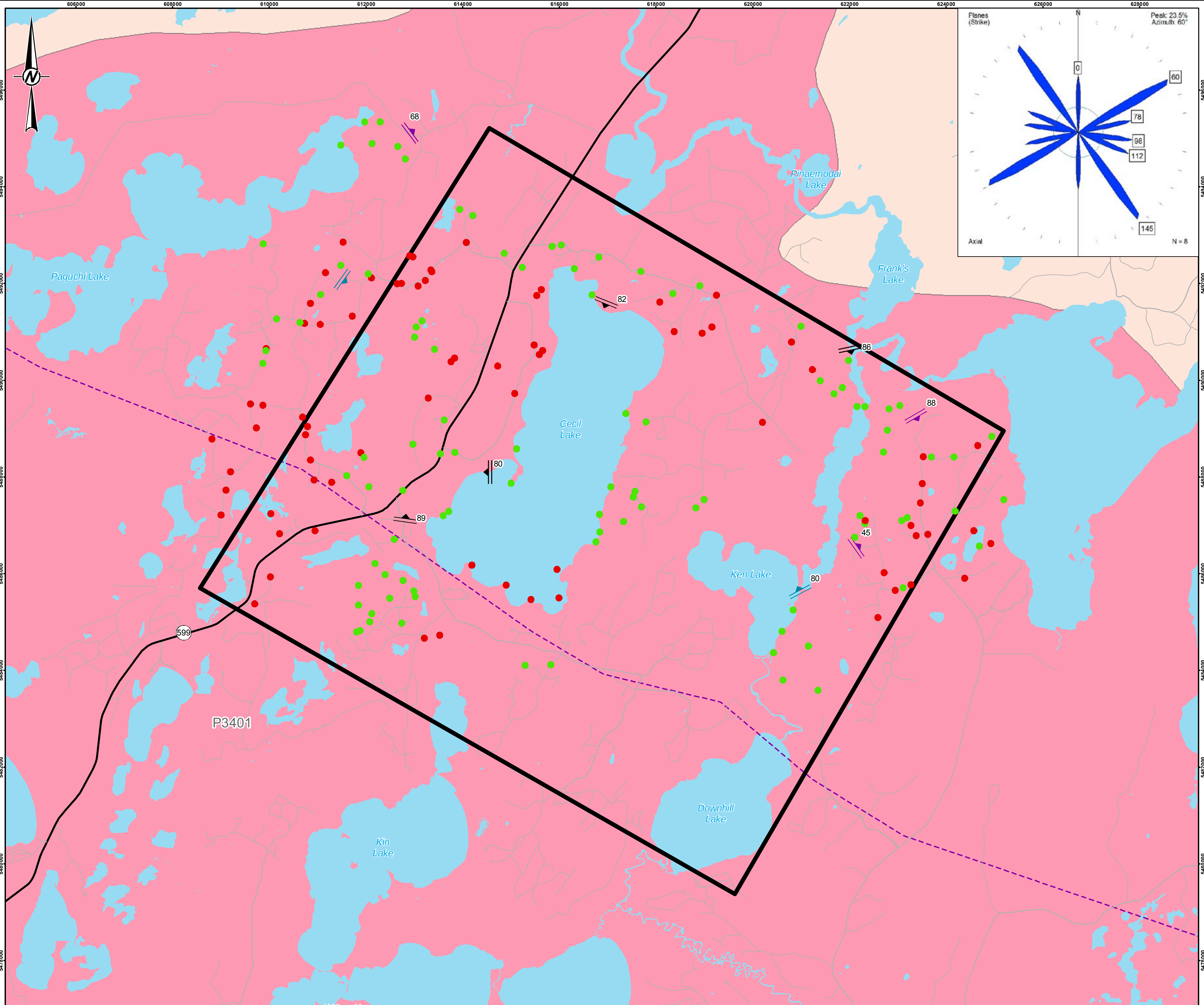


Figure 5.3.18: INDIAN LAKE EAST BATHOLITH AREA – Field Examples of Faults

a - North-striking dextral fault in granite (186/82), developed as a series of cm-spaced fault planes. View to the west, compass for scale (Station 16TC21069).

b - Northeast-striking fault plane in granite (045/90). View to the northwest, hammer for scale (Station 16FB3090).



LEGEND

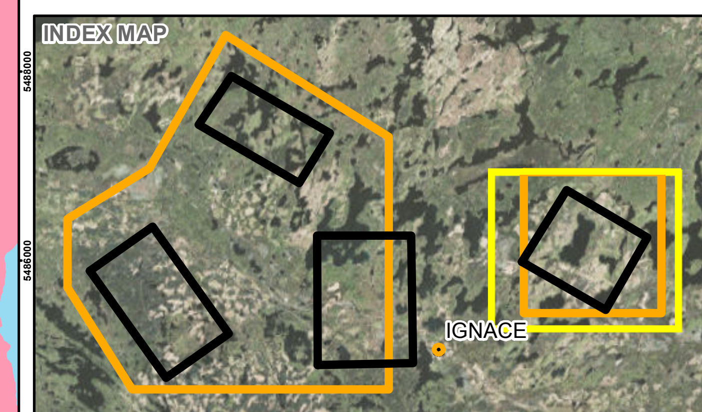
- Withdrawal Area
- Main Road
- Local Road
- Waterbody
- Outcrop (99)
- Overburden (76)

Vein

- Extension (4)
- Shear (2)
- Other (3)
- End moraine

Bedrock Geology

- 15 Massive granodiorite to granite
- 12 Foliated tonalite suite
- 11 Gneissic tonalite suite



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REFERENCE(S)
1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015)

CLIENT
NWMO
IGNACE, ONTARIO

PROJECT
IGNACE DETAILED MAPPING REPORT

TITLE
INDIAN LAKE EAST BATHOLITH AREA - VEINS

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1532407			5.3.19

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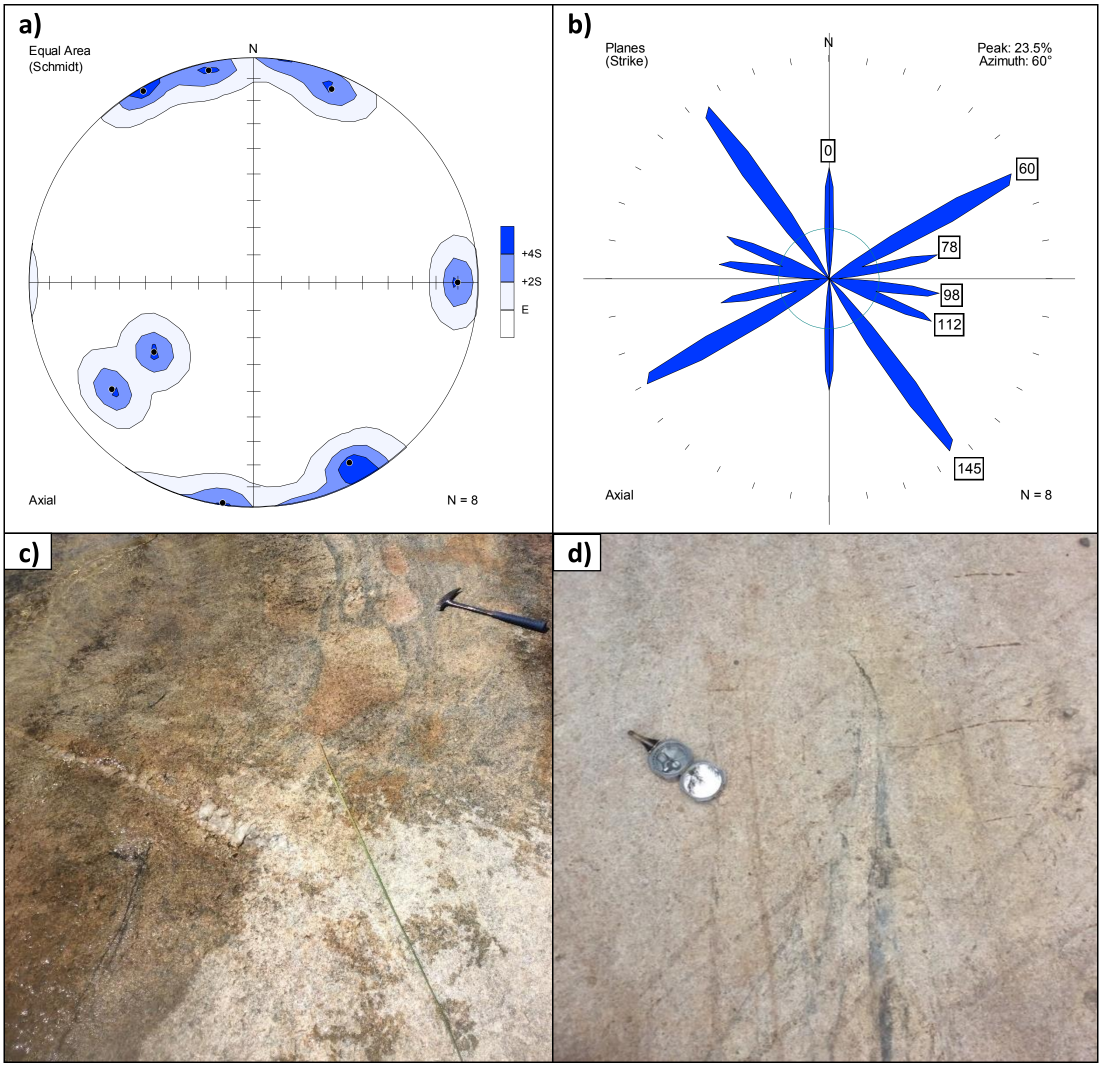


