NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

Phase 2 Geoscientific Preliminary Assessment, Findings from Initial Field Studies

TOWNSHIP OF IGNACE, ONTARIO

APM-REP-06145-0001

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Phase 2 Geoscientific Preliminary Assessment

FINDINGS FROM INITIAL FIELD STUDIES THE TOWNSHIP OF IGNACE, ONTARIO

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Executive Summary

In 2013, a Phase 1 Geoscientific Desktop Preliminary Assessment was completed by Golder Associates to assess whether the Ignace area contains general areas that have the potential to satisfy the geoscientific site evaluation factors outlined in NWMO's site selection process. The assessment was conducted using available geoscientific information and key geoscientific characteristics that can be realistically assessed at the desktop stage. The Phase 1 assessment revealed that the Ignace area contains at least four general areas that have the potential to satisfy NWMO's geoscientific site evaluation factors (Golder, 2013).

In 2014, as part of Phase 2 of the preliminary geoscientific assessment of the Ignace area, NWMO initiated a series of initial geoscientific field studies including the acquisition and interpretation of high-resolution airborne geophysical data and initial geological mapping. The objective of these initial field studies was to advance understanding of the geology of the large general potentially suitable areas identified in the Phase 1 Geoscientific Desktop Preliminary Assessment, and assess whether it is possible to identify candidate areas for further field studies, beginning with detailed geological mapping.

The Phase 2 preliminary geoscientific assessment included the following key activities:

- Acquisition and processing of high-resolution airborne geophysical (magnetic and gravity) data over the four general areas identified in Phase 1 Geoscientific Desktop Preliminary Assessment;
- Detailed interpretation of high-resolution geophysical (gravity and magnetic) data to better understand the bedrock geology, such as geological contacts, depth and extent of rock units, lithological and structural heterogeneity;
- Detailed interpretation of surficial and magnetic lineaments using newly acquired high-resolution remote sensing and magnetic surveys to identify possible structural features such as fractures, shear zones and dykes; and
- Observation of general geological features to confirm/ground truth geologic characteristics, including lithology, structure, bedrock exposures and surface constraints.

The interpretation and analysis of the new Phase 2 data and field observations increased confidence in the potential for finding a repository site that would ultimately satisfy NWMO's geoscientific site evaluation factors in the Ignace area.

The assessment identified four potential areas that could be considered for further geoscientific studies, beginning with detailed geological mapping. These areas appear to have favourable geoscientific characteristics such as relatively homogenous lithology, a relatively low density of interpreted subsurface fractures, and potentially sufficient volumes of competent rock. The four potential areas are located in the northern portion of Revell batholith, the southern portion of the Basket Lake batholith, and the western and eastern portions of the Indian Lake batholith.

While the identified candidate areas appear to have favourable geoscientific characteristics for hosting a deep geological repository, there remain a number of uncertainties that would need to be addressed during subsequent stages of the site evaluation process through detailed geological mapping, and ultimately borehole drilling. Main uncertainties include the presence of overburden cover over some parts of the areas; the thickness of the Basket Lake and Indian Lake batholiths in the areas of interest; the interpreted magnetic lineament density in the northern portion of the Revell batholith due to the impact of the lower magnetic response in this area; and the potential presence of shallow-dipping fractures at repository depth.

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1.0 INTRODUCTION

In 2013, a Phase 1 Geoscientific Desktop Preliminary Assessment was completed by Golder Associates to assess whether the Ignace area contained general areas that had the potential to satisfy the geoscientific site evaluation factors outlined in NWMO's site selection process (Golder, 2013; NWMO, 2010). The desktop preliminary assessment built on an initial screening conducted by Golder Associates in 2011 (Golder, 2011). The preliminary assessment focused on the Township of Ignace and its periphery, as shown on Figure 1-1.

The Phase 1 Geoscientific Desktop Preliminary Assessment was conducted using available geoscientific information and key geoscientific characteristics that could be realistically assessed at the desktop stage. These included: bedrock geology; structural geology; interpreted lineaments; distribution and thickness of overburden deposits; surface conditions; and the potential for economically exploitable natural resources. The consideration of these key geoscientific characteristics revealed that the Ignace area contained at least four general areas that had the potential to satisfy NWMO's geoscientific site evaluation factors. Two of these areas are within the western and eastern parts of the Indian Lake batholith. The two other areas are within the northern part of the Revell batholith and the southern part of the Basket Lake batholith, respectively. The Phase 1 preliminary assessment also identified geoscientific uncertainties associated with these areas, including the low resolution of available geophysical data over most of the potentially suitable areas and significant overburden cover in some areas (Golder, 2013). In order to facilitate Phase 2 field studies, portions of land were temporarily removed from staking for mineral claims in the four identified general potentially suitable areas. These withdrawal areas are shown on Figure 1-2, which also shows the bedrock geology of the Ignace area.

In 2014, as part of Phase 2 of the preliminary geoscientific assessment of the Ignace area, NWMO initiated a series of initial geoscientific field studies including the acquisition and interpretation of high-resolution airborne geophysical surveys and initial geological mapping to observe and ground truth general geological features. The objective of these initial field studies is to advance understanding of the geology of the general potentially suitable areas identified in the Phase 1 Geoscientific Desktop Preliminary Assessment, and assess whether it is possible to identify candidate areas for further field studies, beginning with detailed geological mapping.

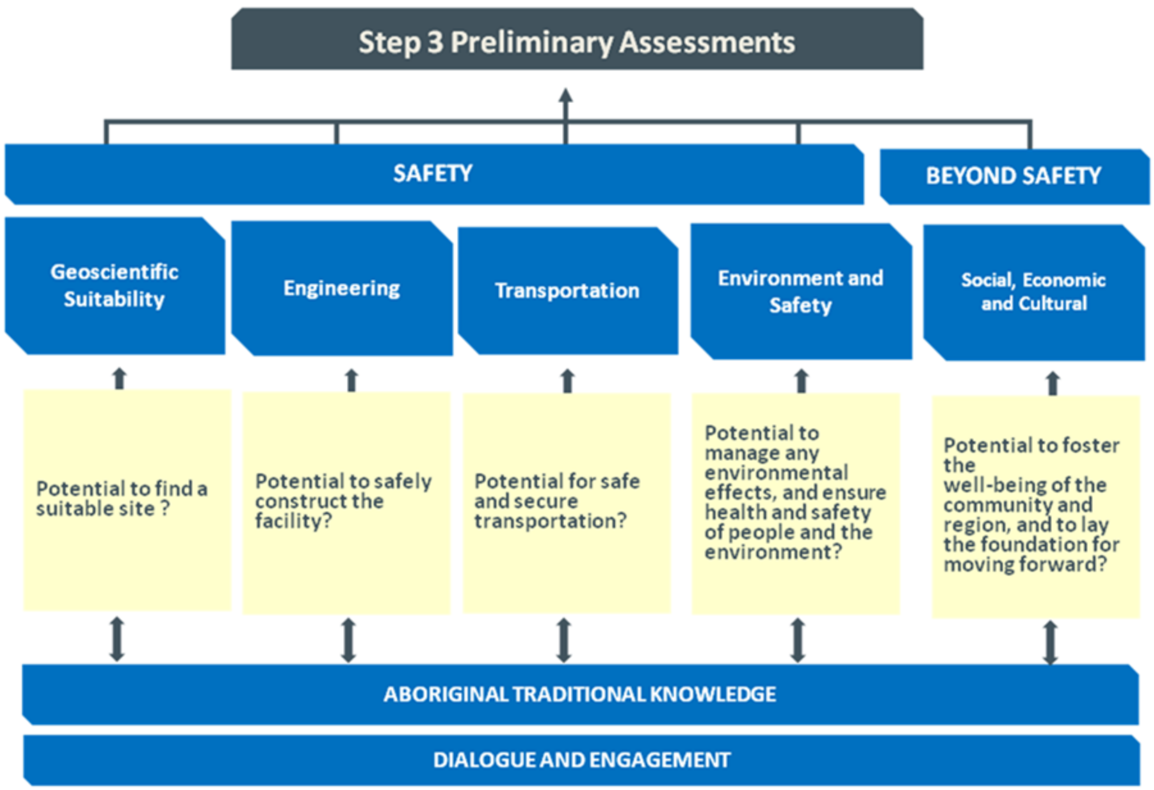
The high-resolution airborne geophysical surveys included both magnetic and gravity surveys that greatly improved understanding of the geological characteristics of the Ignace area. The high-resolution surveys provided new information on rock type, homogeneity, and the depth and extent of the potentially suitable host rock formations. High-resolution geophysical and remote sensing data were then used to conduct a magnetic and surficial lineament interpretation to identify the presence of potential structural features such as fractures and dykes. Initial geological mapping, also referred to as "observing general geological features", was conducted to better understand the lay of the land, and to confirm the presence and nature of key geological features such as fractures, rock types, extent of bedrock exposure and surface constraints. The results from the initial Phase 2 field studies are documented in three supporting documents: Geophysics Interpretation report (SGL, 2015); Lineament Interpretation report (SRK, 2015); and Observation of General Geological Features report (SRK and Golder, 2015).

This report provides the findings of Phase 2 initial field studies conducted in the Ignace area in 2014 as they relate to whether the Ignace area contains candidate areas for further field studies, beginning with detailed geological mapping.

The main sections of this report provide: a description of the approach and evaluation factors used to conduct the Phase 2 preliminary geoscientific assessment; a summary of the initial Phase 2 field studies methods and findings; and the approach, rationale and identification of potential areas for further studies.

2.0 PRELIMINARY ASSESSMENT APPROACH

The overall preliminary assessment is a multidisciplinary study integrating both technical and community well-being assessments, as illustrated in the diagram below. The five components of the preliminary assessment address geoscientific suitability, engineering, transportation, environment and safety, as well as social, economic and cultural considerations. A brief description of the project, the assessment approach and findings of the Phase 1 preliminary assessment are documented in the Ignace integrated Phase 1 preliminary assessment report (NWMO, 2013).



The objective of the geoscientific preliminary assessment is to assess whether the Ignace area contains general areas that have the potential to meet NWMO's site evaluation factors. The geoscientific preliminary assessment is conducted in two phases:

- Phase 1 - Desktop Study: For all communities electing to be the focus of a preliminary assessment. This phase involves desktop studies using available geoscientific information and a set of key geoscientific characteristics and factors that can be realistically assessed at the desktop phase of the preliminary assessment.
- Phase 2 - Preliminary Field Investigations: For a subset of communities selected by the NWMO, to further assess potential suitability. This phase includes a series of initial field studies such as:
  a) Acquisition and interpretation of high-resolution airborne geophysical surveys, geophysical and surficial lineament interpretation, and initial geological mapping (referred to as "observing general geological

features"). The outcome of these initial field studies is to identify potentially suitable candidate areas for detailed geological mapping;

b) Detailed geological mapping to inform the location of potentially suitable sites for borehole drilling; and
c) Drilling of deep boreholes at a selected location within each community.

The subset of communities considered in Phase 2 of the preliminary assessment was selected based on the findings of the overall desktop preliminary assessment considering both technical and community well-being factors illustrated in the above diagram.

The Phase 1 Geoscientific Desktop Preliminary Assessment was completed for the Ignace area in 2013 (Golder, 2013). Initial Phase 2 field studies, including high-resolution airborne geophysical surveys and observing general geological features were conducted in 2014. This report focuses on summarizing the findings of these initial field studies.

3.0 GEOSCIENTIFIC SITE EVALUATION FACTORS

As discussed in the NWMO site selection process document (NWMO, 2010), the suitability of potential sites is evaluated in a step-wise manner through a series of progressively more detailed scientific and technical assessments using a number of geoscientific site evaluation factors, organized under five safety functions that a site would need to ultimately satisfy in order to be considered suitable (NWMO, 2010):

- Safe containment and isolation of used nuclear fuel: Are the characteristics of the rock at the site appropriate to ensuring the long-term containment and isolation of used nuclear fuel from humans, the environment and surface disturbances caused by human activities and natural events?
- Long-term resilience to future geological processes and climate change: Is the rock formation at the siting area geologically stable and likely to remain stable over the very long term in a manner that will ensure the repository will not be substantially affected by geological and climate change processes such as earthquakes and glacial cycles?
- Safe construction, operation and closure of the repository: Are conditions at the site suitable for the safe construction, operation and closure of the repository?
- Isolation of used fuel from future human activities: Is human intrusion at the site unlikely, for instance through future exploration or mining?
- Amenable to site characterization and data interpretation activities: Can the geologic conditions at the site be practically studied and described on dimensions that are important for demonstrating long-term safety?

In the Phase 1 geoscientific desktop preliminary assessment of the Ignace area, the site evaluation factors were applied in two steps. The first step identified at least four general potentially suitable areas within the Ignace area using key geoscientific characteristics that could realistically be assessed at the desktop stage based on available information. The second step confirmed that the four identified potentially suitable areas had the potential to ultimately meet all of the safety functions outlined above.

The identification of candidate areas for detailed geological mapping was conducted through a systematic and iterative process based on the updated understanding of the key geoscientific characteristics of the Ignace area, using the newly acquired Phase 2 data. These key geoscientific characteristics are described in Section 5 and include: bedrock geology; structural geology; lineament analysis; bedrock exposure; protected areas; natural resources and surface constraints.

4.0 PHASE 2 GEOSCIENTIFIC PRELIMINARY ASSESSMENT APPROACH (INITIAL FIELD STUDIES)

The initial Phase 2 geoscientific preliminary assessment included the following key activities:

- Acquisition and processing of high-resolution airborne geophysical (magnetic and gravity) data over the general area identified in Phase 1 Geoscientific Desktop Preliminary Assessment;
- Detailed interpretation of high-resolution geophysical (gravity and magnetic) data to better understand the bedrock geology (e.g. geological contacts, depth and extent of rock units, lithological and structural heterogeneity, etc.);
- Detailed interpretation of surficial and magnetic lineaments using newly acquired high-resolution remote sensing and magnetic data to identify possible structural features such as fractures, shear zones and dykes; and
- Observation of general geological features to confirm/ground truth geologic characteristics, including lithology, structure, bedrock exposures and constraints.

The findings from the above activities were analyzed and interpreted in an integrated manner to achieve the following two objectives:

- Update understanding of key geoscientific characteristics that can be realistically assessed at this stage of the assessment to identify candidate areas for detailed mapping; and
- Assess whether it is possible to identify candidate areas for detailed mapping within the four general potentially suitable areas identified in the Ignace area in the Phase 1 desktop preliminary assessment.

The approach, methods and findings for each of the above activities are described in detail in three supporting documents (SGL, 2015; SRK, 2015; and SRK and Golder, 2015). This section provides a summary of the approach, methods and key results for each activity. The findings are discussed in an integrated manner in Section 5. The identification of candidate areas for additional Phase 2 field work is discussed in Section 6.

4.1 High-resolution Airborne Geophysical Surveys

The objective of the airborne geophysical surveys was to provide additional information to further assess the geology of the Ignace area. The interpretation of the data acquired during the airborne surveys can be used to estimate the geometry and thickness of the potentially suitable host rock formation; the nature of geological contacts; bedrock lithology; the degree of geological heterogeneity and the nature of intrusive phases within the plutons in the area; as well as the nature of structural features such as fractures and shear zones. The newly acquired geophysical data (SGL, 2015) provides significantly higher resolution data compared to the data available in the Phase 1 preliminary assessment (PGW, 2013).

Sander Geophysics Limited (SGL) completed a fixed-wing high resolution airborne magnetic and gravity survey in the Ignace area between April 3 and May 5, 2014 (SGL, 2015). The survey area included two survey blocks located to the west and northeast of the Township of Ignace (Figure 4-1). These survey blocks were designed to cover the four general potentially suitable areas identified in the Phase 1 preliminary assessment, and to cover relevant geological features in the area.

The airborne survey in the Ignace area included a total of 24,453 kilometres of flight lines, covering a surface area of approximately 1,780 square kilometres. Flight operations were conducted out of the Dryden Regional Airport, Dryden, Ontario using two of SGL's Cessna 208 Grand Caravans (Photograph 1). Data were acquired along traverse lines flown in a north-south direction spaced at 100 metres, and control lines flown east-west spaced at 500 metres. The survey was flown at a nominal altitude of 80 metres above ground level, with an average ground speed of 100 knots (185 kilometres per hour).

Airborne magnetic and gravity data were acquired along the flight lines using equipment having high sensitivity and accuracy. The airborne magnetic data was recorded using a magnetometer sensor mounted in a fibreglass stinger extending from the tail of the aircraft. The airborne gravity data was recorded using a gravimeter, which includes three orthogonal accelerometers that are mounted on a platform inside the cabin of the aircraft. A detailed description of the planning, execution and processing of the survey data is provided in SGL (2015). The interpretation of the survey data included both a geophysics interpretation (Section 4.2; SGL, 2015) and a lineament interpretation (Section 4.3; SRK, 2015).

Photograph 1: SGL's Cessna 208 Grand Caravans

4.2 Geophysics Interpretation

The geophysics interpretation was conducted for the Ignace area using the newly acquired high resolution magnetic and gravity data sets (SGL, 2015). The assessment of geological contacts and bedrock lithology in the Phase 2 assessment was performed by analyzing the magnetic and gravity data, and determining the coincidence of magnetic responses with mapped lithology and structures for the Ignace area. Magnetic anomaly characteristics and interpreted contacts were compared to the current bedrock geologic maps in order to identify similarities and/or changes in the lithological contact locations.

In some cases, the geophysical data provided a refined interpretation of the bedrock geological contacts, especially in areas of limited bedrock exposure (e.g. under overburden or water cover). The magnetic data and its vertical derivative products were used for interpreting geological contacts, identifying lithological heterogeneity, and assessing the nature of structural features through the surveyed area. In addition, the gravity data was valuable for interpreting geological contacts between rock units with differences in density. The magnetic and gravity data are shown on Figures 4-2 and 4-3, respectively. At the same time that the magnetic and gravity data were acquired, higher resolution Digital Elevation Model (DEM) topographic data was also generated from the airborne GPS and altimeter data (SGL, 2015), as shown on Figure 4-4.

In order to develop a rough approximation of the depth of the batholiths in the Ignace area, preliminary forward modelling was conducted by SGL (2015). The preliminary modelling used the newly acquired high-resolution geophysical data and readily available information on the mapped bedrock geology at surface to provide a preliminary interpretation of the geometry and subsurface extent of the batholiths and adjacent greenstone units. The preliminary modelling considered scenarios where the batholith are underlain by either greenstone belt units or gneissic basement bedrock with a lower bedrock density than the greenstone belt units to assess influence on estimated depths. Findings from the geophysical interpretation are discussed in an integrated manner in Section 5.

4.3 Lineament Interpretation

The purpose of the Phase 2 lineament interpretation was to provide an updated interpretation of the geological and structural characteristics of the potentially suitable bedrock units located within the survey areas, using the newly acquired high-resolution data. A magnetic and surficial lineament study was conducted for the survey areas using the high resolution magnetic and DEM data from the airborne survey, and purchased high resolution digital aerial imagery (SRK, 2015).

Lineaments are linear features that can be observed on remote sensing and geophysical data, and which may represent geological structures. The presence of these features at depth would need to be confirmed through further field studies such as detailed geological mapping and borehole drilling.

4.3.1 Lineament Interpretation Workflow

The lineament interpretation workflow was designed to limit issues of subjectivity and reproducibility that are inherent to lineament interpretations (SRK, 2015). The workflow follows a set of detailed guidelines involving three stages:

- Step 1: Independent lineament interpretation by two separate interpreters for each data set and assignment of certainty level (low, medium or high certainty);
- Step 2: Integration of lineament interpretations for each individual data set, and determination of reproducibility (i.e. presence of the same lineament within each data set (topography, aerial imagery, magnetic) as interpreted by each interpreter); and
- Step 3: Integration of lineament interpretations for the surficial data sets (topography and aerial imagery) followed by integration of the combined surficial data set with the magnetic data set, with determination of coincidence in each integration step.

Over the course of these three stages, a comprehensive list of attributes for each lineament was compiled (SRK, 2015). The key lineament attributes and characteristics used in the assessment include certainty, length, density and orientation:

- Lineament Certainty: Certainty (low, medium or high) was defined based on the clarity of the lineament interpreted in the data, which provides confidence in the feature being related to bedrock structure. For example, where a surface lineament could be clearly seen on exposed bedrock, it was assigned a certainty value of high. Where a lineament represented a bedrock feature that was inferred from linear features, such as orientation of lakes or streams or linear trends in texture, it was assigned a certainty value of either low or medium. For magnetic lineaments, a certainty value of high was assigned when a clear magnetic susceptibility contrast could be discerned and a certainty value of either low or medium was assigned when the signal was discontinuous or more diffuse. The certainty classification for all three data sets involved expert judgment and experience of the interpreter. For the purpose of this assessment, emphasis was put on lineaments interpreted with high and medium certainty.

- Lineament Length: Interpreted lineaments were classified according to their length, which is calculated based on the sum of all segment lengths that make up a lineament. It is assumed that longer interpreted lineaments may extend to greater depths than shorter interpreted lineaments. In general, longer interpreted lineaments also tend to have higher certainty values. For the purpose of the assessment, lineaments were classified according to four length bins (shorter than 1 kilometre, between 1 and 2.5 kilometres, between 2.5 and 5 kilometres, and longer than 5 kilometres).
- Lineament Density: The density of interpreted brittle lineaments was determined by examining the statistical density of individual lineaments using ArcGIS Spatial Analyst. A grid cell size of 50 metres and a search radius of 1.5 kilometres (equivalent to half the size of the longest boundary of the minimum area size of a potential siting area) were used for this analysis. The spatial analysis used a circular search radius examining the lengths of lineaments intersected within the circular search radius around each grid cell.
- Lineament orientation: The orientation of interpreted lineaments was expressed in degrees ranging between 0 and 180. Lineament sets are defined by direction clustering of the data. The number of identified lineament sets, and their variation in orientation, provides a measure of the complexity of the potential individual fractures or fracture zones.

The following sections provide a summary of interpreted lineaments. A more detailed analysis is provided in Section 5.3, and in SRK (2015).

4.3.2 Magnetic Lineaments

Magnetic lineaments were interpreted using the new high-resolution magnetic data, which provides a significant improvement to the overall resolution and quality of magnetic data compared with the data available during the Phase 1 preliminary assessment. Lineaments interpreted using the magnetic data are typically less affected by the presence of overburden than surficial lineaments, and more likely reflect potential structures at depth that may or may not have surficial expressions. Magnetic lineaments interpreted with medium and high certainty in the survey area are shown on Figure 4-5. In general, a lower density of magnetic lineaments is observed in the intrusive bodies such as the Revell, Indian Lake and Basket Lake batholiths than in the adjacent greenstone belts. A more detailed analysis of magnetic lineaments interpreted within the vicinity of each potentially suitable area is provided in Sections 5.3 and 6. An expanded view of interpreted magnetic lineaments for each area is shown in Section 5 (Figures 5-1, 5-3, 5-5 and 5-7).

4.3.3 Surficial Lineaments

Surficial lineaments were interpreted using newly acquired high resolution topographic data (DEM) from the airborne survey (SGL, 2015), and purchased high resolution digital aerial imagery (SRK, 2015). The digital aerial imagery data has a cell resolution of 0.4 m, which was a significant improvement compared to the lower resolution data (20 m) used during the Phase 1 preliminary assessment. Surficial lineaments were interpreted as linear traces along topographic valleys, escarpments, and drainage patterns such as river streams and linear lakes. These linear traces may represent the expression of fractures on the ground surface. However, it is uncertain what proportion of surficial lineaments represent actual geological structures and if so, whether the structures extend to significant depth. Figure 4-6 shows Phase 2 surficial lineaments interpreted for the Ignace area. The observed distribution and density of surficial lineaments is highly influenced by the presence of overburden cover and water bodies, which can mask the surface expressions of potential fractures. This is particularly evident in some parts of the Indian Lake and Basket Lake batholiths, which are covered by thick overburden deposits. The distribution of overburden is shown on Figure 4-7. A more detailed analysis of surficial lineaments interpreted within the vicinity of each potentially suitable area is provided in Sections 5.3 and 6. Interpreted surficial lineaments for each area are shown in Section 5 on Figures 5-2, 5-4, 5-6 and 5-8.

4.4 Observing General Geological Features (Initial Geological Mapping)

An initial geological mapping campaign was conducted by SRK and Golder in September 2014 to observe general geological features in the Ignace area (SRK and Golder, 2015). These observations were conducted at select locations to better understand the lay of the land and to confirm the presence and nature of key geological features in the area (e.g. Photographs 2 and 3), including: bedrock character (lithology, structure, magnetic susceptibility and rock strength); fracture character; bedrock exposure; and other surface constraints. A detailed description of the approach, methods and observations is provided by SRK and Golder (2015). This section provides an overview of the mapping planning, logistics and use of local and Traditional Knowledge. The findings from the initial observations are discussed in an integrated manner with findings from other initial Phase 2 field data throughout Section 5.

The four general potentially suitable areas identified in Phase 1 preliminary assessment were visited over a period of seven mapping days by two teams of two geologists, and with the aid of one local guide for logistical support. A total of 82 locations were observed during this period (Figure 4-8). Several GIS data sets were used as base maps for the Phase 2 initial geological mapping, including georeferenced historical geological outcrop mapping, high-resolution aerial imagery, and high-resolution geophysical data (SRK and Golder, 2015).

An initial geological mapping campaign was conducted by SRK and Golder in September 2014 to observe general geological features in the Ignace area (SRK and Golder, 2015). These observations were conducted at select locations to better understand the lay of the land and to confirm the presence and nature of key geological features in the area (e.g., Photographs 2 and 3), including: bedrock character (lithology, structure, magnetic susceptibility and rock strength); fracture character; bedrock exposure and other surface constraints. A detailed description of the approach, methods and observations is provided by SRK and Golder (2015). This section provides an overview of the mapping planning, logistics and use of local and Traditional Knowledge. The findings from the initial observations are discussed in an integrated manner with findings from other initial Phase 2 field data throughout Section 5.

Photograph 2: Observing General Geological Features in the Ignace Area

Photograph 3: Example of Biotite Granodiorite from the Basket Lake Batholith in the Ignace Area

4.4.1 Mapping Plans and Logistics

Planning of the Phase 2 initial geological mapping involved a review of all available information for the Ignace area, including access. The planning also included the development of a comprehensive list of source data, equipment and task requirements for the observation of the key geological features (SRK and Golder, 2015).

The observations incorporated the use of a digital data capturing method to allow for seamless integration of the observations into a GIS platform. In addition, hand-sized rock samples were collected to provide a representative example of the different rock types observed in the field. Field and sample magnetic susceptibility measurements were obtained from fresh surfaces of outcrop or from the rock samples using a KT-10 magnetic susceptibility meter. Preliminary geomechanical characterization of the bedrock was undertaken by means of a visual estimation of fracture spacing, primarily of joints, for block size determination and a simple field-based hammer test for intact rock strength (SRK and Golder, 2015).

The initial geological mapping in the Ignace area was conducted using 4X4 vehicle as the primary means of transportation. The Trans-Canada highway (Highway 17) passes through the centre of the Ignace area in an east-west orientation; Highway 599 runs northeast from its intersection with Highway 17 past the Cecil Lake area; and Highway 622 runs southwest from Highway 17 across the Revell batholith. A network of gravel surfaced logging and recreational roads extends off of these paved roads, although some of these roads are impassable to all but all-terrain vehicles (ATVs), and lands in the north-central Revell batholith remain inaccessible by currently existing roads (SRK and Golder, 2015).

Observations made during the initial geological mapping were generally consistent with previous mapping in the area (SRK and Golder, 2015; Golder, 2013). In addition, although observations generally confirmed the existing understanding of bedrock exposure in the area, exposed bedrock was encountered in the eastern portion of the Indian Lake batholith in an area that was previously identified as being completely covered by overburden (SRK and Golder, 2015, Golder, 2013).

4.4.2 Local and Traditional Knowledge Activities

As part of NWMO's promise to develop partnerships with First Nation and Métis people, there is a commitment to interweaving local Traditional Knowledge in all phases of NWMO's work. Traditional Knowledge involves all aspects of Aboriginal people's unique understanding, relationship and how they connect the land to their way of life. This unique understanding influences the way in which Aboriginal people use the land. Prior to the commencement of mapping activities, information sharing meetings and a ceremony involving NWMO staff and mapping contractors along with participating members of local Aboriginal communities took place. The ceremony reminded both participating members of the local Aboriginal and non-Aboriginal communities, contractors and NWMO staff that as humans we are dependent on the land for sustaining life.

Through their knowledge of the land, local Aboriginal and non-Aboriginal people greatly enhanced the planning of mapping activities. Meetings held provided an opportunity to work collaboratively on planning to ensure activities would be carried out in a manner that was respectful of the land and local trap lines. Open dialogue was maintained during the execution of mapping activities. To facilitate this open dialogue, local First Nation guides were hired to provide logistical support and to bring local knowledge of the land.

5.0 KEY GEOSCIENTIFIC CHARACTERISTICS

The following subsections provide an updated description of the key geoscientific characteristics that were used to identify areas for detailed geological mapping based on both the Phase 1 preliminary assessment and the newly acquired field data during initial Phase 2 field work. The updated description focuses on the general areas that were identified as potentially suitable in the Phase 1 Geoscientific Desktop Preliminary Assessment. These include the northern part of the Revell batholith, the southern part of the Basket Lake batholith, and the eastern and western portions of the Indian Lake batholith (Figure 1-2).

5.1 Bedrock Geology

The bedrock geology of the Ignace area was described in detail in the Phase 1 Geoscientific Desktop Preliminary Assessment based on publically available reports and geological maps, as well as from the Phase 1 geophysical interpretation (Golder, 2013; PGW, 2013). This section provides an updated description of the bedrock geology of each of the four general potentially suitable areas based on the integrated interpretation of Phase 2 field data.

5.1.1 Revell Batholith (Northern Portion)

The Revell batholith is an elongated, northwest-trending multiphase intrusion with an approximate surface area of 455 square kilometres (Figure 1-2). Previous geologic mapping and interpretation of existing geophysical data identified a number of compositionally variable intrusive phases within the batholith, the youngest of which includes a distinct oval-shaped signature in the magnetic data (Stone et al., 2007, 2011a, 2011b; PGW, 2013; SGL, 2015). This multi-phased intrusion was emplaced approximately 2.734 to 2.694 billion years ago (Larbi et al., 1998; Buse et al., 2010).

The high resolution magnetic data acquired as part of Phase 2 across the Revell batholith generally has a uniformly smooth and low character, with the distinct exception of an oval-shaped magnetic high area in the centre, with abundant internal variation (Figure 4-2; SGL, 2015). This pronounced, oval-shaped high magnetic response centered in the Revell batholith reflects a mapped distinct feldspar megacrystic phase with higher magnetite content (Stone et al. 2011a; PGW, 2013; SGL, 2015). Northwest of the oval-shaped feature, the Revell batholith shows a uniform, low magnetic response likely due to the low magnetic susceptibility of the rock. This was confirmed by magnetic susceptibility values measured during the preliminary geological mapping conducted as part of the initial Phase 2 field work (SRK and Golder, 2015).

Locally, in the northern part of the Revell batholith, a few west-northwest oriented linear magnetic highs occur that coincide with previously mapped Wabigoon dykes. The magnetic data does not provide any indications of additional dykes within this area (SRK, 2015).

The gravity data acquired as part of Phase 2 shows a predominantly low response throughout the Revell batholith. The gravity response transitions into a pronounced gravity high, with generally steep gradients, into the Raleigh Lake greenstone belt (Figure 4-3). The mapped boundaries of the Revell batholith are clearly defined by distinct highs in the horizontal derivative of the gravity data (SGL, 2015). The gravity data also shows an anomaly that is consistent with the mapped tonalite units to the west of the megacrystic phase. The boundary of the batholith is also well marked by a sharp change in magnetic amplitude and frequency across the boundary into the Raleigh Lake greenstone belt, largely due to the nature of the magnetic susceptibility contrasts between the units (Figure 4-2). This interpretation agrees with the mapped boundaries as presented by OGS (2011) and Stone et al. (2011a, b).

The initial field observations identified three lithologically distinct phases of the batholith that generally coincide with those distinguished by previous mapping (Stone et al., 2011a, 2011b) and those identified in the Phase 2 magnetic data (SGL, 2015). The phases identified during initial mapping included: the oval-shaped megacrystic phase in the centre of the batholith, an enveloping granodioritic phase, and a granodioritic to tonalitic phase that coincides with the northwesterly region of lowest magnetic response. The high magnetic susceptibility measured in the field in the megacrystic phase is attributed to the existence of magnetic minerals. The tonalite-granodiorite phase is crosscut by mafic dykes of the Wabigoon dyke swarm, and has a uniformly low magnetic susceptibility that appears to be principally attributable to a lack of magnetic minerals. A much higher magnetic susceptibility was measured for the crosscutting Wabigoon dykes. The enveloping granodioritic phase also exhibits a uniform low magnetic susceptibility that appears to be principally attributable to a lack of magnetic minerals. Near its contact with the megacrystic phase, the granodiorite shows strong silicification and recrystallization of quartz, as well as bleaching (SRK and Golder, 2015).