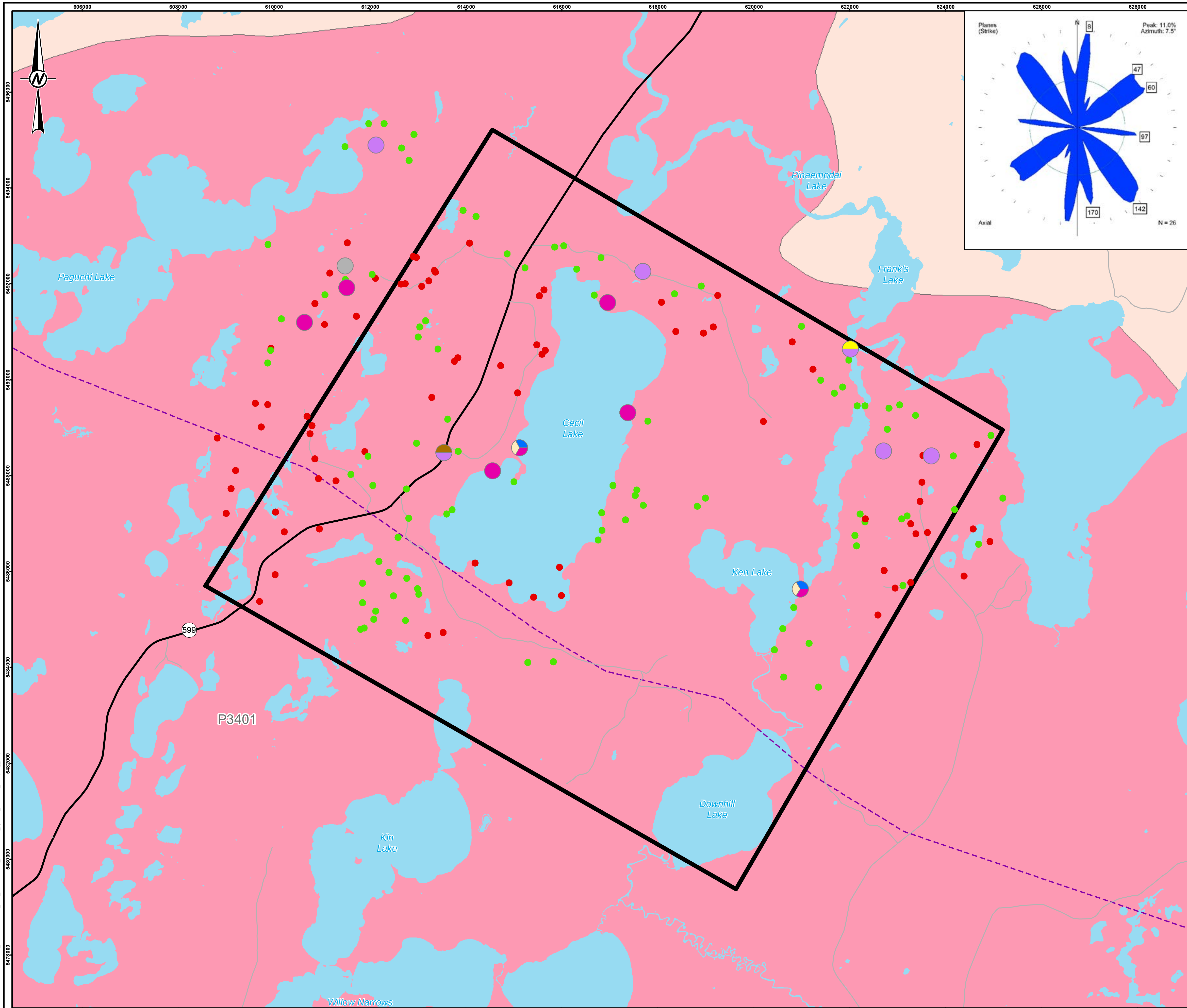
Figure 5.3.20: INDIAN LAKE EAST BATHOLITH AREA - Vein Orientation Data and Field Examples

a - All vein data displayed as equal area lower hemisphere stereonet plot of poles to veins (N=8).

b - All vein data displayed as lower hemisphere stereonet plot of great circles of veins (N=8).

c - Photo of an extensional quartz vein. View to the northeast, hammer for scale (Station 16TC2098).

d - Photo of a shear vein. View to the northeast, compass for scale (Station 16TC2127).

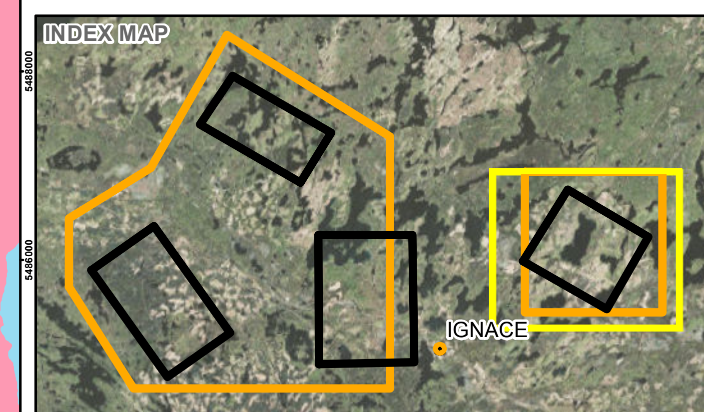


LEGEND

- Withdrawal Area
- Main Road
- Local Road
- Waterbody
- Outcrop
- Overburden
- End moraine
- Secondary Minerals and Alteration
- Alkali Feldspar (2)
- Biotite (1)
- Chlorite (1)
- Epidote (1)
- Hematite (6)
- Plagioclase (2)
- Pyrite (0)
- Quartz (7)

Bedrock Geology

- 15 Massive granodiorite to granite
- 12 Foliated tonalite suite
- 11 Gneissic tonalite suite



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REFERENCE(S)
1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011
3. LOGGING ROAD DATA PROVIDED BY RESOLUTE FORESTRY PRODUCTS (2015)

CLIENT
NWMO
IGNACE, ONTARIO

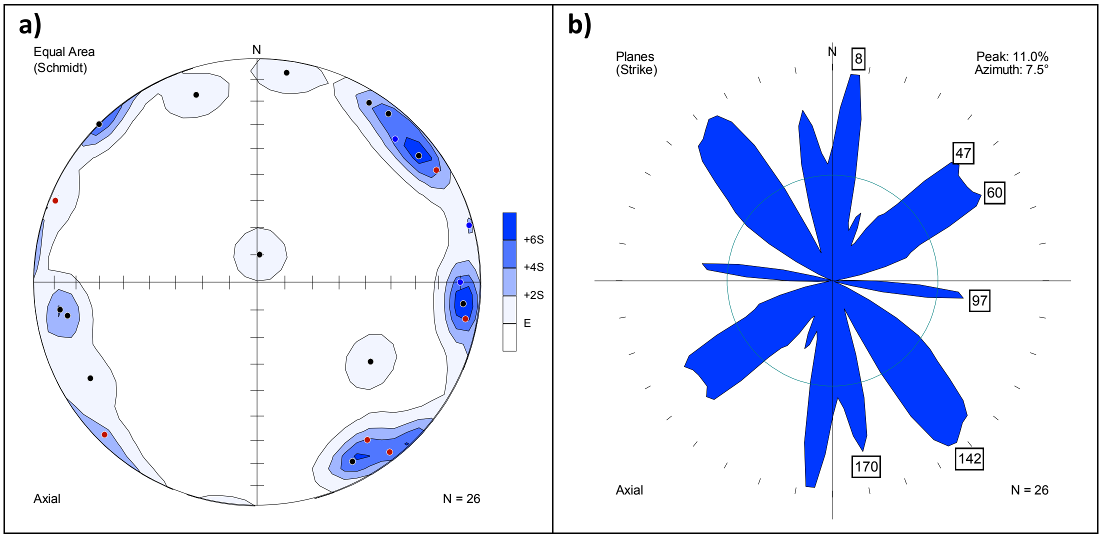
PROJECT
IGNACE DETAILED MAPPING REPORT

TITLE
INDIAN LAKE EAST BATHOLITH AREA - SECONDARY MINERAL INFILL AND ALTERATION

CONSULTANT

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1532407			5.3.21



<u>Figure 5.3.22: INDIAN LAKE EAST BATHOLITH AREA – Secondary Minerals and Alteration Orientation Data</u>

a - All mineral infill data displayed as equal area lower hemisphere stereonet plot of poles to joints, faults, or veins (N=26). Quartz infill: blue (N=6). Hematite infill: red (N=7). Other infill (epidote, feldspar, breccia, chlorite, biotite, bleaching, carbonate): black (N=13). Contours show multiples of the standard deviation S above the expectant count E calculated using Gaussian K-100.

b - All mineral infill data displayed as rose diagram of trends of joints, faults, or veins (N=26). Bins for rose diagrams are 10°.