Szewczyk and West (1976) interpreted the Revell batholith (referred to as the Hodgson Intrusion by the authors) as a sheet-like intrusion with an estimated thickness of up to 1.6 kilometres. Updated preliminary modelling, including sensitivity analyses, using the higher resolution Phase 2 geophysical data (SGL, 2015) indicates that the Revell batholith may extend deeper, with depths estimated to be greater than 2.5 kilometres, and shows evidence of gradual thinning towards the northeast. The dip of the batholith contacts adjacent to the surrounding greenstone belt units is interpreted as near vertical on both sides (SGL, 2015).

5.1.2 Basket Lake Batholith

The Basket Lake batholith is a mostly granitoid (granodiorite to granite) intrusion with a surface area of approximately 420 square kilometres. No direct age information is available for this batholith. The batholith is primarily surrounded by foliated tonalite and lesser so by gneissic tonalite (Figure 1-2).

The Phase 2 magnetic data within the Basket Lake batholith and surrounding tonalite units has a pattern of uniform magnetic character, which continues southeast into the western portion of the Indian Lake batholith (Figure 4-2). The northwestern portion of the Basket Lake batholith within the survey area shows an area of high magnetic variability (Figure 4-2). The combined magnetic and gravity data in this area reveals the presence of additional geological complexity that may correspond to a previously unmapped sliver of greenstone belt material that was not identifiable with the resolution of data available during the Phase 1 assessment (Figures 4-2 and 4-3).

The observations made during preliminary geological mapping (SRK and Golder, 2015) confirm that the Basket Lake batholith, southeast of the area of high magnetic variability mentioned above, appears to be a single lithological domain of biotite-granodiorite. Field observations also indicate that, in agreement with previous mapping, the Basket Lake batholith is surrounded by a foliated tonalite unit, though it is perhaps narrower than shown on the existing bedrock geology map where it separates the Basket Lake batholith from the Indian Lake batholith (SRK and Golder, 2015; Figure 1-2).

A few west-northwest oriented linear magnetic highs have been interpreted as dykes (SRK, 2015), which pass through the southern edge of the batholith. Although these are parallel to the Wabigoon dykes mapped in the Revell batholith, these have not been previously mapped in the Basket Lake batholith. Kenora-Fort Frances dykes are mapped near the southeastern edge of the batholith but are not identifiable from the magnetic data. The magnetic data shows a few additional dykes along the northern boundary of the batholith (Figure 5-3; SRK, 2015).

The Phase 2 gravity data shows a southeast trending boundary that coincides generally well with the mapped southern edge of the Basket Lake batholith, which may be reflecting a change in bedrock lithology between the granite to granodiorite and the adjacent foliated tonalities, or a variation in thickness of the unit (Figure 4-3). A clear northwest-trending linear peak in the gravity data generally coincides with the mapped boundary between the tonalitic units south of the Basket Lake batholith and the Raleigh Lake greenstone belt. This boundary is also discernible in the magnetic data (Figures 4-2).

Based on preliminary modelling using the high-resolution geophysical data (SGL, 2015), the Basket Lake batholith has an estimated thickness of approximately 3.0 to 5.0 kilometres. Modelled thickness results indicate that this batholith thins towards the southeast, which is generally consistent with qualitative interpretations from the Phase 1 assessment (Golder, 2013), as well as previous modelling results from Szewczyk and West (1976) using low resolution datasets. Szewczyk and West (1976) previously estimated that the Basket Lake batholith has a greater thickness on the northwestern side of the intrusion (thickness of approximately 7.7 kilometres), and interpreted a thinning of the intrusion to 0.5 kilometres towards its southeastern edge. Their estimates were based on the assumption that the batholith may be underlain by gneissic bedrock. Based on similar assumptions, SGL (2015) estimated the depth of the Basket Lake batholith to be up to approximately 7.5 kilometres and thinning to approximately 3 kilometres towards its southeastern edge.

5.1.3 Indian Lake Batholith (Western and Eastern Portions)

The Indian Lake batholith is approximately 2.671 billion years old (Tomlinson et al., 2004) and mostly composed of biotite granodiorite. Previous geological mapping for the Indian Lake batholith suggests that the majority of this intrusion is compositionally uniform (Stone et al., 2007; Stone and Hallé, 2005). The Indian Lake batholith in the Ignace area covers a surface area of approximately 1,366 square kilometres (Figure 1-2).

As previously discussed (Section 5.1.2), the Phase 2 magnetic data within the western portion of the Indian Lake batholith has a pattern of uniform magnetic character, which continues northwest into the Basket Lake batholith (Figure 4-2). The eastern part of the Indian Lake batholith shows a slightly more variable magnetic response (Figure 4-2), which may represent different lithologies. However, initial field observations, at the few stations visited (Figure 4-8), characterized both the eastern and western parts of the Indian Lake batholith as a weakly foliated to massive granodiorite (SRK and Golder, 2015). The preliminary field mapping did not include direct investigation of any of the higher magnetic response regions within the eastern portion of the Indian Lake batholith.

A few west-northwest oriented linear magnetic highs have been interpreted as dykes within the Indian Lake batholith (SRK, 2015). One occurs parallel and adjacent to the Raleigh Lake greenstone belt, and extends through into the northwestern portion of the Revell batholith. This dyke is coincident with a mapped Wabigoon dyke (Figure 5-5). A similarly oriented dyke is interpreted in the eastern portion of the Indian Lake batholith.

The gravity data acquired as part of initial Phase 2 field work indicate a general low throughout the Indian Lake batholith, which contrasts with the high gravity of the Raleigh Lake greenstone belt. This contrast coincides with the mapped boundary between the two units (Figure 4-3). The boundary between the Indian Lake batholith and the surrounding tonalite units is not discernible in either the magnetic or gravity data (SGL, 2015).

Preliminary modelling using the high-resolution geophysical data (SGL, 2015), indicates that the Indian Lake batholith shallows from a depth of approximately 3.0 kilometres at its boundary with the tonalite in the northwest, to a depth of approximately 2.0 kilometres towards the southeast. Modelling in the eastern portion of the Indian Lake batholith indicates a depth that ranges from approximately 4.0 to 7.5 kilometres towards the south.

Previous modelling done by Szewczyk and West (1976) assumed a uniform thickness of 2 kilometres for the batholith, and assumed underlying gneissic bedrock with variable density. Other previous studies had also interpreted the Indian Lake batholith to be a sheet-like intrusion less than 2 kilometres thick (Everitt, 1999). Sensitivity analyses done by SGL (2015) also assumed the batholith is underlain by gneissic bedrock, but assuming a uniform density of the gneiss rather than uniform thickness of the batholith. The sensitivity analyses indicated that the batholith could thin to approximately 0.5 kilometres in its western portion and to approximately 0.8 kilometres towards the north.

5.1.4 Mafic Dykes in the Ignace Area

Two suites of mafic dykes have been mapped at the regional scale in the Ignace area, including west-northwest-trending Wabigoon dykes and northwest-trending Kenora-Fort Frances dykes (Figure 4-1). A series of en echelon Wabigoon dykes have been mapped to transect the northern part of the Revell batholith and the southwestern part of the Indian Lake batholith in a linear zone that extends from the western boundary of the Ignace area to the southeastern corner of the Ignace area. Kenora-Fort Frances dykes have been mapped in the area between the southeastern part of the Basket Lake batholith and the northwestern part of the Indian Lake batholith (Figure 4-1).

The Phase 2 lineament analysis identified 13 discrete linear magnetic highs that were interpreted as dyke lineaments with high certainty (SRK, 2015). These dyke lineaments are predominantly in a west-northwest orientation that is consistent with the orientation of the previously mapped dykes attributed to the Wabigoon suite (Figure 4-5). One of these west-northwest-trending dyke lineaments was interpreted in the eastern portion of the Indian Lake batholith, while several dyke lineaments were interpreted to cut across the southern margin of the Basket Lake batholith and extend just into the western part of the Indian Lake batholith. In addition, several dyke lineaments were interpreted to cut through the northern part of the Revell batholith and the southwestern margin of the Indian Lake batholith. These interpreted dyke lineaments are coincident with previously mapped Wabigoon dykes (Figure 4-5). The Kenora-Fort Frances suite of mapped dykes bisects the acute angle between interpreted west-northwest and north-northwest oriented lineaments. However, the Phase 2 lineament analysis did not identify the previously mapped Kenora-Fort Frances dykes (SRK, 2015).

The preliminary geological mapping observed several examples of the previously mapped dykes of the Wabigoon dyke suite in the northern part of the Revell batholith (SRK and Golder, 2015). Here, the dykes cut the tonalite-granodiorite phase of the Revell batholith, are fine-grained, and are composed of millimetre-scale biotite and amphibole. A high magnetic susceptibility was measured for the Wabigoon dykes during the preliminary geological mapping (SRK and Golder, 2015), which is consistent with their character in the magnetic data (SGL, 2015). The preliminary geological mapping did not observe any examples of Kenora-Fort Frances dykes in the area where there were previously mapped.

5.2 Structural Geology

For the purpose of identifying general potentially suitable areas and areas for additional field work, the preliminary assessments focused on assessing the presence and significance of major structural features such as faults and shear zones. Three major regional-scale faults have been mapped within and proximal to the Ignace area (Figure 1-2). These include the northeast-trending Finlayson-Marmion fault and the east-trending Washeibemaga Lake fault located approximately 35 kilometres southeast and 28 kilometres west of the Township of Ignace, respectively. In addition, an unnamed northeast-trending mapped fault occurs in the northwest corner of the Ignace area. The larger Quetico fault lies outside of the Ignace area, about 40 kilometres to the south. All of the mapped faults are outside of the survey area where high resolution geophysical data was acquired and interpreted (Figure 4-1).

The Finlayson-Marmion fault occurs as a broad zone of ductile deformation (Stone and Hallé, 1999), and transects the Indian Lake batholith beyond the eastern margin of the Ignace area (Figure 1-2). The Washeibemaga Lake fault is interpreted as a deep-seated structure curving from the east to the southeast through the Bending Lake greenstone belt (Stone, 2009; Stone, 2010). While the initial geological mapping did not include direct observation of any of these major structures, the fractures measured during the initial mapping represent the outcrop-scale manifestation of the regional-scale fracture pattern (SRK and Golder, 2015). Similar structural trends were also identified during the Phase 2 lineament interpretation. Additional results from the initial geological mapping and lineament interpretation are discussed below.

5.3 Lineament Analysis

This section provides an integrated analysis of interpreted lineaments (SRK, 2015) for each of the four general potentially suitable areas in the Ignace area, using the newly acquired high-resolution magnetic, topographic and aerial imagery data (Section 4.1).

For the purpose of the analysis, and as outlined in Section 6, magnetic lineaments with high and medium certainty were given emphasis in the analysis, as these lineaments are considered most likely to represent potential bedrock structures. Surficial lineaments were also considered, in particular, in areas where the overburden cover was low or non-existent, and in areas were the low magnetic susceptibility of the rock impacted the ability to interpret magnetic lineaments.

5.3.1 Revell Batholith (Northern Portion)

Magnetic lineaments of high and medium certainty interpreted in the northern part of the Revell batholith (SRK, 2015) are shown on Figure 5-1. The density of magnetic lineaments over the Revell batholith is variable. In the central megacrystic phase a relatively high density is associated with tight lineament spacing (less than 1 kilometre between lineaments) when medium and high certainty magnetic lineaments are considered. Within the megacrystic phase the spacing between magnetic lineaments with high certainty is similar (less than 1 kilometre), given that most of the magnetic lineaments in this area were attributed with high certainty. Similar lineament densities are evident off the southern end of the feldspar megacrystic phase.

Throughout the northwestern part of the batholith, magnetic lineament density is generally lower, with wider lineament spacing (up to 3 kilometres) when medium and high certainty magnetic lineaments are considered. When considering only high certainty lineaments, spacing is generally 5 kilometres or more. The lower magnetic lineament density in this northwestern area may be a reflection of the uniformly low magnetic response and low magnetic susceptibility, which can inhibit the magnetic contrast required to identify lineaments in the geophysical data set, rather than a lack of features. This is confirmed by field observations which measured low magnetic susceptibility values in this area (Section 5.1.1). As a result, there is some uncertainty in the interpreted magnetic lineament density in these areas. Length analysis of magnetic lineaments shows that long lineaments (greater than 2.5 kilometres) are irregularly distributed across the entire northern Revell batholith, and generally trend to the northwest, to the northeast and to a lesser degree to the north. The majority of shorter lineaments (i.e. those lineaments less than 2.5 kilometres in length) are primarily concentrated within and around the megacrystic phase, and exhibit variable orientations.

The extensive bedrock exposure in the northern portion of the Revell batholith makes surficial lineaments readily mappable. Surficial lineament density is generally uniform over the entire northern Revell batholith, with some local variability (Figure 5-2). Surficial lineament spacing is uniformly tight, generally less than 1 kilometre when medium and high certainty surficial lineaments are considered. This spacing increases to approximately 2.5 kilometres or less when only high certainty lineaments are considered. Long surficial lineaments (greater than 2.5 kilometres) are broadly distributed over the northern portion of the batholith, and in general display north, east, and northeast orientations. Short surficial lineaments are also broadly distributed, and exhibit northeast and northwest orientations (Figure 5-2). At this stage of the assessment, it is uncertain what proportion of the surficial lineaments represent real bedrock structures, and if so, how far they extend to depth, particularly the shorter lineaments.

Observations during the initial geological mapping (Section 4.4) identified predominantly west- to northwest-striking outcrop scale fractures throughout the tonalite-granodiorite phase of the Revell batholith, along with a set of horizontal joints (SRK and Golder, 2015). In the central megacrystic phase of the batholith, four steeply-dipping fracture sets were identified with northwest, northeast, north and west orientations, in addition to a set of sub-horizontal sheet joints. Excluding the sub-horizontal set, there is good agreement between the fracture orientations observed in the field in the northern Revell batholith and those identified in the Phase 2 lineament analysis. Some of the fractures were observed to exhibit fault offset and mineral alteration, in particular within and proximal to the megacrystic phase of the batholith. Northwest of the megacrystic phase, field observations suggest that bedrock is sparsely fractured (SRK and Golder, 2015). Field observations indicate that fracture density tends to decrease at distances greater than approximately 20 metres (locally up to 60 metres) from observed linear surficial features and dykes (SRK and Golder, 2015).

5.3.2 Basket Lake Batholith (Southern Portion)

The magnetic lineament density over the southern portion of the Basket Lake batholith is variable (Figure 5-3). Throughout the majority of the Basket Lake batholith (with the exception of the northwestern portion), magnetic lineament density is generally lower, associated with a well-defined pattern of west-northwest and north-northwest trending lineaments. Lineament spacing in this area is up to 2 kilometres when considering medium and high certainty lineaments. The spacing is up to 4 kilometres when considering only the highest certainty magnetic lineaments. In the northwest part of the survey area (Figure 5.3), higher density of magnetic lineaments is associated with a northeast trending curvilinear pattern of high variability in the magnetic data. The lineament analysis revealed the presence of this additional geological complexity that was not visible in the low resolution data available during the Phase 1 preliminary assessment. This area exhibits tight lineament spacing (less than 1 kilometre) when medium and high certainty magnetic lineaments are considered. A similar spacing is seen when only high certainty lineaments are considered. A higher lineament density is also identified in proximity to an interpreted set of west-northwest trending dykes that cut through the southern portion of the batholith (Figure 5-3). Length analysis of magnetic lineaments shows that long lineaments (i.e. those longer than 2.5 kilometres) are generally uniformly distributed across the southern portion of the Basket Lake batholith, with the exception of the higher density area to the northwest. The longer lineaments are predominantly northwesterly trending, except in the northwestern portion of the survey area where they exhibit a curvilinear pattern (Figure 5-3). The shorter lineaments (less than 2.5 kilometres in length) are generally bounded by the longer lineaments and tend to be northeasterly trending.

Surficial lineaments interpreted in the southern part of the Basket Lake batholith are shown on Figure 5-4. Similar to the magnetic lineament density, surficial lineament density is higher in the northwestern part of the survey area. Elsewhere, surficial lineament density is variable, but generally lower. Surficial lineament spacing in the northwestern part of the survey area is relatively tight (less than 0.5 kilometres between lineaments) when medium and high certainty surficial lineaments are considered. A wider spacing of approximately 2 kilometres is observed when considering only the highest certainty surficial lineaments. Throughout the rest of the Basket Lake batholith, surficial lineaments exhibit a spacing of less than 1 kilometre for medium and high certainty lineaments, and a wider spacing of up to 2.5 kilometres using only lineaments of high certainty. Both the longer and shorter surficial lineaments in the southern portion of the Basket Lake batholith trend predominantly to the northeast (Figure 5-4). The variable nature of both the surficial lineament density and spacing could be strongly influenced by overburden distribution and surface water coverage across the batholith. As a result, there is some uncertainty as to whether or not the surficial lineament interpretation is an accurate representation of bedrock structure in this area. At this stage of the assessment, it is uncertain what proportion of the surficial lineaments represent real bedrock structures and if so, how far they extend to depth, particularly the shorter lineaments.

Prominent broadly-spaced west-northwest and north-northwest trending magnetic lineaments (Figure 4-5), and tighter spaced northeast-trending surficial lineaments comprise a well-defined structural domain that extends continuously from the Basket Lake batholith into the western portion of the Indian Lake batholith. However, the northeast trending lineaments were not prominent in the magnetic data. The Phase 2 preliminary geological mapping observed fracture sets of all three orientations in both the Basket Lake batholith and the western portion of the Indian Lake batholith (SRK and Golder, 2015), as described below.

Field observations during the initial geological mapping identified three major outcrop-scale fracture sets trending broadly west-northwest to north, northeast and east-northeast, as well as a shallowly dipping to subhorizontal set, within the Basket Lake batholith. Excluding the sub-horizontal set, there is good agreement between the fracture orientations observed in the field in the Basket Lake batholith and those identified in the Phase 2 lineament analysis. However the northeast-trending set is more prominent in the field observations than in the lineament analysis. Fault observations in the Basket Lake batholith were sparse. Observed faults exhibit similar orientations as joints and include west-northwest to north-northwest, east-northeast and north-northeast striking faults of moderate to steep dip. Initial field observations found that the rock in the batholith was generally sparsely fractured to intact, except in some cases where fracture intensity was observed to be higher within approximately 20 to 50 metres of observed linear surficial features (SRK and Golder, 2015).

5.3.3 Indian Lake Batholith (Western and Eastern Portion)

Magnetic lineaments interpreted in the western and eastern parts of the Indian Lake batholith are shown on Figures 5-5 and 5-7, respectively. The magnetic lineament density is higher in the eastern portion than in the western portion of the batholith. In the western portion of the Indian Lake batholith the density of magnetic lineaments appears to be higher in close proximity to the greenstone belt. When medium and high certainty magnetic lineaments in the western part of the batholith are considered, the lineament spacing is up to approximately 2 kilometres, increasing up to 3.5 kilometres when only high certainty lineaments are considered. The eastern portion of the batholith exhibits similar (up to 2 kilometres) lineament spacing when medium and high certainty magnetic lineaments are considered. However, when considering only high certainty magnetic lineaments the spacing tends to be more variable than in the western part of the batholith, with a minor increase of up to approximately 2.5 kilometres between lineaments. When considering the lengths of the magnetic lineaments in the western and eastern parts of the batholith, the lineaments with lengths greater than 5 kilometres tend to be associated with a well-defined pattern of west-northwest and north-northwest trending lineaments as seen in the magnetic data. The shorter lineaments (i.e. those less than 2.5 kilometres) tend to be more variable in orientation and primarily terminate against, or are offset by, the longer lineaments (Figures 5-5 and 5-7).

Surficial lineaments interpreted in the western and eastern parts of the Indian Lake batholith are shown on Figures 5-6 and 5-8, respectively. Surficial lineaments in the western and eastern portions of the batholith show variable density that appears to be influenced by the distribution of overburden and surface water coverage. In the western portion of the batholith, the spacing of surficial lineaments is up to 1.5 kilometres when medium and high certainty lineaments are considered, and increases up to approximately 3 kilometres when only high certainty lineaments are considered. Medium and high certainty lineaments in the eastern portion of the Indian Lake batholith show a spacing of up to approximately 1 kilometre. When only high certainty lineaments are considered in this area, the spacing increases to about 2.5 kilometres. Long surficial lineaments (i.e. more than 2.5 kilometres) in the western and eastern portions of the Indian Lake batholith are predominantly northeast-trending, but there are also numerous west-northwest trending surficial lineaments in proximity to the Raleigh Lake greenstone belt. At this stage of the assessment, there is some uncertainty as to what proportion of surficial lineaments represent bedrock structure, and if so, whether these structures extend to depth, particularly the shorter lineaments.

As described in Section 5.3.2, the northeast trending surficial lineaments were not prominent in the magnetic data. However, the Phase 2 preliminary geological mapping observed fracture sets of all three orientations in both the Basket Lake batholith and the western portion of the Indian Lake batholith (SRK and Golder, 2015).

Field observations during the initial geological mapping identified three outcrop-scale fracture sets trending west to northwest, north-northwest to north-northeast and northeast- to east-northeast within the Indian Lake batholith, and an additional subhorizontal to shallowly-dipping set. Two prominent fault sets are observed: one set is subvertical and strikes approximately north, the other set is subvertical and strikes west-northwest. Both of these orientations overlap with the orientations of identified joint sets. Excluding the sub-horizontal set, there is good agreement between the fracture orientations observed in the field in the Indian Lake batholith and those identified in the Phase 2 lineament analysis. In particular, the prominent west-northwest and north-northwest orientations are distinct in both the field observation data set and lineament analysis. Initial field observations found that the rock in the batholith was generally sparsely fractured to intact, except in some cases where fracture intensity was observed to be higher within generally less than 20 m from observed linear surficial features (SRK and Golder, 2015).

5.4 Bedrock Exposure

The distribution and thickness of overburden cover is an important site characteristic to consider when assessing amenability to site characterization of an area. At this stage of the assessment preference was given to areas with greater mapped bedrock exposures. The extent of bedrock exposure in the Ignace area is shown on Figure 4-7. Areas mapped as bedrock terrain are assumed, based on initial field observations, to be covered, at most, with a thin veneer of overburden and are therefore considered amenable to geological mapping.

Phase 2 preliminary geological mapping (SRK and Golder, 2015) confirmed the presence of generally good bedrock exposure across the identified general potentially suitable area of the Revell batholith. Few heavily vegetated areas of the Revell batholith exhibit a thick moss cover. The initial field work confirmed that there is highly variable bedrock exposure in the Basket Lake batholith area, with some areas nearly completely covered by glacial sediments and areas of exposure on elongated ridges and around some lakes. Field observations also showed highly variable bedrock exposure across the eastern and western portions of the Indian Lake batholith. Although observations generally confirmed the existing understanding that bedrock exposure in the eastern area was relatively poor, exposed bedrock was encountered in an area that was previously identified as being completely overburden covered. Much of the western portion of the Indian Lake batholith is characterized by a low degree of exposed bedrock, with some notable exceptions in the Butler Quarry and some areas along Highway 17. Two very large glacial moraines, the Hartman and Lac Seul moraines, traverse the Ignace area in a west-northwest direction, and several eskers are also mapped. The preliminary geological mapping indicated that lakeshores in the Ignace area may have the highest potential for continuous bedrock exposure for the purpose of geological mapping (SRK and Golder, 2015).

5.5 Protected Areas

All provincial parks, conservation reserves and provincial nature reserves in the Ignace area were excluded from consideration (Golder, 2013). The largest protected areas in the Ignace area include the Turtle River-White Otter Lake Provincial Park (368 square kilometres) and the Campus Lake Conservation Reserve (194 square kilometres) (Figure 1-1). Other protected areas include the Sandbar Lake and East English River Provincial Parks and the Bonheur River Kame Provincial Nature Reserve, which cover relatively small portions of the Indian Lake batholith (Golder, 2013). The preliminary Phase 2 assessment reaffirmed that the identified areas are outside of these protected areas.

5.6 Natural Resources

Areas with known potential for exploitable natural resources such as the rocks of the greenstone belts were excluded from further consideration for the identification of potentially suitable areas (Golder, 2013). All granitoid intrusions in the Ignace area have low potential for economically exploitable natural resources. In addition to the information gathered during the Phase 1 preliminary assessment (Golder, 2013), the newly acquired Phase 2 geophysical data (SGL, 2015) was used to identify geophysical anomalies that may be indicative of rock units that have mineral potential.

In the northwestern portion of the Basket Lake batholith in the survey area, the combined magnetic and gravity data reveals the presence of additional geological complexity that may correspond to a previously unmapped sliver of greenstone belt material that was not identifiable with the resolution of data available during the Phase 1 assessment (Figures 4-2 and 4-3).

In addition to the information gathered during the Phase 1 preliminary assessment (Golder, 2013), the mineral resources and claim maps were updated as part of the initial Phase 2 assessment (Figure 5-9). There are no mineral claims in the general potentially suitable areas, except one claim in the western portion of the Indian Lake batholith. Quarrying of building stone is known to have occurred in the Indian Lake batholith, along Highway 17, west of the Township of Ignace (Figure 5-9). At this stage of the assessment, areas of active mining claims located in geologic environments judged to have low mineral resource potential were not systematically excluded from consideration as candidate areas for detailed mapping.

5.7 Potential Surface Constraints

Areas of obvious topographic constraints (high density of steep slopes), large water bodies (wetlands, lakes), and areas of poor accessibility were documented. While areas with such constraints were not explicitly excluded from consideration as a candidate area for detailed mapping, they are identified as potential surface constraints that would need to be considered when planning future field studies. Distribution of large lakes in the Ignace area is variable (Figure 1-1). Certain portions of the Indian Lake and Basket Lake batholiths have extensive lake cover. While lake coverage is generally considered a constraint for conducting detailed mapping, initial field work (SRK and Golder, 2015) has confirmed that lake shores provide some of the best bedrock exposures in the Ignace area for the purpose of geological mapping. Topography in the Ignace area is generally subdued, although considerable relief (>100 m) is observed between lakes in some areas.

Preliminary geological mapping conducted as part of initial Phase 2 field work documented that access and surface constraints vary across the Revell batholith (SRK and Golder, 2015). Highway 622 passes through the centre of the batholith, transecting the megacrystic phase (Figure 1-2). Many subsidiary logging roads extend to the west and east off of this main corridor, and were generally found to be passable. The northwestern (magnetically quiet) zone of the Revell batholith is more difficult to access. There are no logging roads and only a few large lakes. River systems are navigable by canoe but rapids make portaging power boats difficult. There may be the potential for fixed-wing floatplane or helicopter access to many of the remote lakes that are otherwise particularly difficult to reach. Preliminary geological mapping (SRK and Golder, 2015) found that for the Basket Lake batholith, access is moderately good along the existing network of logging roads. In addition, it is possible to put a boat in at several different locations to access the extensive shorelines. Highway 17 extends through the western area of the Indian Lake batholith and local roads north and south of the highway can be used to access the rest of this part of the batholith. The eastern portion of the Indian Lake batholith is accessible via Highway 599, and a network of logging roads. There is also a boat launch for access to Cecil Lake. Logging roads to the south and southeast of Cecil Lake were accessible by vehicle, whereas smaller roads to the north of Cecil Lake were overgrown and could only be accessed on foot (SRK and Golder, 2015).

6.0 CANDIDATE AREAS FOR DETAILED GEOLOGICAL MAPPING IN THE IGNACE AREA

This section describes how the key geoscientific characteristics and constraints described in Section 5 were applied to further assess the suitability of the Ignace area, and determine whether it is possible to identify candidate areas for further field studies, beginning with detailed geological mapping. The assessment was conducted in a systematic and iterative manner based on the updated understanding of the key geoscientific characteristics and constraints discussed in Section 5, using the following general approach:

a) Bedrock Geology: Identify areas with the most favourable geological setting in terms of rock type, lithology and homogeneity, using the newly interpreted magnetic and gravity data, as well as initial field observations. The estimated depth and extent of the potentially suitable host rock formations were also considered.
b) Structural Geology: Refine the location and extent of the areas based on updated understanding of the structural geology based on the newly interpreted magnetic, gravity and lineament data, as well as initial field observations. The refinements were focused on identifying bounding structures that could potentially define favourable rock volumes, taking into account the nature and complexity of prominent structural geological features in the area such as faults, dykes, shear and deformation zones, and geological boundaries.
c) Lineament Analysis: Use lineament analysis (geophysical and surficial) to identify most favourable structural domains for hosting a repository, using the following approach:
    - Identify areas with lower lineament density, as these areas have a higher potential to contain structurally favourable rock volumes for hosting a repository. In identifying the potentially suitable areas, emphasis was put on magnetic lineaments, as their interpretation is relatively unaffected by the presence of overburden. Surficial lineaments were also considered, particularly in areas with greater bedrock exposure and/or areas with low magnetic susceptibility of the rocks.
    - Emphasis was also put on lineaments which were interpreted as high and medium certainty, and on longer lineaments as they are considered more likely to extend to greater depth.
    - At this stage of the assessment, all interpreted lineaments were conservatively assumed to be potentially permeable features (i.e. hydraulically conductive), noting that many of these interpreted lineaments may be sealed due to the higher rock stresses at depth and/or the presence of mineral infillings.
d) Protected Areas: The general potentially suitable areas identified in the Phase 1 preliminary assessment were all outside protected areas such as provincial parks, conservation reserves and provincial nature reserves (Golder, 2013). The initial Phase 2 assessment reaffirmed that identified candidate areas for detailed geological mapping are outside of these protected areas.
e) Natural Resources: In addition to the information gathered during the Phase 1 preliminary assessment (Golder, 2013), the newly acquired Phase 2 geophysical data were used to identify geophysical anomalies that may be indicative of rock units that have mineral potential. Mineral resources and claim maps were also updated as part of the initial Phase 2 assessment.

f) Overburden: The distribution and thickness of overburden cover is an important site characteristic to consider when assessing amenability to site characterization of an area. At this stage of the assessment, preference was given to areas with better bedrock exposure, as indicated by available Quaternary mapping (Golder, 2013) and by preliminary field observations, as these areas are more amenable to detailed geological mapping.
g) Potential Surface Constraints: Areas of obvious topographic constraints (high density of steep slopes), large water bodies (wetlands, lakes), and accessibility are identified as potential constraints that would need to be considered in the selection of a repository site. Accessibility was documented during preliminary geological mapping (SRK and Golder, 2015), noting that large lakes have been included in some of the areas as they provide opportunities for detailed mapping at exposed bedrock locations along their shorelines.

The iterative consideration of the above key geoscientific characteristics and constraints revealed that the Ignace areas contains a number of candidate areas that warrant further studies, beginning with detailed geological mapping. These candidate areas are located in the general potentially suitable areas identified in the Phase 1 desktop preliminary assessment, within and in the vicinity of the four withdrawn areas shown on Figure 1-2. The extent of these candidate areas will be further refined after the detailed geological mapping is completed. Figures 6.1 to 6.4 show interpreted magnetic lineaments with high and medium certainty, as well as other geoscientific characteristics and constraints such as geology, protected areas, water bodies, and active mining claims for each withdrawn area, in the northern portion of the Revell batholith, the southern portion of the Basket Lake batholith and the western and eastern portions of the Indian Lake batholith, respectively. The legend in each figure shows a 2 by 3 kilometre box which illustrates the approximate required underground repository footprint.

The following sections provide the rationale for selecting candidate areas for further study in each of the three batholiths in the Ignace area. Remaining geoscientific uncertainties that would need to be addressed in future studies are also described.

6.1 Candidate Area for Detailed Geological Mapping in the Revell Batholith

The candidate area identified for further study in the Revell batholith is located in the northern portion of the withdrawn area shown on Figure 6-1. It is located in the northern part of the batholith which was identified as potentially suitable in Phase 1 desktop assessment. The candidate area was identified for its fairly uniform magnetic response compared to the rest of the batholith (Section 5.1.1 and Figure 4-2). The megacrystic phase of the batholith in the southern part of the withdrawn area was avoided since it shows a generally higher degree of structural complexity (Figures 4-2 and 6-1). Based on available information and the gravity modelling conducted as part of this assessment, the Revell batholith has an estimated thickness of greater than 2.5 kilometres (SGL, 2015), which is sufficient for the purpose of a deep geological repository.