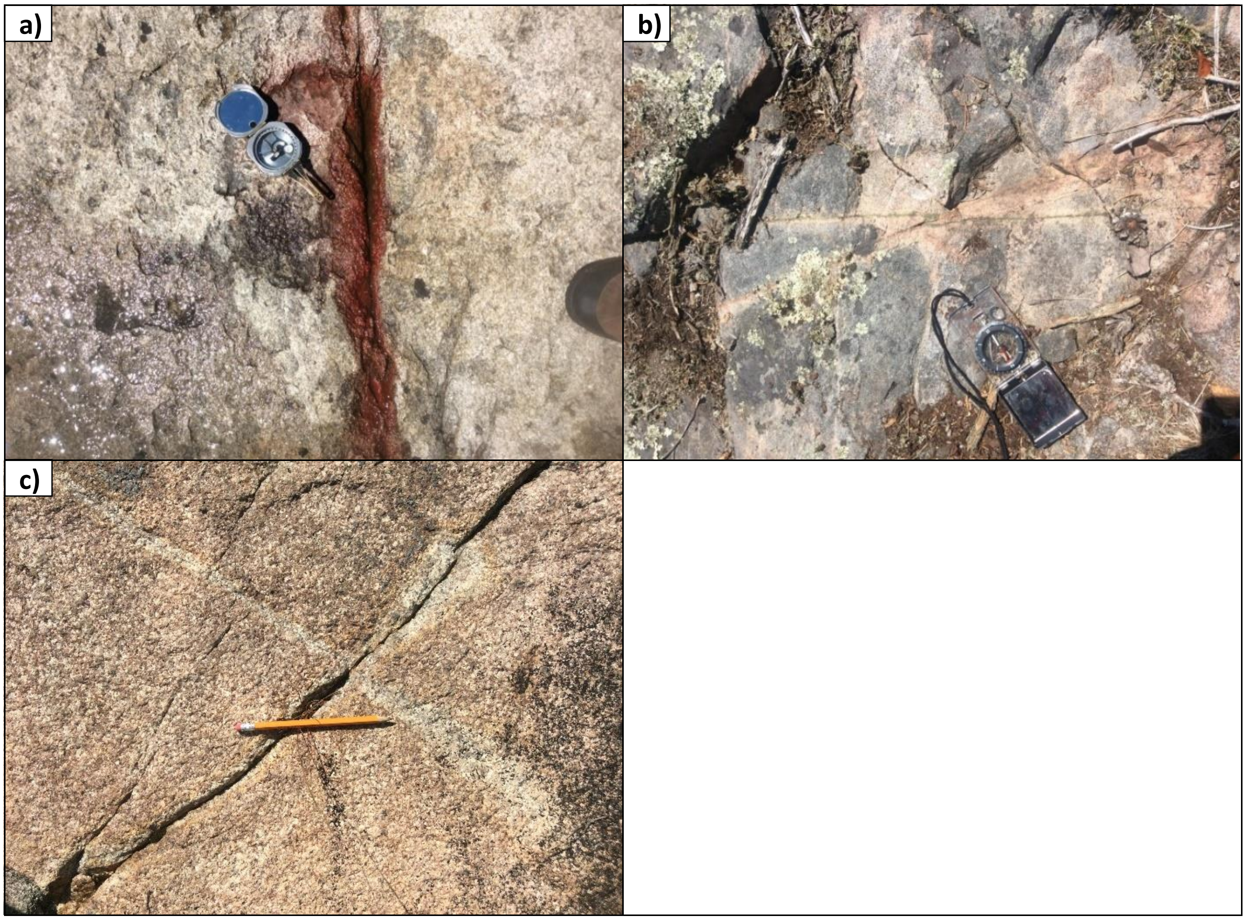
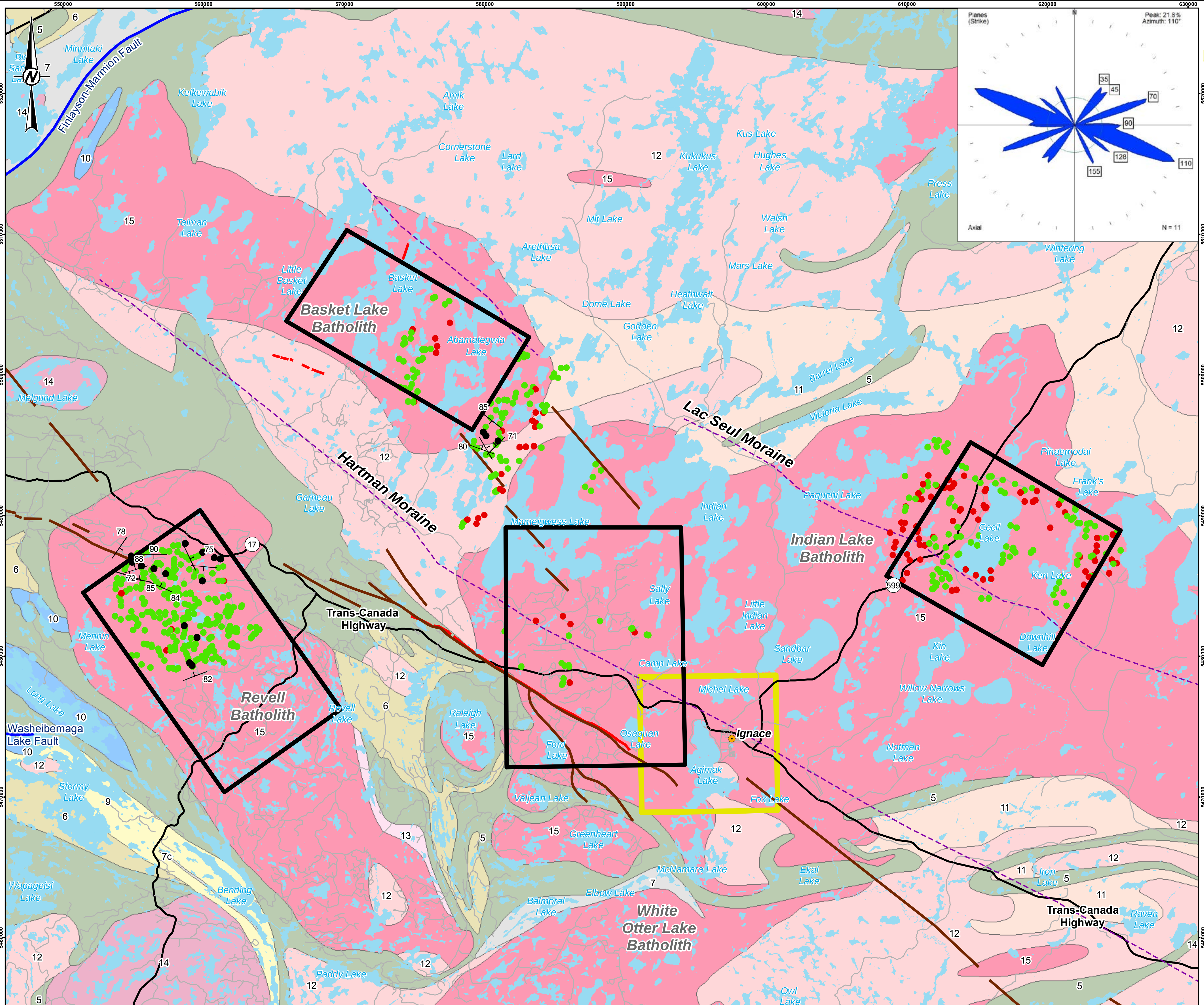


Figure 5.3.23: INDIAN LAKE EAST BATHOLITH AREA – Field Examples of Secondary Minerals and Alteration

a - Hematized granite-gneiss contact at Cecil Lake shoreline. View to the southeast, compass for scale (Station 16TC2098).

b - Epidote infill in joint associated with bleached halo. View to the southwest, compass for scale (Station 16IL1116).

c - 3 cm wide bleaching around a joint. View to the west, pencil for scale (Station 16IL1116).

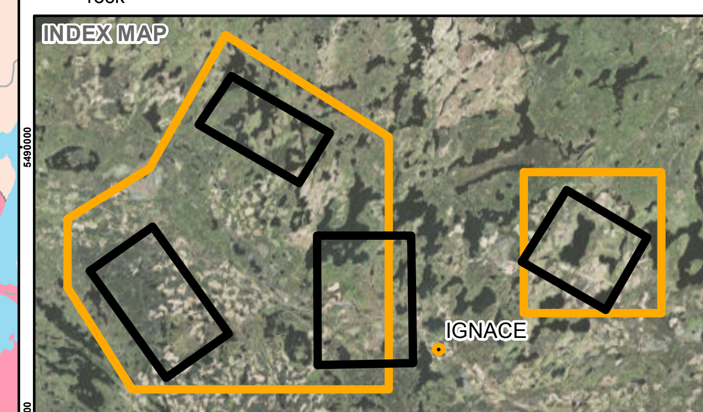


LEGEND

- Withdrawal Area
- Municipal Boundary (Township of Ignace)
- Community
- Main Road
- Local Road
- Waterbody
- Outcrop
- Overburden
- Mafic Dyke - Lithology (17)
- Mafic Dyke - Structural (13)
- End moraine
- Geologic Fault
- Interpreted Dyke (PGW, 2012)
- Mapped Dyke (OGS, MRD 126)
- Interpreted Dyke (SRK, 2015)