The general location of the identified candidate area in the Revell batholith was also guided by the density of interpreted magnetic lineaments, as well as the density of longer surficial lineaments, which are more likely to exist at depth. As shown on Figure 6-1 and discussed in Section 5.3.1, the density of magnetic lineaments in the selected area is generally lower than in other areas of the batholith. Spacing between magnetic lineaments with high and medium certainty is up to 2.5 kilometres, which could indicate the existence of large, structurally bounded rock volumes that are favourable for hosting a deep geological repository. However, the lower density of magnetic lineaments may be a reflection of the uniformly low magnetic response in the northwestern area of the Revell batholith rather than a lack of structural features (Figure 4-2). A low magnetic response can inhibit the magnetic contrast required to identify lineaments in the geophysical data set. The low magnetic susceptibility of the rock in the northwestern area of the Revell batholith was confirmed through field measurements during the initial geological mapping conducted as part of this assessment (SRK and Golder, 2015).

As shown on Figure 5-2 and discussed in Section 5.3.1, the density of surficial lineaments in the candidate area is uniform, and similar to other areas of the batholith. However, the area contains relatively few long surficial lineaments. The spacing between surficial lineaments longer than 5 kilometres is roughly 2 to 4 kilometres. Field observations during the preliminary geological mapping (Section 5.3.1; SRK and Golder, 2015) found the rock to be generally sparsely fractured, except in proximity to observed linear surficial features. A set of horizontal sheet joints (SRK and Golder, 2015) was also observed. In addition, a few west-northwest trending dykes have been interpreted (SRK, 2015) and mapped as part of the Wabigoon dyke suite in the northernmost part of the candidate area (Section 5.1.4).

There is generally good road access to the identified candidate area via a network of logging roads, except for its western part, which is considerably less accessible by vehicle using existing roads (Figure 1-2). Overall, the candidate area is amenable to detailed geological mapping as it is has good bedrock exposure, with some overburden deposits along the northwest side of the area (Figure 4-7; SRK and Golder, 2015). The area contains only a few small lakes and is outside of protected areas. With respect to natural resource potential, there are numerous mineral occurrences along the contact zone between the Revell batholith and the Raleigh Lake greenstone belt, but not within the candidate area (Figure 5-9). There are no active mining claims in the candidate area.

In summary, the assessment identified a candidate area for further study. The area is located within the northern half of the withdrawn area in the Revell batholith. The candidate area appears to have favourable geoscientific characteristics. However, it is still uncertain whether the low density of interpreted magnetic lineaments is indicative of the absence of geological structures or is simply due to the low magnetic susceptibility of the rock in the area. This would need to be assessed through more detailed geological mapping, and ultimately through borehole drilling, if the area is considered for further studies. Another particular feature that would need to be assessed in the future is whether or not shallowly-dipping fractures observed at the surface occur at depth, or are simply a result of near surface exfoliation in the area.

6.2 Candidate Area for Detailed Geological Mapping in the Basket Lake Batholith

The candidate area identified for further study in the Basket Lake batholith is located within the southern half of the withdrawn area shown on Figure 6-2. The candidate area also extends to the southeast into the adjacent tonalitic units outside of the southern boundary of the withdrawn area.

The Phase 2 magnetic data over the candidate area in the southern part of the Basket Lake batholith exhibits a uniform pattern which continues southeast into the western portion of the Indian Lake batholith (Figure 4-2). The southern portion of the Basket Lake batholith was preferred primarily for its favourable structural character. This portion of the batholith is overprinted by a well-defined network of long magnetic lineaments that exhibit wide spacing between west-northwest and north-northwest lineaments (Section 5.1.2, Figure 4-2). These two orientations were also observed during the Phase 2 preliminary geological mapping (SRK and Golder, 2015).

However, the magnetic data does not clearly show a northeast-trending fracture set that was observed during the preliminary geological mapping, as well as in the surficial lineament interpretation.

Previous gravity modelling using low-resolution gravity data estimated the thickness of the Basket Lake batholith to be approximately 7.7 kilometres on the northwestern side of the intrusion, and thinning to 0.5 kilometres towards its southeastern edge. Based on gravity modelling conducted as part of this assessment using the new high-resolution gravity data, the thickness of the Basket Lake batholith is estimated to be greater than 3 kilometres (SGL, 2015) although this would need to be confirmed during future studies.

The northern half of the withdrawn area in the Basket Lake batholith was avoided because of its higher magnetic variability (Figure 4-2). The combined magnetic and gravity data in this area reveals the presence of additional geological complexity that may correspond to a previously unmapped sliver of greenstone belt material. In addition, this area exhibited a relatively higher magnetic lineament density (Figure 6-2).

The general location of the candidate area in the Basket Lake batholith was further refined using interpreted magnetic lineaments. Surficial lineaments were not considered as key factors to identify the candidate area as they are masked by the presence of overburden coverage and large water bodies (Figure 4-7). As shown on Figure 6-2 and discussed in Section 5.3.2, magnetic lineament spacing in the candidate area is up to 2 kilometres when considering medium and high certainty lineaments, which could indicate the existence of large structurally bounded rock volumes that are favourable for hosting a deep geological repository. The spacing is up to 4 kilometres when considering only the highest certainty magnetic lineaments. This is consistent with field observations, which found that the rock in the area was generally sparsely fractured to intact, except in proximity to observed linear surficial features (Section 5.3.2; SRK and Golder, 2015). Observations during preliminary geological mapping identified a set of horizontal sheet joints (SRK and Golder, 2015). In addition, several west-northwest trending Wabigoon dykes were interpreted along the southern boundary of the candidate area (Section 5.1.4; SRK, 2015).

The candidate area identified in the Basket Lake batholith is outside of protected areas and is generally accessible via a sparse network of logging roads (Section 5.7). Large water bodies in the area include Abamategwia Lake and a portion of Basket Lake. There is a moderate amount of bedrock exposure, predominately through the central and eastern portion of the area. There are no known mineral occurrences or active mining claims in the candidate area in the Basket Lake batholith (Figure 5-9). However, in the northwestern portion of the Basket Lake batholith north of the candidate area, the magnetic pattern may correspond to a previously unmapped sliver of greenstone belt that may have higher natural resource potential (Section 5.6).

The main geological uncertainty in the candidate area for detailed geological mapping in the Basket Lake batholith is related to the presence of overburden cover in certain parts of the area. The presence of thick overburden and scarcity of bedrock exposure in some parts of the area may limit the ability to carry out detailed geological mapping activities. In addition, the thickness of the southern portion of the Basket Lake batholith would also need to be further assessed. A particular feature that would need to be assessed in the future is whether or not shallowly-dipping fractures evident at the surface in the area occur at depth, or are a result of near-surface exfoliation in the area.

6.3 Candidate Area for Detailed Geological Mapping in the Western Portion of the Indian Lake Batholith

The candidate area identified for further study in the western portion of the Indian Lake batholith is located within the northern half of the withdraw area shown on Figure 6-3. The candidate area also extends to the northeast into the adjacent tonalitic units outside of the northeastern corner of the withdrawn area.

As discussed in Section 5.1.3, the Phase 2 magnetic data shows that the western portion of the Indian Lake batholith and the southern part Basket Lake batholith appear to be in the same structural domain, exhibiting a well-defined network of widely-spaced linear structural features. Therefore, the preferred area for detailed geological mapping in the western part of the Indian lake batholith was identified using the same approach used for the southern part of the Basket Lake batholith (Section 6.2). Similar to the Basket Lake batholith, the northeast-trending surficial lineaments were not prominently observed in the magnetic data for the western portion of the Indian Lake batholith. Based on available information and the gravity modelling conducted as part of this assessment (Section 5.1.3), the western portion of the Indian Lake batholith has a thickness of greater than 2 kilometres (SGL, 2015). However, a sensitivity analysis 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. This would need to be further assessed in the future.

The general location of the candidate area in the western portion of the Indian Lake batholith was further refined using interpreted magnetic lineaments. Surficial lineaments were not considered as they are masked by the presence of overburden coverage and large water bodies in many areas (Figure 4-7). As shown on Figure 6-3 and discussed in Section 5.3.3, magnetic lineament spacing in the candidate area is up to approximately 2 kilometres when considering medium and high certainty lineaments. The spacing is up to 3.5 kilometres when considering only the highest certainty magnetic lineaments. This is consistent with field observations, which found that the rock in the area was generally sparsely fractured to intact, except in proximity to observed linear surficial features (Section 5.3.3; SRK and Golder, 2015). Observations during preliminary geological mapping identified a set of horizontal sheet joints (SRK and Golder, 2015).

The candidate area in the western portion of the Indian Lake batholith is outside of protected areas and is readily accessible via a network of logging roads. The area includes some large water bodies, and has a mixture of exposed bedrock terrain and overburden deposits (Figure 4-7). Quarrying of building stone is known to have occurred in the Indian Lake batholith, along Highway 17 west of the Township of Ignace (Figure 5-9). There is currently one active claim in the area, however the potential for economically exploitable natural resources in the Indian Lake batholith is considered to be low.

The main geological uncertainty in the candidate area for detailed geological mapping in the western portion of the Indian Lake batholith is related to the presence of overburden cover over a significant portion of the area. The presence of thick overburden and scarcity of bedrock exposure in some parts of the area may limit the ability to carry out detailed geological mapping activities. In addition, the thickness of the western portion of the Indian Lake batholith would also need to be further assessed. A particular feature that would need to be assessed in the future is whether or not shallowly-dipping fractures evident at the surface in the area occur at depth, or are simply a result of near-surface exfoliation in the area.

6.4 Candidate Area for Detailed Geological Mapping in the Eastern Portion of the Indian Lake Batholith

The candidate area identified for further study in the eastern portion of the Indian Lake batholith is located within most of the central portion of the withdrawn area shown on Figure 6-4. The candidate area also extends slightly to the northwest and southeast outside the northern and southern boundaries of the withdrawn area.

As discussed in Section 5.1.3 and shown on Figure 4-2, the magnetic data over the eastern portion of the Indian Lake batholith shows a slightly more variable magnetic response compared to the rest of the batholith, but is also overprinted by a network of widely spaced faults and a minor presence of dykes.

The general location of the candidate area in the eastern portion of the Indian Lake batholith was primarily identified using interpreted magnetic lineaments. Surficial lineaments were not considered as key factors to identify the candidate area they are masked by the presence of overburden coverage and large water bodies in many areas (Figure 4-7). Figure 6-4 shows that the central portion of the withdrawn area contains several large, structurally-bounded blocks with fewer, long magnetic lineaments. Figure 6-4 also shows that the magnetic lineament spacing in the candidate area is up to approximately 2 kilometres when considering medium and high certainty lineaments. The spacing is up to 2.5 kilometres when considering only the highest certainty magnetic lineaments. This is consistent with field observations, which found that the rock in the area was generally sparsely fractured to intact, except in proximity to observed linear surficial features (Section 5.3.3; SRK and Golder, 2015). Observations during the preliminary geological mapping also identified a set of horizontal sheet joints (SRK and Golder, 2015).

The magnetic data over the candidate area shows a similar variable magnetic response as the western portion of the batholith, with the exception of some areas with a slightly more variable magnetic response (Figure 4-2), which may represent different lithologies (SGL, 2015). The preliminary gravity modeling estimates that the eastern portion of the Indian Lake batholith has a thickness of greater than 4 kilometres. However, a sensitivity analysis suggests that the batholith could thin to 0.8 kilometres north of the identified candidate area (Section 5.1.3; SGL, 2015).

The candidate area is outside of protected areas and is readily accessible via Highway 559 and a network of logging roads (Section 5.7). There is significant overburden cover in many areas and large water bodies, such as Cecil Lake, are present. However, preliminary geological mapping identified exposed bedrock in an area that was previously identified as being completely overburden covered (Section 5.4). Preliminary geological mapping also indicated that lakeshores in the area may have the highest potential for continuous bedrock exposure for detailed geological mapping (SRK and Golder, 2015). With respect to natural resource potential, there are no known mineral occurrences in the area in the eastern portion of the Indian Lake batholith (Figure 5-9).

The main geological uncertainty that would need to be further assessed for the candidate area in the eastern portion of the Indian Lake batholith relates to the presence of overburden cover over a significant portion of the area. The presence of thick overburden and scarcity of bedrock exposure in some parts of the area may limit the ability to carry out detailed geological mapping activities. In addition, the thickness of the eastern portion of the Indian Lake batholith would also need to be further assessed. A particular feature that would need to be assessed in the future is whether or not shallowly-dipping fractures evident at the surface occur at depth, or are simply a result of near-surface exfoliation in the area.

6.5 Other Potential Areas in the Ignace Area

In addition to the four candidate areas identified for further field study, there are other areas in the Indian Lake and Basket Lake batholiths that could also be potentially suitable. However, at this stage of the assessment, the identified candidate areas are those judged to have more favourable geoscientific characteristics based on available information.

7.0 SUMMARY OF INITIAL PHASE 2 GEOSCIENTIFIC FINDINGS FOR THE IGNACE AREA

This report provides the findings of the initial Phase 2 geoscientific studies conducted in the Ignace area in 2014. These studies were conducted to advance understanding of the geology in the Ignace area, and to assess whether it is possible to identify potentially suitable candidate areas for further field studies, beginning with detailed geological mapping. The assessment included the following key activities:

- Acquisition and processing of high-resolution airborne geophysical (magnetic and gravity) data over the four general areas identified in Phase 1 Geoscientific Desktop Preliminary Assessment;
- Detailed interpretation of high-resolution gravity and magnetic data to better understand the bedrock geology such as geological contacts, depth and extent of rock units, lithological and structural heterogeneity;
- Detailed interpretation of surficial and magnetic lineaments using newly acquired high-resolution remote sensing and magnetic data to identify possible structural features such as fractures, shear zones and dykes; and
- Observation of general geological features to confirm/ground truth geologic characteristics, including lithology, structures, bedrock exposures and surface constraints.

The interpretation and analysis of the new Phase 2 data and field observations increased confidence in the potential for finding a repository site that would ultimately satisfy NWMO’s geoscientific site evaluation factors in the Ignace area.

The assessment identified four potential areas that could be considered for further geoscientific studies, beginning with detailed geological mapping. These areas appear to have favourable geoscientific characteristics such as relatively homogenous lithology, a relatively low density of interpreted subsurface fractures, and potentially sufficient volumes of competent rock. The four potential areas are located in the northern portion of Revell batholith, the southern portion of the Basket lake batholith, and the western and eastern portions of the Indian Lake batholith.

While the identified candidate areas appear to have favourable geoscientific characteristics for hosting a deep geological repository, there remain a number of uncertainties that would need to be addressed during subsequent stages of the site evaluation process through detailed geological mapping, and ultimately borehole drilling. Main uncertainties include the presence of overburden cover over some parts of the areas; the thickness of the Basket Lake and Indian Lake batholiths in the areas of interest; the interpreted magnetic lineament density in the northern portion of the Revell batholith due to the impact of the lower magnetic response in this area; and the potential presence of shallow-dipping fractures at repository depth.

8.0 REFERENCES

Buse, S., D. Stone, D. Lewis, D. Davis and M.A. Hamilton, 2010. U/Pb Geochronology Results for the Atikokan Mineral Development Initiative; Ontario Geological Survey, Miscellaneous Release Data 275.

Everitt, R.A., 1999. Experience Gained from the Geological Characterization of the Lac du Bonnet Batholith, and Comparison with Other Sparsely Fractured Granite Batholiths in the Ontario Portion of the Canadian Shield. OPG Report 06819-REP-01200-0069-R00. Toronto, Canada.

Golder (Golder Associates Ltd.), 2011. Initial Screening for Siting a Deep Geological Repository for Canada's Used Nuclear Fuel. The Corporation of the Township of Ignace, Ontario. Prepared for Nuclear Waste Management Organization (NWMO). Golder Report 10-1152-0110(2000B). Mississauga, Canada.

Golder (Golder Associates Ltd.), 2013. Phase 1 Desktop Geoscientific Preliminary Assessment of Potential Suitability for Siting a Deep Geological Repository for Canada's Used Nuclear Fuel, Township of Ignace, Ontario. Prepared for Nuclear Waste Management Organization (NWMO). NWMO Report APM-REP-06144-0011. Mississauga, Canada.

Larbi, Y., R. Stevenson, F. Breaks, N. Machado and C. Gariepy, 1998. Age and Isotopic Composition of Late Archean Leucogranites: Implications for Continental Collision in the Western Superior Province. Canadian Journal of Earth Sciences 36, pp.495-510.

NWMO (Nuclear Waste Management Organization), 2010. Moving Forward Together: Process for Selecting a Site for Canada's Deep Geological Repository for Used Nuclear Fuel. Toronto, Canada. (Available at www.nwmo.ca)

NWMO (Nuclear Waste Management Organization), 2013. Preliminary Assesment for Siting a Deep Geological Repository for Canada's Used Nuclear Fuel - Township of Ignace, Ontario - Findings from Phase One Studies. NWMO Report APM-REP-06144-0009. Toronto, Canada.

PGW (Patterson, Grant and Watson Ltd.), 2013. Phase 1 Geoscientific Desktop Preliminary Assessment, Processing and Interpretation of Geophysical Data, Township of Ignace, Ontario. Prepared for Nuclear Waste Management Organization (NWMO). NWMO Report APM-REP-06144-0013.

SGL (Sander Geophysics Ltd.), 2015. Phase 2 Geoscientific Preliminary Assessment, Acquisition, Processing and Interpretation of High-Resolution Airborne Geophysical Data, Township of Ignace, Ontario. Prepared for Nuclear Waste Management Organization (NWMO). NWMO Report APM-REP-06145-0002. Toronto, Canada.

SRK (SRK Consulting Inc.), 2015. Phase 2 Geoscientific Preliminary Assessment, Lineament Interpretation, Township of Ignace, Ontario. Prepared for Nuclear Waste Management Organization (NWMO). NWMO Report APM-REP-06145-0003. Toronto, Canada.

SRK (SRK Consulting Inc.) and Golder (Golder Associates Ltd.), 2015. Phase 2 Geoscientific Preliminary Assessment, Observation of General Geological Features, Township of Ignace, Ontario. Prepared for Nuclear Waste Management Organization (NWMO). NWMO Report APM-REP-06145-0004. Toronto, Canada.

Stone, D., 2009. Geology of the Bending Lake Area, Northwestern Ontario. In Summary of Field Work and Other Activities 2009. Ontario Geological Survey, Open File Report 6240, 14-1 to 14-7. Sudbury, Canada.

Stone, D. 2010. Geology of the Stormy Lake Area, Northwestern Ontario, Project Unit 09-003. In Summary of Field Work and Other Activities 2010. Ontario Geological Survey, Open File Report 6260, 13-1 to 13-12. Sudbury, Canada.

Stone, D., B. Hellebrandt and M. Lange, 2011a. Precambrian Geology of the Bending Lake Area (South Sheet). Ontario Geological Survey, Preliminary Map P.3623, Scale 1:20 000. Sudbury, Canada.

Stone, D., B. Hellebrandt and M. Lange, 2011b. Precambrian Geology of the Bending Lake Area (South Sheet). Ontario Geological Survey, Preliminary Map P.3624, Scale 1:20 000. Sudbury, Canada.

Stone, D., J. Hallé, M. Lange, B. Hellebrandt and E. Chaloux, 2007. Precambrian Geology, Ignace Area. Ontario Geological Survey, Preliminary Map P3360 – Revised, Scale 1:50 000. Sudbury, Canada.

Stone, D. and Hallé, J, 2005. Precambrian Geology, Bonheur Area. Ontario Geological Survey, Preliminary Map P3401-Revised, Scale 1:50 000. Sudbury, Canada.

Stone, D. and J. Hallé, 1999. Geology of the Entwine Lake and Bonheur Areas, South-Central Wabigoon Subprovince. In Summary of Field Work and Other Activities 1999. Ontario Geological Survey, Open File Report 6000, 21-1 to 21-8. Sudbury, Canada.

Szewczyk, Z.J. and G.F. West, 1976. Gravity Study of an Archean Granitic Area Northwest of Ignace, Ontario. Canadian Journal of Earth Sciences 13, pp.1119-1130.

Tomlinson, K.Y., G.M. Stott, J.A. Percival and D. Stone, 2004. Basement Terrane Correlations and Crustal Recycling in the Western Superior Province: Nd Isotopic Character of Granitoid and Felsic Volcanic Rocks in the Wabigoon Subprovince, N. Ontario, Canada. Precambrian Research 132, pp.245-274.

Report Signature Page

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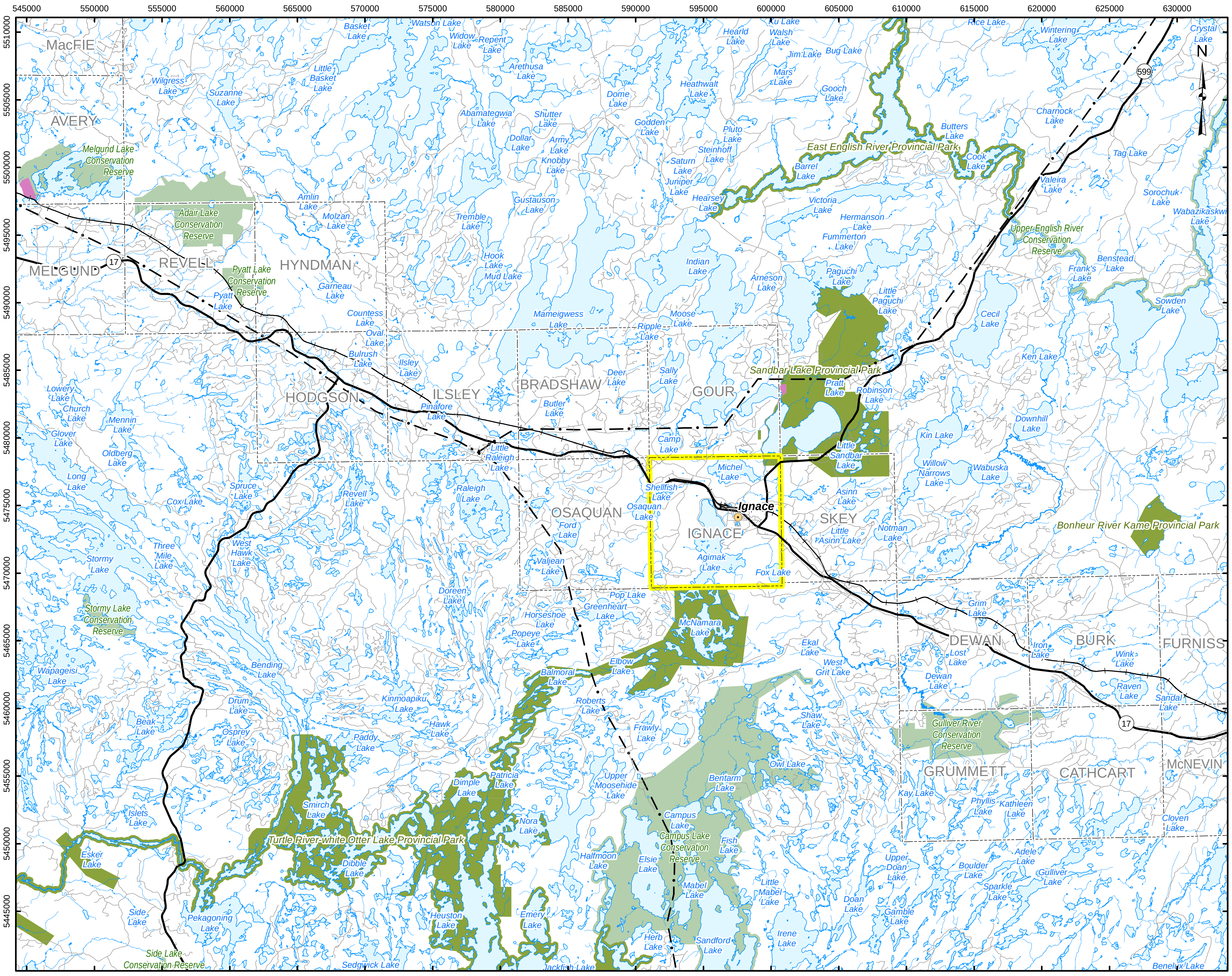
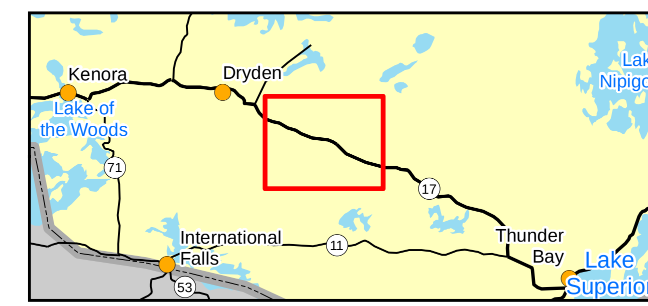


LEGEND

- Ignace
- Main Road
- Local Road
- Railway
- Transmission Line
- Municipal Boundary (Township of Ignace)
- Geographic Township
- Waterbody
- Watercourse
- Forest Reserve
- Conservation Reserve
- Provincial Park



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Natural Earth 2015
Projection: Universal Transverse Mercator
Datum: NAD 83 Coordinate System: UTM Zone 15N

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PROJECT
PHASE 2 GEOSCIENTIFIC PRELIMINARY ASSESSMENT
FINDINGS FROM INITIAL FIELD STUDIES
THE TOWNSHIP OF IGNACE, ONTARIO

TITLE
The Ignace Area

Golder Associates
Mississauga, Ontario

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GIS	JB/CP	2 Mar. 2015		
CHECK	CM	2 Mar. 2015		
REVIEW	GWS	2 Mar. 2015		

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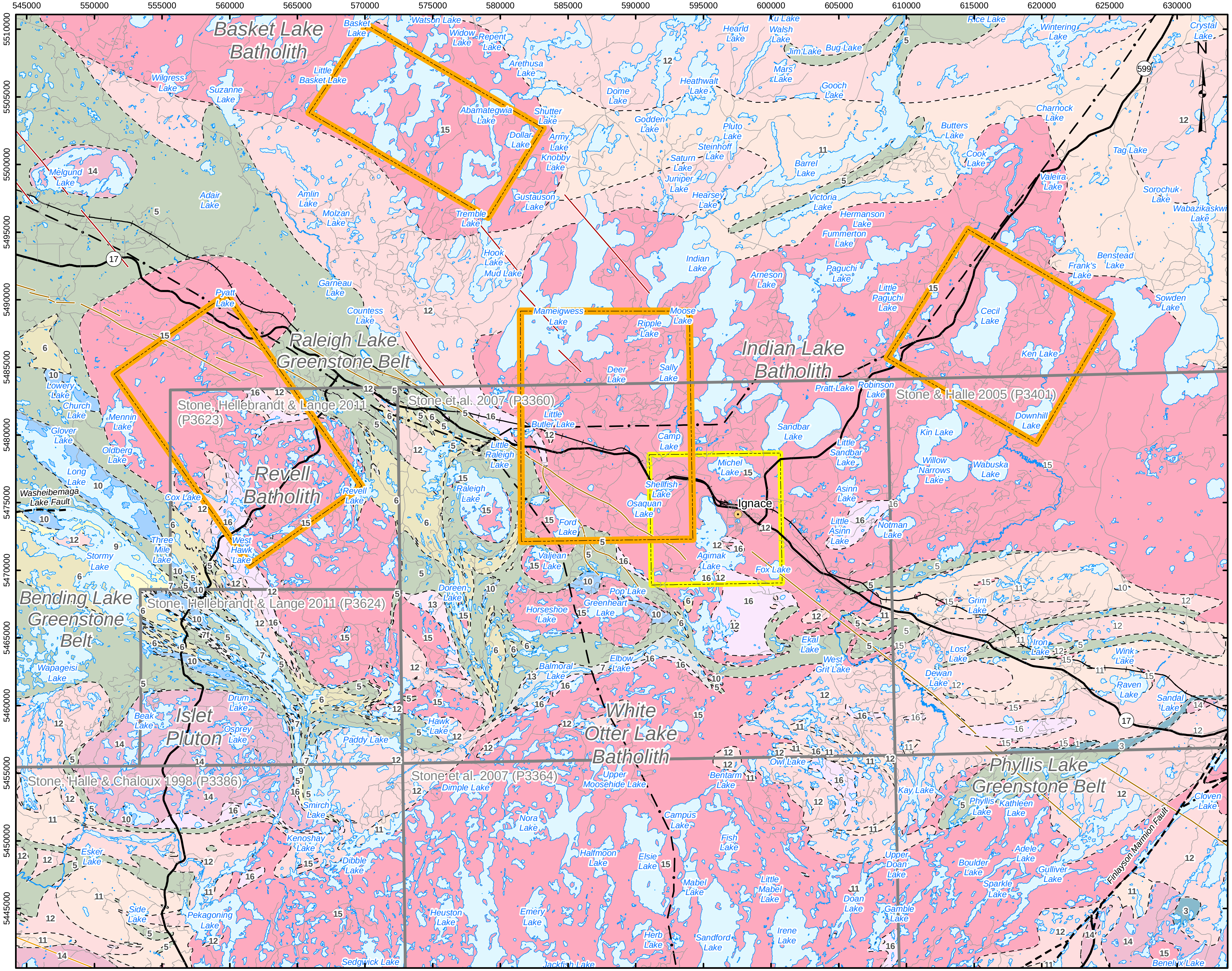


LEGEND

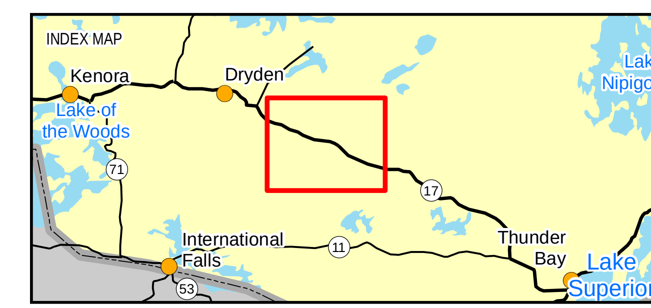
- Withdrawn Area
- Ignace
- Main Road
- Local Road
- Railway
- Transmission Line
- Municipal Boundary (Township of Ignace)
- Waterbody
- Detailed Geology Extents
- Fault

Dykes

- Kenora-Fort Frances Dyke
- Wabigoon Dyke
- Dyke (Other)

Bedrock Geology

- Bedrock Geology Outline
- 31 Sibley Gp.
- 23 Mafic and related intrusive rocks
- 16 Hornblendite - nepheline syenite suite
- 15 Massive granodiorite to granite
- 14-Diorite-monzodiorite-granodiorite 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
- 4 Mafic to ultramafic metavolcanic rocks
- 3 Mafic metavolcanic and metasedimentary rocks
- 1 Metasedimentary rocks and mafic to ultramafic metavolcanic rocks



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Stone et al. 2007 (P3360)
Stone et al. 2007 (P3364)
Stone, Halle & Chaloux 1998 (P3386)
Stone, Hellebrandt & Lange 2011 (P3623)
Stone, Hellebrandt & Lange 2011 (P3624)
Stone & Halle 2005 (P3401)

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PROJECT
PHASE 2 GEOSCIENTIFIC PRELIMINARY ASSESSMENT
FINDINGS FROM INITIAL FIELD STUDIES
THE TOWNSHIP OF IGNACE, ONTARIO

TITLE
Land Withdrawn to Facilitate Phase 2 Studies in the Ignace Area

Golder Associates
Mississauga, Ontario

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CHECK	CM	2 Mar. 2015		
REVIEW	GWS	2 Mar. 2015		