Bedrock Geology

- 15 Massive granodiorite to granite
- 14 Diorite-monzodiorite-grano... suite
- 13 Muscovite-bearing granitic rock
- 12 Foliated tonalite suite
- 11 Gneissic tonalite suite
- 10 Mafic and ultramafic rocks
- 9 Coarse clastic metasedimentary rocks
- 7 Metasedimentary rocks
- 7c Marble, chert, iron formation, minor metavolcanic rocks
- 6 Felsic to intermediate metavolcanic rocks
- 5 Mafic to intermediate metavolcanic rocks



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REFERENCE(S)
1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011

CLIENT
NWMO
IGNACE, ONTARIO

PROJECT
IGNACE DETAILED MAPPING REPORT

TITLE
IGNACE AREA - MAFIC DYKES

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1532407			5.4.1

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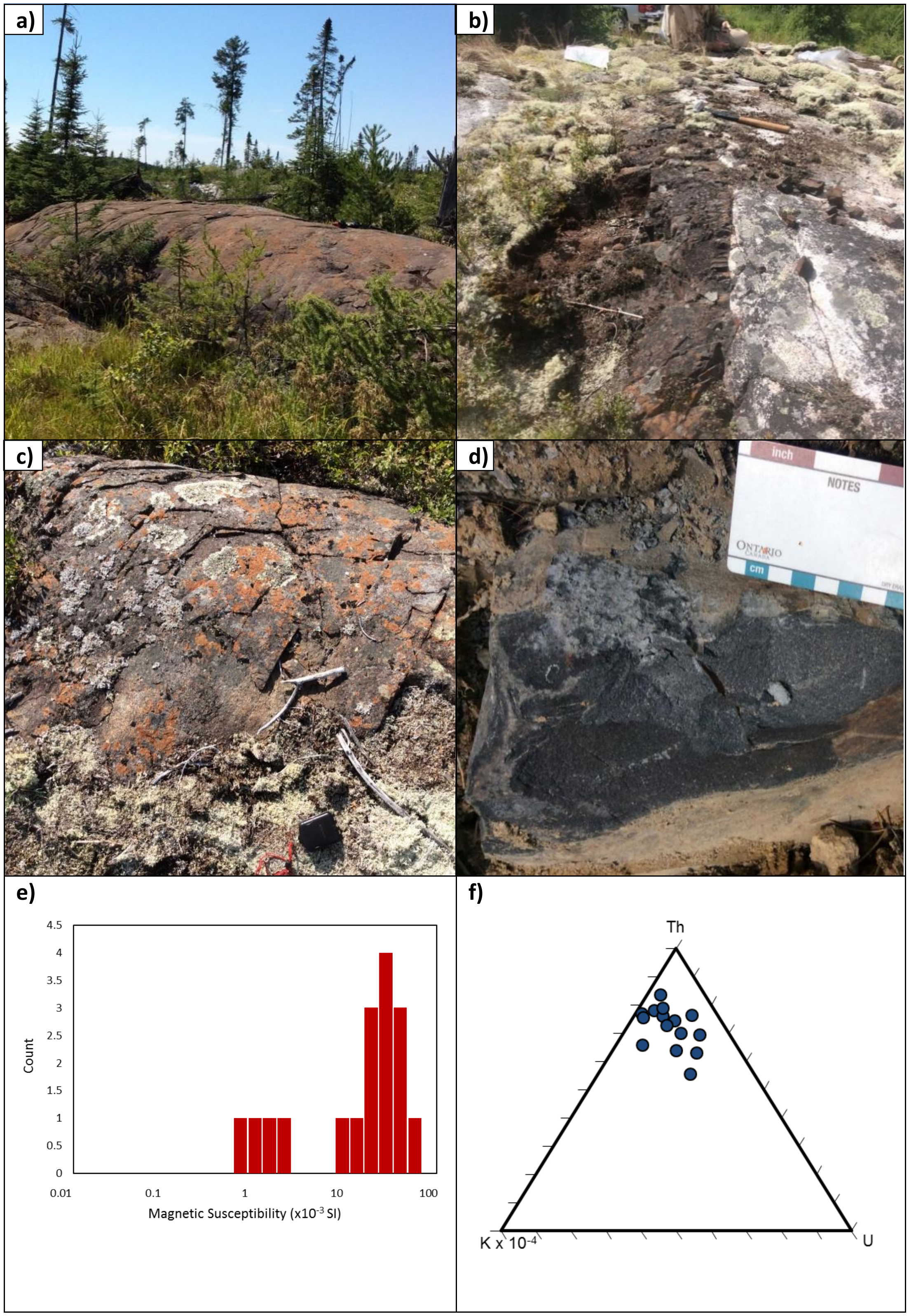
a)
b)
c)
d)
inch
NOTES
ONTARIO
cm
e)
4.5
4
3.5
3
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2
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0.01
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Magnetic Susceptibility (x10-3 SI)
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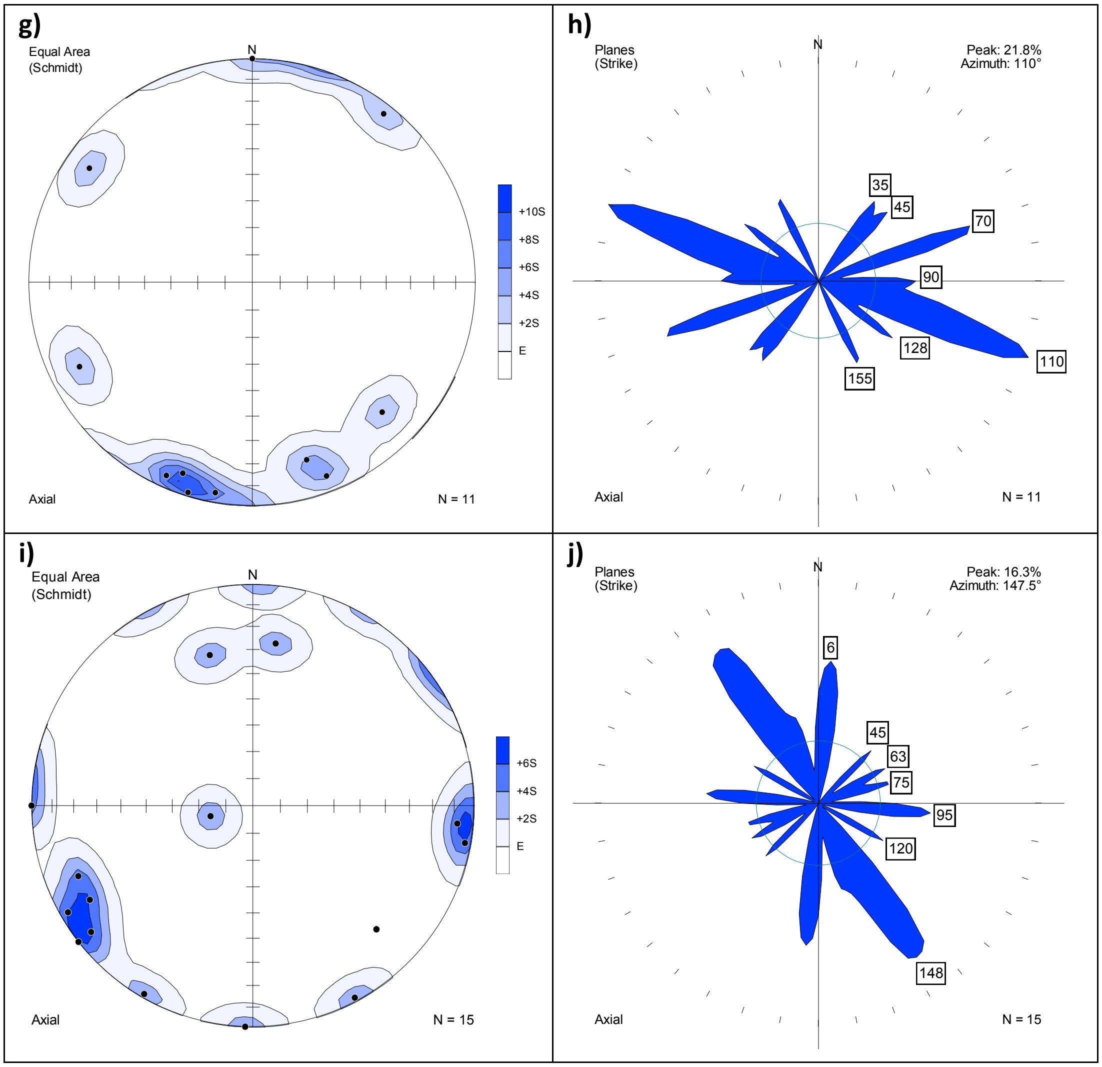

g)
Equal Area
(Schmidt)
N
+10S
+8S
+6S
+4S
+2S
E
Axial
N = 11
h)
Planes
(Strike)
N
Peak: 21.8%
Azimuth: 110°
35
45
70
90
128
110
155
Axial
N = 11
i)
Equal Area
(Schmidt)
N
+6S
+4S
+2S
E
Axial
N = 15
j)
Planes
(Strike)
N
Peak: 16.3%
Azimuth: 147.5°
6
45
63
75
95
120
148
Axial
N = 15

Figure 5.4.2: IGNACE AREA – Mafic Dyke Orientation Data and Field Examples

a - Outcrop photo of a 17m wide diabase dyke of the Wabigoon dyke swarm. View to the west, person for scale (Station 16TC2196).

b - Photo of mafic dyke contact with granodiorite bedrock. View to the east, hammer for scale (Station 16TC2133).

c - Photo of rust coloured weathering surface of mafic dyke. View to the northwest, compass for scale (Station 16FB3134).

d - Close-up photo of mafic dyke in the Indian Lake West area. View to the north, card for scale, (Station 16IL1173).

e - Logarithmic plot of magnetic susceptibility for mafic dykes (N= 16).

f - Ternary plot of gamma ray spectrometer data for mafic dykes (N= 16).

g - All mafic dyke contact data displayed as equal area lower hemisphere stereonet plot of poles to contact planes (N=11). Contours show multiples of the standard deviation S above the expectant count E calculated using Gaussian K-100.

h - All mafic dyke contact data displayed as rose diagram of trends of dyke contacts (N=11). Bins for rose diagrams are 10°.

i - Joints within mafic dykes displayed as equal area lower hemisphere stereonet plot of poles to joints (N=15). Contours show multiples of the standard deviation S above the expectant count E calculated using Gaussian K-100.

j - Joints within mafic dykes displayed as rose diagram of trends of joints (N=15). Bins for rose diagrams are 10°.

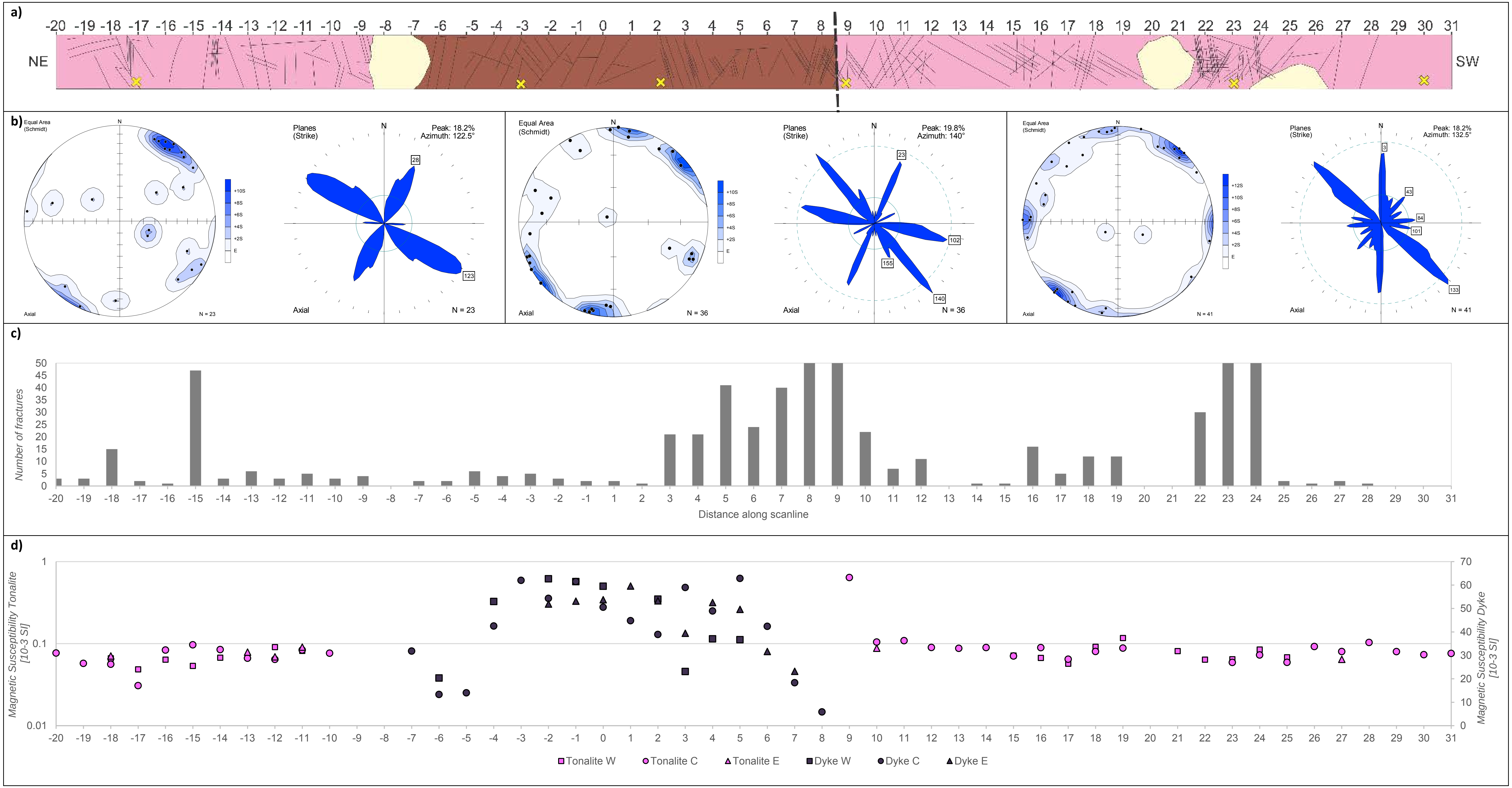

a)
NE
SW
b)
Equal Area (Schmidt)
Planes (Strike)
Peak: 18.2% Azimuth: 122.5°
Axial
N = 23
Peak: 19.8% Azimuth: 140°
N = 36
Peak: 18.2% Azimuth: 132.5°
N = 41
c)
Number of fractures
Distance along scanline
d)
Magnetic Susceptibility Tonalite [10-3 SI]
Magnetic Susceptibility Dyke [10-3 SI]
Tonalite W
Tonalite C
Tonalite E
Dyke W
Dyke C
Dyke E

Figure 5.4.3 IGNACE AREA - Mafic Dyke Scanline – Lithology, Joints, Fracture Frequency, and Magnetic Susceptibility

a - Simplified NE-SW profile of 50 m long scanline across an 18 m wide mafic dyke (shown in brown) within tonalite (pink) bedrock. Small sections of the profile are covered by vegetation or overburden (pale yellow). The southwestern contact of the mafic dyke against the tonalite is exposed and oriented 307/89. Yellow crosses indicate photograph locations for Figure 5.4.4.

b - Joint data displayed as equal area lower hemisphere stereonet plot of poles to joints as well as rose diagrams for the northern tonalite bedrock (left, N=23), the mafic dyke (center, N=36) and the southern tonalite bedrock (right, N=41). Contours show multiples of the standard deviation S above the expectant count E calculated using Gaussian K-100. Bins for rose diagrams are 10°.

c - Fracture frequency chart showing number of fractures per 1 m interval. All values over 40 are estimates from sub-decimetre spaced joint sets.

d - Magnetic Susceptibility measurements at 1 m intervals along the scanline profile. Each point represents the average of five measurements taken on the west side (W, square symbols), east side (E, triangle symbols) and center (C, circle symbols) of the scanline profile. Left axis shows tonalite magnetic susceptibility values in 10^{-3} SI on a logarithmic scale, right axis shows dyke magnetic susceptibility values in 10^{-3} SI on a linear scale.