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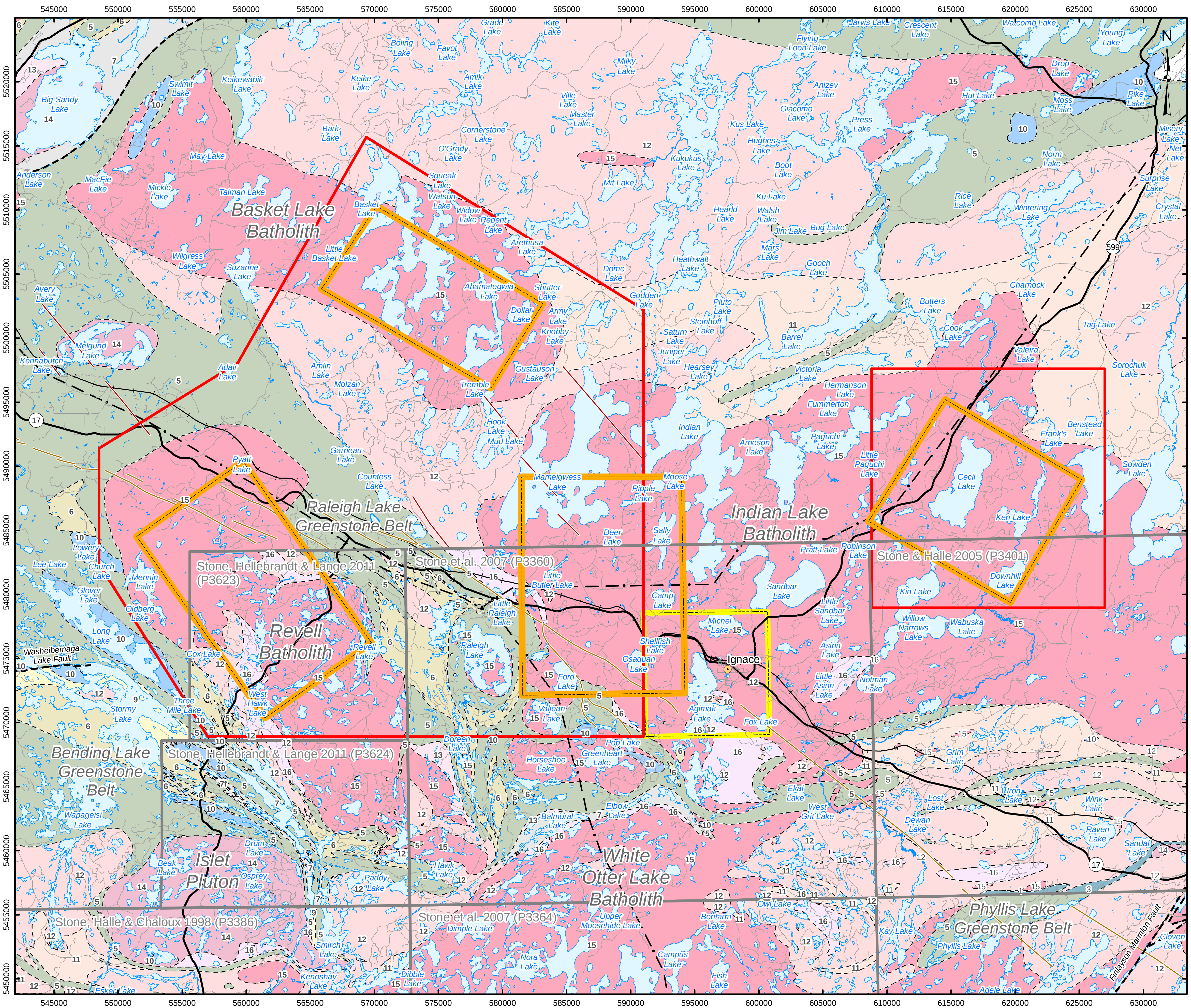

LEGEND

- Airborne Survey Block
- Withdrawn Area
- Ignace
- Main Road
- Local Road
- Railway
- Transmission Line
- Municipal Boundary (Township of Ignace)
- Waterbody
- Detailed Geology Extents
- Fault

Dykes

- Kenora-Fort Frances Dyke
- Wabigoon Dyke

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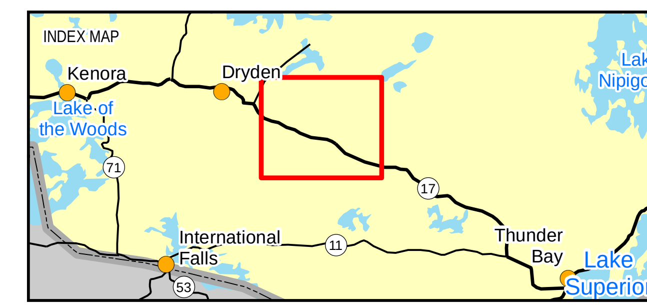

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Base Data - MNR LIO, obtained 2009-2015, CANMAP v2006.4
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Stone & Halle 2005 (P3401)

4 2 0 4 8 12
SCALE 1:300,000 KILOMETRES

PROJECT
PHASE 2 GEOSCIENTIFIC PRELIMINARY ASSESSMENT
FINDINGS FROM INITIAL FIELD STUDIES
THE TOWNSHIP OF IGNACE, ONTARIO

TITLE
Airborne Survey Blocks in the Ignace Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 12-1152-0026			SCALE AS SHOWN	REV. 0.0
DESIGN	CP	20 Feb. 2015	FIGURE: 4-1	
GIS	JB/CP	2 Mar. 2015		
CHECK	CM	2 Mar. 2015		
REVIEW	GWS	2 Mar. 2015		

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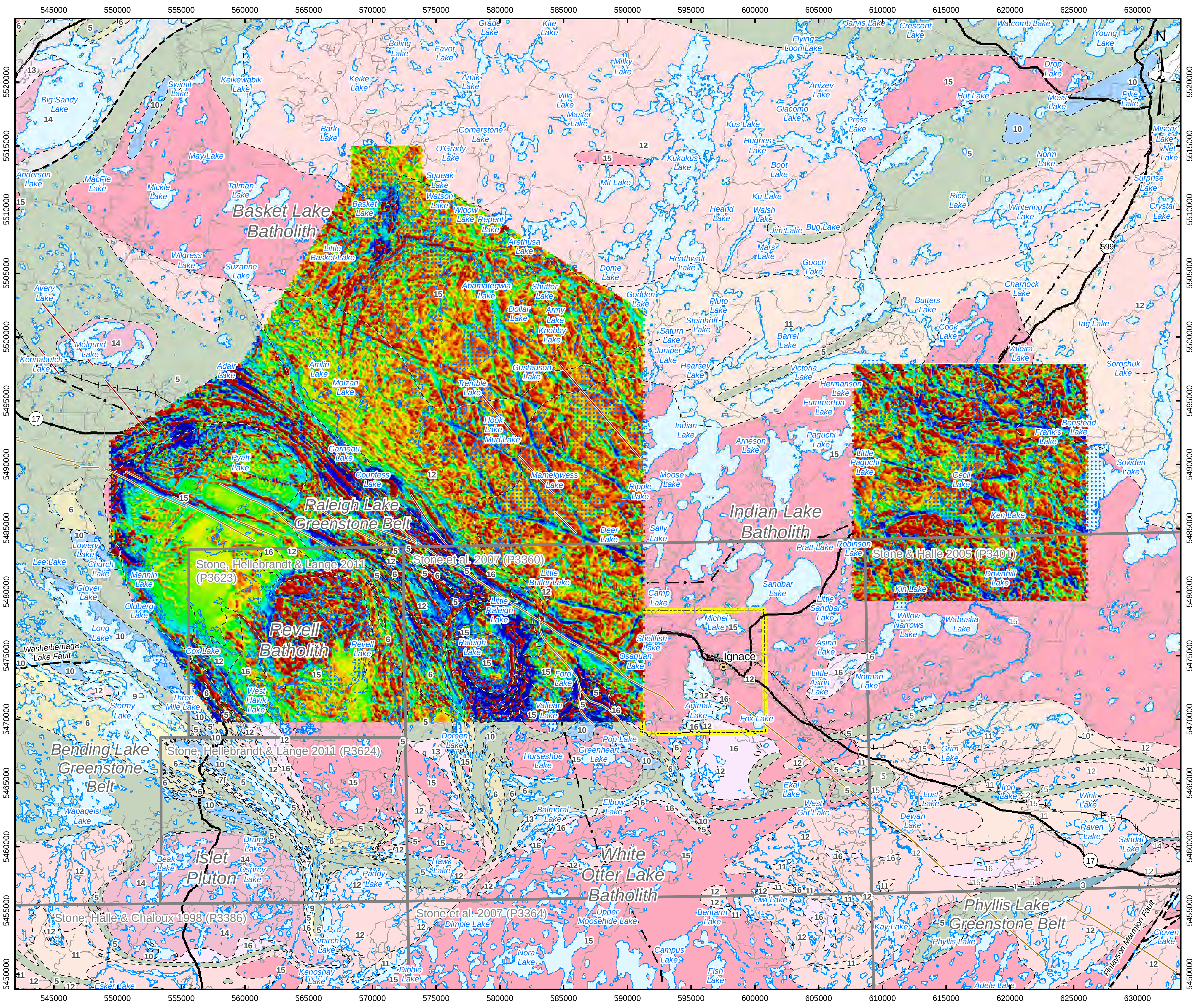


LEGEND

- Ignace
- Main Road
- Local Road
- Railway
- Transmission Line
- Municipal Boundary (Township of Ignace)
- Waterbody (within magnetic data extents)
- Waterbody
- Detailed Geology Extents
- Fault

Dykes

- Kenora-Fort Frances Dyke
- Wabigoon Dyke

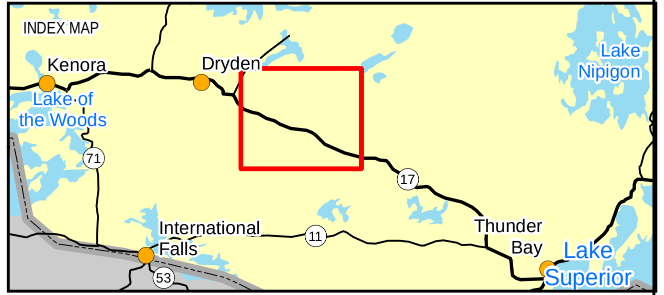
Bedrock Geology

- Bedrock Geology Outline
- 31 Sibley Gp.
- 23 Mafic and related intrusive rocks
- 16 Hornblendite - nepheline syenite suite
- 15 Massive granodiorite to granite
- 14-Diorite-monzodiorite-granodiorite 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
- 4 Mafic to ultramafic metavolcanic rocks
- 3 Mafic metavolcanic and metasedimentary rocks
- 1 Metasedimentary rocks and mafic to ultramafic metavolcanic rocks

First Vertical Derivative (nT/km)

397.4, 250.1, 168.9, 127.6, 100.7, 80.7, 64.5, 50.6, 38.2, 26.7, 16.0, 5.9, -4.0, -13.5, -22.7, -31.0, -38.9, -47.1, -56.1, -66.3, -77.7, -90.7, -105.8, -124.1, -147.5, -178.5, -223.0, -304.4, -445.0

INDEX MAP



REFERENCE

Base Data - MNR LIO, obtained 2009-2015, CANMAP v2006.4
Produced by Golder Associates Ltd under license from
Ontario Ministry of Natural Resources, © Queens Printer 2012
OGS MRD126 - Revision 1
Geophysics: SGL 2015
Natural Earth 2015
Projection: Universal Transverse Mercator
Datum: NAD 83 Coordinate System: UTM Zone 15N

Stone et al. 2007 (P3360)
Stone et al. 2007 (P3364)
Stone, Halle & Chaloux 1998 (P3386)
Stone, Hellebrandt & Lange 2011 (P3623)
Stone, Hellebrandt & Lange 2011 (P3624)
Stone & Halle 2005 (P3401)

4 2 0 4 8 12
SCALE 1:300,000 KILOMETRES

PROJECT
PHASE 2 GEOSCIENTIFIC PRELIMINARY ASSESSMENT
FINDINGS FROM INITIAL FIELD STUDIES
THE TOWNSHIP OF IGNACE, ONTARIO

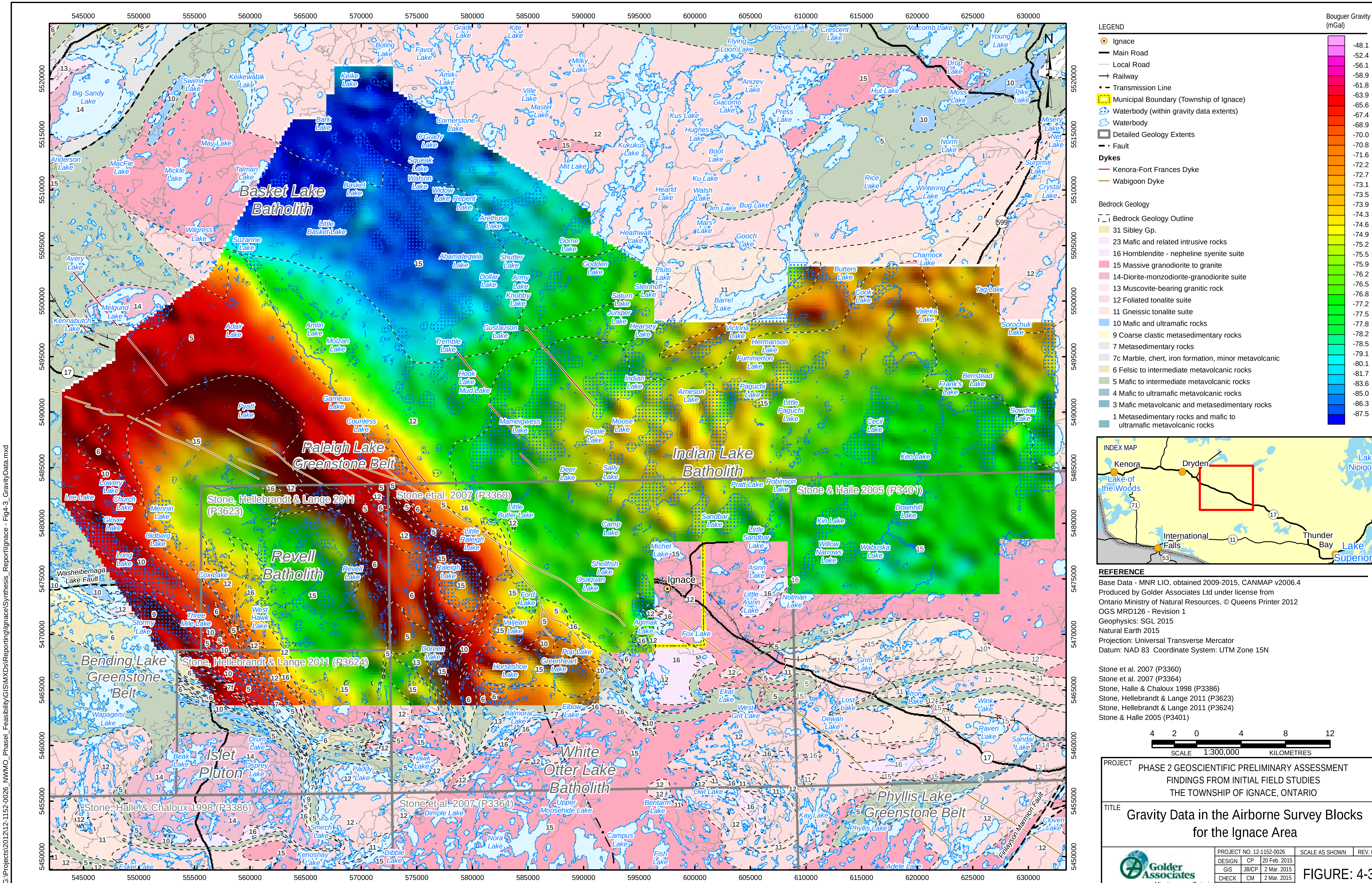
TITLE
Magnetic Data in the Airborne Survey Blocks for the Ignace Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 12-1152-0026			SCALE AS SHOWN	REV. 0.0
DESIGN	CP	20 Feb. 2015		
GIS	JB/CP	2 Mar. 2015		
CHECK	CM	2 Mar. 2015		
REVIEW	GWS	2 Mar. 2015		

FIGURE: 4-2

G:\Projects\2012\12-1152-0026_NWMO_PhaseI_Feasibility\GIS\MXDs\Reporting\Ignace\Synthesis_Report\Ignace - Fig4-2_MagneticData.mxd