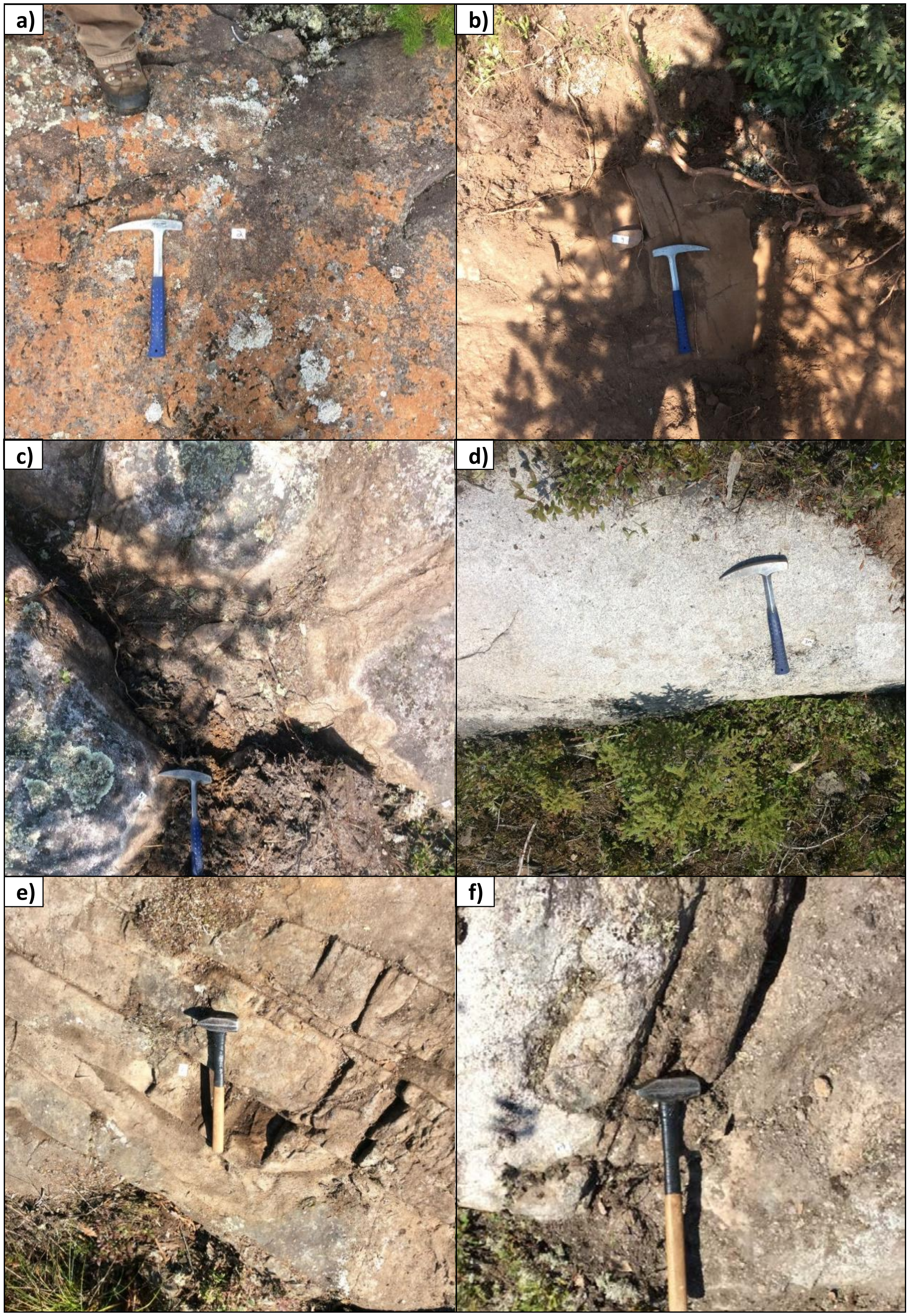


Figure 5.4.4: IGNACE AREA - Mafic Dyke Scanline – Field Examples

Figure 5.4.4 (Cont'd): IGNACE AREA - Mafic Dyke Scanline – Field Examples

a - Wide, > 100 cm, joint spacing at center of dyke. Location is 2 m south of scanline center. All photographs are view to the northeast and with a hammer for scale.

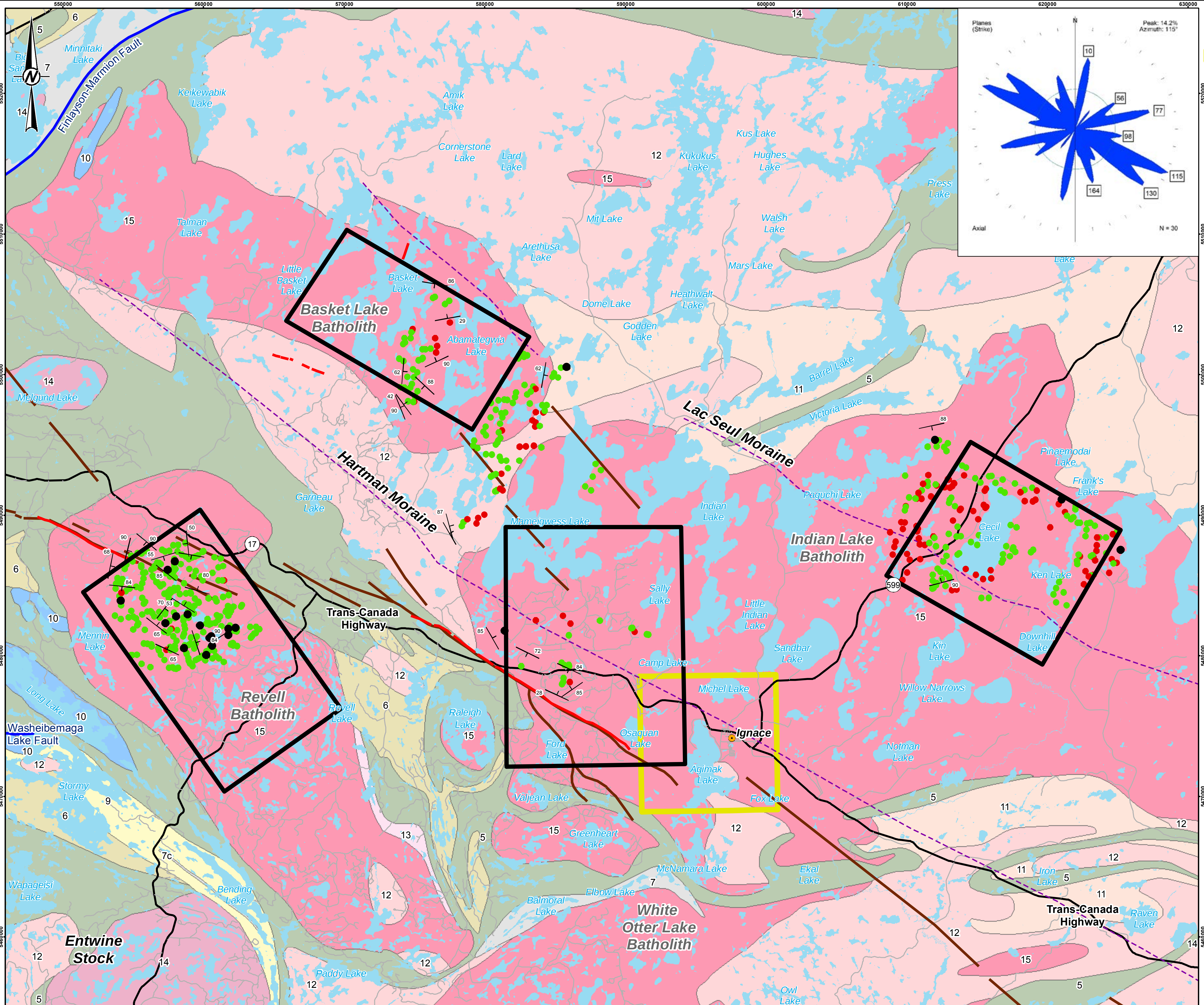
b - Dyke-tonalite contact with abundant parallel joints. Location is 9 m south of scanline center.

c - Multiple tightly, 3-10 cm spacing, spaced joints. Location is 23 m south of scanline center.

d - No joints are observed at the southwestern end of scanline. Location is 30 m south of scanline center.

e - Northeast-striking joints (065/72) terminate on 10-30 cm spaced NW-striking joints (338/88). Location is 3 m north of scanline center.

f - Two joint sets (152/64 and 295/88) at a low angle to dyke contact. Location is 17 m north of scanline center.



LEGEND

- Withdrawal Area
- Municipal Boundary (Township of Ignace)
- Community
- Main Road
- Local Road
- Waterbody
- Outcrop
- Overburden
- Felsic Dyke - Lithology (20)
- Felsic Dyke Structural - (32)
- End moraine
- Geologic Fault
- Interpreted Dyke (SRK, 2015)
- Mapped Dyke (OGS, MRD 126)

Bedrock Geology

- 15 Massive granodiorite to granite
- 14-Diorite-monzodiorite-gra... suite
- 13 Muscovite-bearing granitic rock
- 12 Foliated tonalite suite
- 11 Gneissic tonalite suite
- 10 Mafic and ultramafic rocks
- 9 Coarse clastic metasedimentary rocks
- 7 Metasedimentary rocks
- 7c Marble, chert, iron formation, minor metavolcanic rocks
- 6 Felsic to intermediate metavolcanic rocks
- 5 Mafic to intermediate metavolcanic rocks

INDEX MAP

IGNACE

0 10 20

1:275,000 KILOMETRES

REFERENCE(S)
1. LIO 2013
2. GEOLOGY - MRD126-BEDROCK GEOLOGY OF ONTARIO, 2011

CLIENT
NWMO
IGNACE, ONTARIO

PROJECT
IGNACE DETAILED MAPPING REPORT

TITLE
IGNACE AREA - FELSIC DYKES

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	JB
PREPARED	JB
REVIEWED	IL
APPROVED	GWS

PROJECT NO.	CONTROL	REV.	FIGURE
1532407			5.4.5

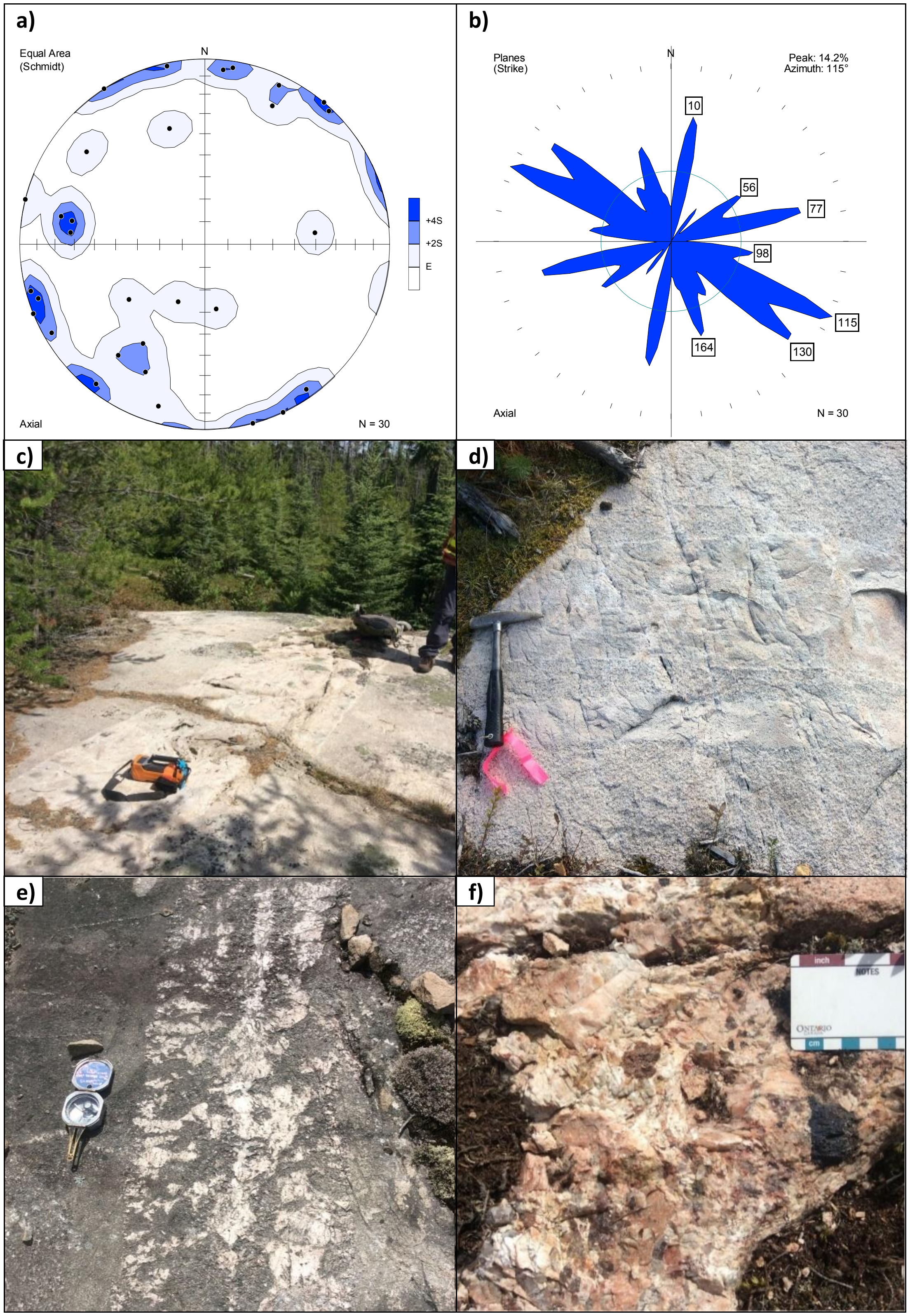


Figure 5.4.6: IGNACE AREA – Felsic Dykes Orientation Data and Field Examples

Figure 5.4.6 (Cont'd): IGNACE AREA – Felsic Dykes Orientation Data and Field Examples

a - All dyke contact data displayed as equal area lower hemisphere stereonet plot of poles to contact planes (N=30). Contours show multiples of the standard deviation S above the expectant count E calculated using Gaussian K-100.

b - All dyke contact data displayed as rose diagram of trends of dyke contacts (N=30). Bins for rose diagrams are 10°.

c - Outcrop-scale photo of a one metre wide aplite dyke. View to the east, instrument for scale (Station 16IL1147).

d - Photo of parallel aplite dykes. View to the north, hammer for scale (Station 15IL1003).

e - Photo of pegmatite dyke. View to the north, compass for scale (Station 16TC2186).

f - Garnet and magnetite bearing pegmatite in Indian Lake west area. View to the north, card for scale (Station 16IL1992).

APPENDIX A

Supporting Tables from the Work Plan

Table A.1: Source Data Descriptions

Source Data	Format
Water bodies	Ignace_Water.gdb Ignace_Waterbody Ignace_Lake_Depth Ignace_Watercourse Ignace_Wetland Ignace_Wetland_Interpreted Ignace_Watershed_Boundary Ignace_Watershed_English_SubBasin Ignace_Watershed_Outflow Ignace_Watershed_Quaternary Ignace_Watershed_Tertiary Ignace_Watershed_Turtle_SubBasin Ignace_Watershed_Wabigoon_SubBasin Ignace_Surface_Water_Flow
Roads network	Ignace_Base_Map.gdb Ignace_Road Ignace_Trails_r1.shp
Other base map data	Ignace_Base_Map.gdb Ignace_Municipal_Upper_Tier Ignace_Municipal_Lower_Tier Ignace_Geographic_Township Ignace_Railway Ignace_Utility_Lines Ignace_Transmission_Line Ignace_Indian_Reserve Ignace_Airport Ignace_Waste_Water_Treatment_Plant Ignace_Domestic_Waste_Sites Ignace_Building_Points Ignace_Building_Footprint Ignace_Community Ignace_Township Ignace_Lot_Fabric Ignace_Wooded_Area
Overburden	Ignace_Quaternary_Geology.gdb Ignace_Overburden_Surficial_Geology Ignace_Overburden_Surficial_Geology_Features Ignace_Dunes Ignace_Moraine_Trend Ignace_IlsleyGulliver_Trough Ignace_Quaternary_Geology Ignace_Quaternary_Features

Source Data	Format
Forest Resources Inventory (FRI) Imagery	FRI Revell.tif IndianW.tif IndianE.tif Basket.tif
Geophysics	I_MAG_RTP.grd I_1VDRTP.grd I_2VDRTP.grd I_ASIGMAG.grd I_HORMAG.grd
Bedrock Geology	Ignace_Bedrock_Geology.gdb Ignace_Bedrock_Geology Ignace_Bedrock_Contacts Ignace_Sub_Province_Boundries Ignace Iron_Formations Ignace_Dyke_Merged Ignace_Detailed_Geology_Outlines Ignace_Major_Batholiths Ignace_Major_Batholiths_Outline Ignace_Exposed_Bedrock_Major_Batholiths Ignace_Terrane_Boundaries
Predicted outcrop locations	Revell_predicted_outcrops_r1 Indian_Lake_W_predicted_outcrops_r1 Indian_Lake_E_predicted_outcrops_r1 Basket_Lake_predicted_outcrops_r1
Faults	Ignace_Bedrock_Geology.gdb Ignace_Faults
Historical geological maps	Ignace_Bedrock_Geology.gdb Ignace_P3360_Geology Ignace_P3364_Geology Ignace_P3386_Geology Ignace_P3401_Geology Ignace_P3623_Geology Ignace_P3624_Geology
Protected Areas	Ignace_Protected_Area.gdb Ignace_Natural_Heritage_Value_Area Ignace_Conservation_Reserves Ignace_Provincial_Park Ignace_Crown_Leased_Land Ignace_Crown_Land_Unpatented Ignace_Forest_Management_Unit Ignace_Land_Ownership Ignace_CULPA_Primary_Landuse Ignace_Significant_Ecologial_Area Ignace_Crown_Land_NonFreehold_Dispositions Ignace_Fish_Management_Zone

Source Data	Format
	Ignace_Registered_Archaeological_Site
OGGF Results	OGGF Ignace_OGGF_Station.shp Ignace_OGGF_Intrusive.shp Ignace_OGGF_Metamorphic.shp Ignace_OGGF_Sample.shp Ignace_OGGF_Structure.shp Ignace_OGGF_Fracdense.shp Ignace_OGGF_Domain_Boundaries.shp
Lineaments	Lineaments Ignace_SRK_Phase2_Geophysical_Ductile_Lineaments_AF.shp Ignace_SRK_Phase2_Geophysical_ Lineaments_RA1_AF_IL_jps.shp Ignace_SRK_Phase2_DEM_ Lineaments_RA1_AF_IL_jps.shp Ignace_SRK_Phase2_AERIAL_ Lineaments_RA1_AF_IL_jps.shp Ignace_SRK_Phase2_Surficial_ Lineaments_RA2_AF_IL_jps.shp Ignace_SRK_Phase2_Final_Integrated_Lineaments_RA2_AF_IL_jps.shp

Table A.2: Equipment Requirements

Equipment	Calibration Required
Compass (Brunton Pocket Transit or similar)	Y – Check magnetic declination setting daily
Digital Camera	N
iPad field data collector w/GPS	Y – Check against hand held GPS
iPad with Collector-GanFeld software	Y – Daily check of uploaded data against hard copy maps
Magnetic Susceptibility Meter (KT-20)	Y – Calibrated by supplier before rental and upon return from rental period / daily check of reading at a reference rock outcrop. Certificate of Calibration provided by supplier and provided to NWMO.
Gamma Spectrometer (RS-125 or equivalent)	Y – Calibrated by supplier before rental and upon return from rental period. Certificate of Calibration provided by supplier and provided to NWMO.
Notebook and Pen	N
Handheld GPS	N
Geological Hammer	N
Sample Bags	N
Personal Protective Equipment	N

Table A.3: Task Allocation

Task	Responsibility
Daily safety briefing	Engineering Geologist
Daily equipment calibration	Engineering Geologist
Host rock lithology characterization	Lead Geologist
Host rock structural characterization	Lead Geologist
Digital photographs	Lead Geologist
Fracture characterization	Lead Geologist
Lineament observation/assessment	Lead Geologist
Data input into ArcPad	Lead/Engineering Geologist
Manual (pencil and paper) note transcription	Lead/Engineering Geologist
Magnetic susceptibility measurements	Engineering Geologist
Rock strength assessment - Hammer test	Engineering Geologist
Bedrock overburden assessment	Engineering Geologist
Sample collection	Engineering Geologist
Surface constraint assessment	Lead/Engineering Geologist
Identification of potential detailed mapping areas	Lead Geologist
Daily QC verification of notebook with digital entry for two locations for each team	Lead/Engineering Geologist
Daily QC verification of instrument readings (KT-20, RS-125) with entries in notebook and digital database	Lead/Engineering Geologist
Daily report write-up and transmittal	Lead/Engineering Geologist
Daily data back-up (and back-up for the back-up)	Lead/Engineering Geologist
Planning the next day traverse	Lead Geologist and Project Manager

Table A.4: Key Geological Attributes to be characterized during Detailed Outcrop Mapping

<table>
<tr><th>Geological Attribute</th><th colspan="2">Characterization Method</th><th>Data Capture Protocol[1]</th></tr>
<tr><td>Station Location</td><td colspan="2">• iPad GPS with Trimble booster to give sub-metre accuracy
• Uniquely named and linked to nearby observations and measurements</td><td>Station Feature Class</td></tr>
<tr><td>Lithology</td><td colspan="2">• Visually inspection of weathered and fresh rock surfaces for identification of major and minor lithological units (including dykes) and their constituent colour, minerals[A] (e.g., granitic rocks have varying proportions of quartz, K-feldspar and plagioclase, phenocrysts, plus other indicator minerals including micas, hornblende, etc.), grain size, texture, etc
• Name of lithological unit(s) in terms of relative abundance at the outcrop scale, including dykes
• Collected representative sample(s) of the dominant lithological unit(s) at each outcrop (using a hammer only; fist-sized piece with both weathered and fresh surface)[B]
• Digital photographs of representative lithological unit(s) across the area of interest [documentation included file name (photo number), scale, GPS coordinates, direction of view and description of the photo.][C]
• Recorded 5 magnetic susceptibility measurements for each identified lithological unit (using a KT-20 magnetic susceptibility meter)
• Measured gamma ray readings for each identified lithological unit (using an RS-125 gamma ray spectrometer)
• Estimated field rock strength test on representative lithologies at each station and in spatial relation to identified structural features (i.e. lineaments, fracture zones, dykes) [refer to Table 6 below]</td><td>Intrusive Feature Class
Alteration Feature Class
Volcanic Flow Feature Class
Volcanic Pyroclastic Feature Class
Sediment Feature Class
Metamorphic Feature Class
Rock Properties Feature Class</td></tr>
<tr><td>Structure</td><td>General</td><td>• Observed and documented the bedrock structural features (e.g., bedding, foliations, lineations, shear zones)
• Digital photographs/field sketches of representative key structural features[C]
• Measured and documented (by hand with compass-clinometer and subsequent digital and manual entry):
  • Strike and dip of planar structures[D]
  • Trend and plunge of linear structures</td><td>Structure Feature Class
Alteration Feature Class</td></tr>
<tr><td>Structure</td><td>Fractures</td><td>• Visually inspected the rock surface for identification of systematic fracture sets[E]
• Characterized fracture sets by type (tension fractures (joints), hydrofractures (veins and mineral-infilled fractures), faults
• Measured and documented (by hand with compass-clinometer and subsequent digital and manual entry):
  • Strike and dip of planar structures</td><td>Structure Feature Class
Fracture Density Feature Class
Scanline Feature Class</td></tr>
</table>

Geological Attribute	Characterization Method		Data Capture Protocol[1]
		• Trend and plunge of linear structures on fracture planes • Where possible, documented: • Fracture aperture • Fracture mineral filling • Abutting, cross-cutting and intersection (relative age) relationships between fracture sets • Displacement (strike separations and dip separations if visible) • Fracture surface ornamentation • Fracture set spacing	
Structure	Dykes	• Documented: • Internal structure • Width • Nature of contact with host rock (e.g., welded, fractured, sheared, altered, etc.) • Measured and documented (by hand with compass-clinometer and subsequent digital and manual entry): • Strike and dip • Conducted fracture orientation and spacing characterization perpendicular to a dyke using a scanline method • Observations will be collected systematically along a traverse line between two points with measured UTM coordinates • Measurements of all systematic fractures will be taken within a 1 to 2 m wide swath parallel to the traverse	Intrusive Feature Class
Bedrock exposure and overburden thickness	• Visually inspected the distribution and thickness of overburden vs. exposed bedrock during the daily traverse (in comparison to existing understanding) • Geo-located key observations		Station Feature Class Overburden Feature Class
Surface Constraints	• Visually identified and geo-located any surface constraints that would create challenges for further geological characterization activities (e.g., bridge wash-outs, poorly or unmaintained logging roads, beaver dams, steep and deep (impassable) valleys, etc.) • Visually identified access issues in areas without mapped roads or navigable waterways		Station Feature Class

Notes:
1 All observations were recorded in digital format (iPad running Collector + GanFeld database) with manual (pen and paper) backup for most pertinent field observations only, unless required due to digital device failure. The data collection protocol refers to NWMO's minimum

requirements for digital data capture within the GanFeld database structure. The observer may have included addition observations based on perceived importance of that feature in conveying the heterogeneity or homogeneity of a specific outcrop area or larger region. In addition, the 'Notes' tab in all feature classes was utilized at the observers discretion in order to capture additional relevant information.

A Lithology Tab: Form and Rock Fabric, with Colour Index and Colour (typed in) was collected to help characterize different phases of a multi-phase pluton.

B Samples were stored in bags with waterproof tags numbered in accordance with the sample number generated in the GanFeld database.

C The photos taken with the iPad were automatically linked to the station by GPS.

D Strike and dip measurements followed Canadian right-hand-rule notation.

E Effort was made to characterize fractures of all dip magnitudes (including horizontal to shallow dipping features)

Table A.5: Field Estimates of Intact Rock Strength (after Barton, 1978)

Grade	Description	Field identification
R6	Extremely strong	Specimen can only be chipped with a geological hammer
R5	Very strong	Specimen requires many blows of a geological hammer to fracture it
R4	Strong	Specimen requires more than one blow of a geological hammer to fracture it
R3	Medium strong	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with a single blow from a geological hammer
R2	Weak	Can be peeled with a pocket knife with difficulty, shallow indentation made by firm blow with point of a geological hammer
R1	Very weak	Crumbles under firm blows with a geological hammer, can be peeled by a pocket knife
R0	Extremely weak	Indented by thumbnail

Table A.6: Filtering of Priority Outcrops

Filtered by	Buffer	Filter Criteria	Reason
Relative lineament age (also proxy for orientation/fracture family)	200 m	Early D5-D6 lineaments and Intermediate D5-D6 lineaments (From Final Integrated lineament dataset)	Likely most structurally complex brittle deformation and probability of observing cross-cutting relationships
	200 m	Inverse of above (> 200 m from outcrops with intersection of Early and Late D5-D6 lineaments) (From Final Integrated lineament dataset)	Likely least complex brittle deformation, most intact rock
	200 m	D1-D4, Early D5-D6 and Intermediate D5-D6 lineaments (From Final Integrated lineament dataset)	Most complex ductile and brittle deformation
Lineaments with surface expression	1 m	RA_2 Surface Lineaments	Best opportunity to see surface expression of lineaments
Dykes	50 m	Dyke lineaments (From Final Integrated lineament dataset)	Ground truth interpreted dykes
Specific target lineaments	200 m	Identified long and high certainty lineaments determined by consensus from Final Integrated lineament dataset	Characterize specific target lineaments/fracture zones that bound large, relatively intact blocks of rock
	500 m	Greater than 500 m from specific target lineaments	Alternative method to characterize most intact regions

APPENDIX B

Remote Predictive Bedrock Analysis

Potential outcrop locations were identified through an automated object based image analysis (OBIA), filtered, and prioritized for use in planning and implementing the Phase 2 Geological Mapping in the Ignace area of Ontario. This work involved 2 main tasks: 1) automated OBIA and 2) manual filtering of OBIA results to produce an output of potential outcrop locations.

Object Based Image Analysis using eCognition

Automated OBIA was conducted using Trimble's eCognition 9.1 software for the two withdrawal areas identified for detailed mapping in the White River area. Forest Resource Inventory (FRI) orthoimagery of the Ignace area, from 2009, was the primary dataset used in the analysis. FRI imagery is 4-band (red, green, blue, near infra-red) multi-resolution, 40 cm airborne imagery collected and used for forest resource purposes by the Ministry of Natural Resources.

A ruleset was developed in eCognition which initially employed multi-resolution segmentation to develop small image objects of almost pixel size. Through a series of iterative steps, the ruleset was refined and the small image objects were merged into larger more identifiable objects of distinct classes. Areas of water were classified first, followed by those areas that are spatially and spectrally similar to exposed bedrock, such as unpaved road surfaces, sand covered areas and brightly reflecting bogs. The remaining image objects were considered to most likely represent exposed outcrop and output as a distinct data set. This raw eCognition output provided a framework for remotely interpreting the location of probable bedrock outcrops in the four potentially suitable areas.

Filtering of OBIA results

It is understood that similarities in spectral response of areas of ground cover versus areas of exposed bedrock in the Manitouwadge area results in instances of false positive exposed bedrock classification when classifying by means of OBIA. In order to use the remotely predicted outcrop data set in a meaningful way for detailed outcrop mapping an additional step of manually comparing the raw output, against the FRI imagery, was required.

The process to undertake this filtering was straightforward and involved examining the FRI imagery in areas where the eCognition output showed clusters of pixels locating possible exposed bedrock. The cluster area was visually evaluated in the FRI imagery and a determination by consensus of two or more individual interpreters was made as to whether the location in question did or did not likely represent actual exposed bedrock. If it was determined likely, then the location was outlined and defined as a unique polygon. This analysis produced a set of shapefiles of polygons representing interpreted priority outcrop locations, for both withdrawal areas in the Manitouwadge area (see Figure 1.2 from main report). The planning for the Phase 2 Geological Mapping activity in Ignace is based upon these interpreted priority outcrop locations.

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