LEGEND
Ignace
Main Road
Local Road
Railway
Transmission Line
Municipal Boundary (Township of Ignace)
Waterbody (within gravity data extents)
Waterbody
Detailed Geology Extents
Fault
Dykes
Kenora-Fort Frances Dyke
Wabigoon Dyke
Bedrock Geology
Bedrock Geology Outline
31 Sibley Gp.
23 Mafic and related intrusive rocks
16 Hornblendite - nepheline syenite suite
15 Massive granodiorite to granite
14-Diorite-monzodiorite-granodiorite 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
6 Felsic to intermediate metavolcanic rocks
5 Mafic to intermediate metavolcanic rocks
4 Mafic to ultramafic metavolcanic rocks
3 Mafic metavolcanic and metasedimentary rocks
1 Metasedimentary rocks and mafic to ultramafic metavolcanic rocks
Bouguer Gravity (mGal)
-48.1
-52.4
-56.1
-58.9
-61.8
-63.9
-65.6
-67.4
-68.9
-70.0
-70.8
-71.6
-72.2
-72.7
-73.1
-73.5
-73.9
-74.3
-74.6
-74.9
-75.2
-75.5
-75.9
-76.2
-76.5
-76.8
-77.2
-77.5
-77.8
-78.2
-78.5
-79.1
-80.1
-81.7
-83.6
-85.0
-86.3
-87.5
INDEX MAP
Kenora
Dryden
Lake of the Woods
International Falls
Thunder Bay
Lake Nipigon
Lake Superior
Basket Lake Batholith
Raleigh Lake Greenstone Belt
Indian Lake Batholith
Revell Batholith
Bending Lake Greenstone Belt
Islet Pluton
White Otter Lake Batholith
Phyllis Lake Greenstone Belt
Washeibemaga Lake Fault
Finlayson-Marmion Fault
Ignace
Stone, Hellebrandt & Lange 2011 (P3623)
Stone et al. 2007 (P3360)
Stone & Halle 2005 (P3401)
Stone, Hellebrandt & Lange 2011 (P3624)
Stone, Halle & Chaloux 1998 (P3386)
Stone et al. 2007 (P3364)
REFERENCE
Base Data - MNR LIO, obtained 2009-2015, CANMAP v2006.4
Produced by Golder Associates Ltd under license from
Ontario Ministry of Natural Resources, © Queens Printer 2012
OGS MRD126 - Revision 1
Geophysics: SGL 2015
Natural Earth 2015
Projection: Universal Transverse Mercator
Datum: NAD 83 Coordinate System: UTM Zone 15N
Stone et al. 2007 (P3360)
Stone et al. 2007 (P3364)
Stone, Halle & Chaloux 1998 (P3386)
Stone, Hellebrandt & Lange 2011 (P3623)
Stone, Hellebrandt & Lange 2011 (P3624)
Stone & Halle 2005 (P3401)
SCALE 1:300,000 KILOMETRES
PROJECT
PHASE 2 GEOSCIENTIFIC PRELIMINARY ASSESSMENT
FINDINGS FROM INITIAL FIELD STUDIES
THE TOWNSHIP OF IGNACE, ONTARIO
TITLE
Gravity Data in the Airborne Survey Blocks for the Ignace Area
Golder Associates
Mississauga, Ontario
PROJECT NO. 12-1152-0026
DESIGN CP 20 Feb. 2015
GIS JB/CP 2 Mar. 2015
CHECK CM 2 Mar. 2015
REVIEW GWS 2 Mar. 2015
SCALE AS SHOWN
REV. 0.0
FIGURE: 4-3
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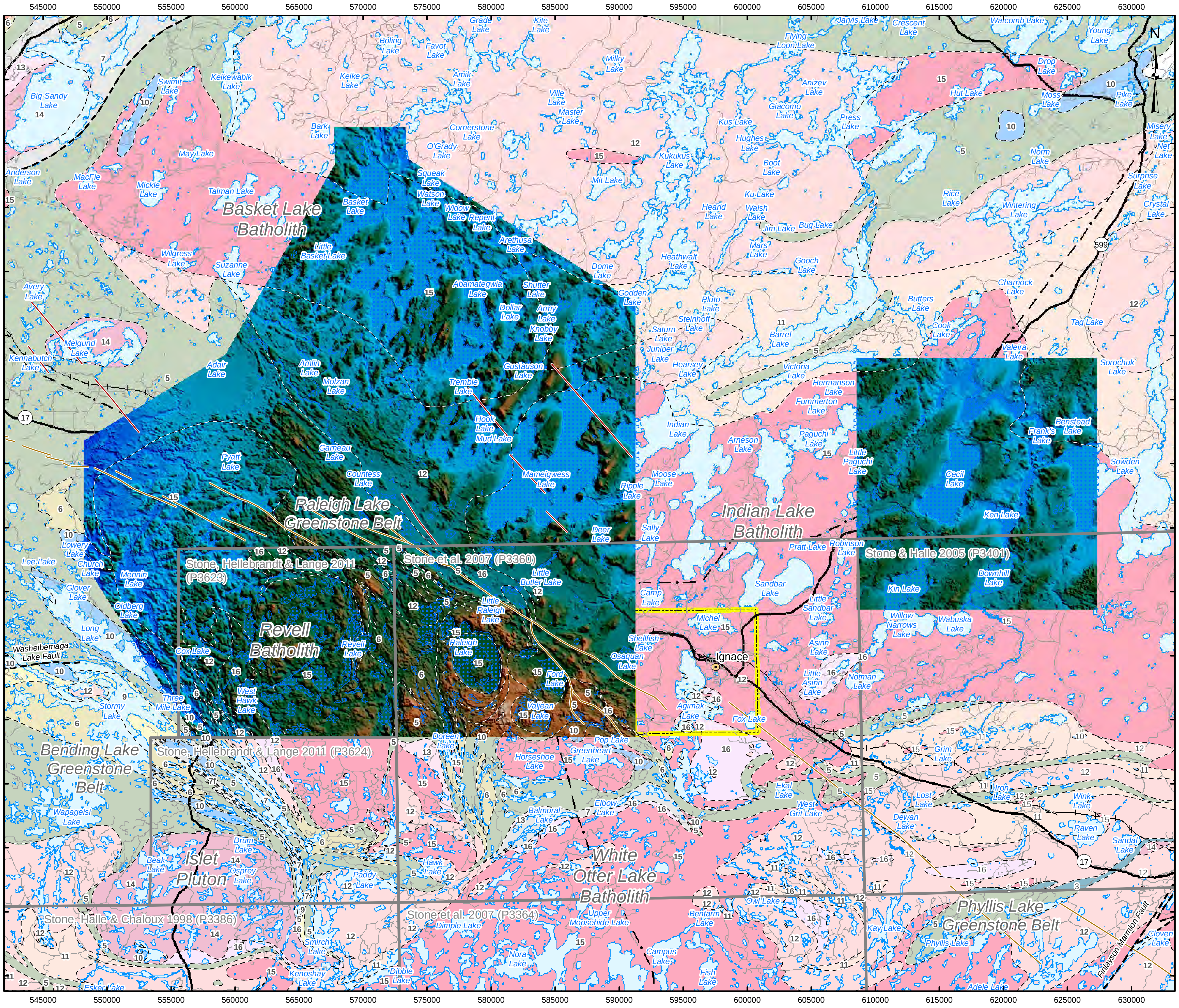


LEGEND

- Ignace
- Main Road
- Local Road
- Railway
- Transmission Line
- Municipal Boundary (Township of Ignace)
- Waterbody (within DEM extents)
- Waterbody
- Detailed Geology Extents
- Fault

Dykes

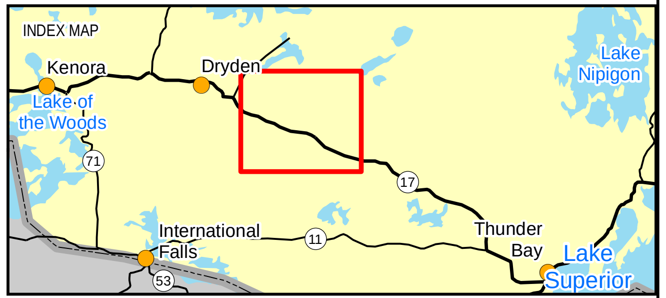
- Kenora-Fort Frances Dyke
- Wabigoon Dyke

Bedrock Geology

- Bedrock Geology Outline
- 31 Sibley Gp.
- 23 Mafic and related intrusive rocks
- 16 Hornblendite - nepheline syenite suite
- 15 Massive granodiorite to granite
- 14-Diorite-monzodiorite-granodiorite 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
- 4 Mafic to ultramafic metavolcanic rocks
- 3 Mafic metavolcanic and metasedimentary rocks
- 1 Metasedimentary rocks and mafic to ultramafic metavolcanic rocks

Elevation (mAMSL)

529.0, 523.0, 517.1, 511.2, 505.2, 499.3, 493.3, 487.4, 481.5, 475.5, 469.6, 463.7, 457.7, 451.8, 445.8, 439.9, 434.0, 428.0, 422.1, 416.1, 410.2, 404.3, 398.3, 392.4, 386.5, 380.5, 374.6, 368.8



REFERENCE

Base Data - MNR LIO, obtained 2009-2015, CANMAP v2006.4
Produced by Golder Associates Ltd under license from
Ontario Ministry of Natural Resources, © Queens Printer 2012
OGS MRD126 - Revision 1
DEM: SGL 2015
Natural Earth 2015
Projection: Universal Transverse Mercator
Datum: NAD 83 Coordinate System: UTM Zone 15N

Stone et al. 2007 (P3360)
Stone et al. 2007 (P3364)
Stone, Halle & Chaloux 1998 (P3386)
Stone, Hellebrandt & Lange 2011 (P3623)
Stone, Hellebrandt & Lange 2011 (P3624)
Stone & Halle 2005 (P3401)

4 2 0 4 8 12
SCALE 1:300,000 KILOMETRES

PROJECT
PHASE 2 GEOSCIENTIFIC PRELIMINARY ASSESSMENT
FINDINGS FROM INITIAL FIELD STUDIES
THE TOWNSHIP OF IGNACE, ONTARIO

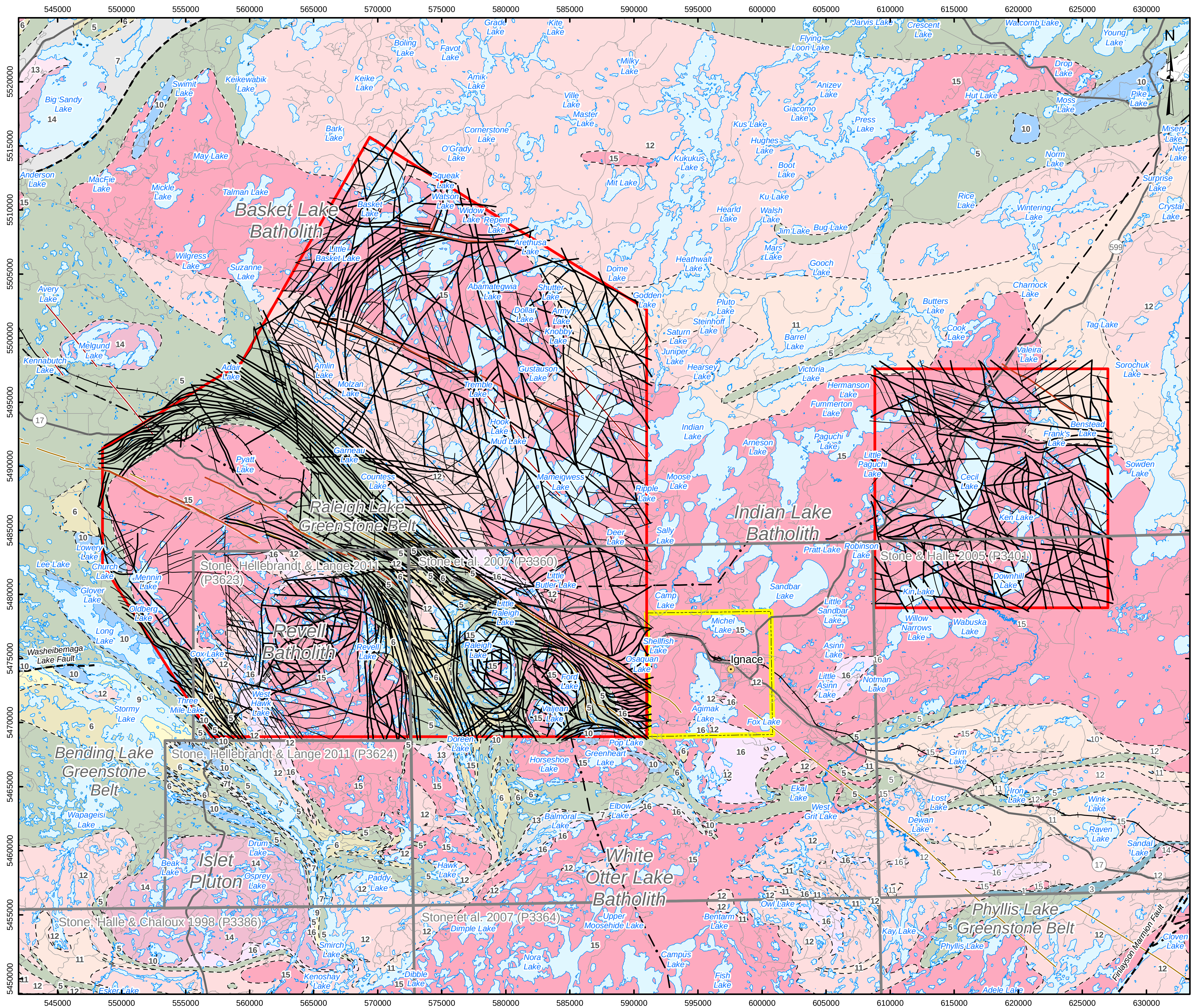
TITLE
Digital Elevation Model (DEM) Data in the Airborne Survey Blocks for the Ignace Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 12-1152-0026			SCALE AS SHOWN	REV. 0.0
DESIGN	CP	20 Feb. 2015		
GIS	JB/CP	2 Mar. 2015		
CHECK	CM	2 Mar. 2015		
REVIEW	GWS	2 Mar. 2015		

FIGURE: 4-4

G:\Projects\2012\12-1152-0026_NWMO_PhaseI_Feasibility\GIS\MXDs\Reporting\Ignace\Synthesis_Report\Ignace - Fig4-4_DEMData.mxd



LEGEND

- Airborne Survey Block
- Ignace
- Main Road
- Local Road
- Railway
- Transmission Line
- Municipal Boundary (Township of Ignace)
- Waterbody
- Detailed Geology Extents
- Fault

Dykes

- Kenora-Fort Frances Dyke
- Wabigoon Dyke

Magnetic Lineaments

- Medium Certainty
- High Certainty

Dyke Lineaments

- Medium Certainty
- High Certainty

Bedrock Geology

- Bedrock Geology Outline
- 31 Sibley Gp.
- 23 Mafic and related intrusive rocks
- 16 Hornblendite - nepheline syenite suite
- 15 Massive granodiorite to granite
- 14-Diorite-monzodiorite-granodiorite suite
- 13 Muscovite-bearing granitic rock
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- 11 Gneissic tonalite suite
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- 7 Metasedimentary rocks
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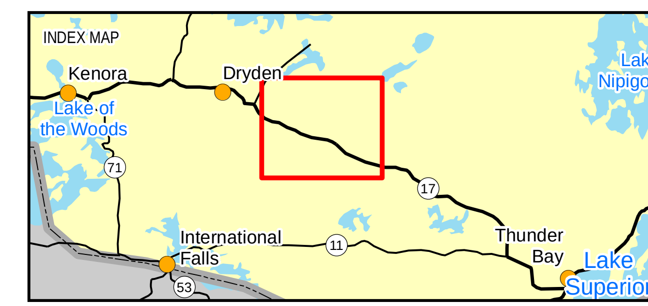
- 4 Mafic to ultramafic metavolcanic rocks
- 3 Mafic metavolcanic and metasedimentary rocks
- 1 Metasedimentary rocks and mafic to ultramafic metavolcanic rocks



REFERENCE

Base Data - MNR LIO, obtained 2009-2015, CANMAP v2006.4
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OGS MRD126 - Revision 1
Lineaments: SRK 2015
Natural Earth 2015
Projection: Universal Transverse Mercator
Datum: NAD 83 Coordinate System: UTM Zone 15N

Stone et al. 2007 (P3360)
Stone et al. 2007 (P3364)
Stone, Halle & Chaloux 1998 (P3386)
Stone, Hellebrandt & Lange 2011 (P3623)
Stone, Hellebrandt & Lange 2011 (P3624)
Stone & Halle 2005 (P3401)

SCALE 1:300,000 KILOMETRES (4 2 0 4 8 12)

PROJECT
PHASE 2 GEOSCIENTIFIC PRELIMINARY ASSESSMENT
FINDINGS FROM INITIAL FIELD STUDIES
THE TOWNSHIP OF IGNACE, ONTARIO

TITLE
Magnetic Lineaments in the Airborne Survey Blocks with Medium and High Certainty

Golder Associates, Mississauga, Ontario

PROJECT NO. 12-1152-0026			SCALE AS SHOWN	REV. 0.0
DESIGN	CP	20 Feb. 2015	FIGURE: 4-5	
GIS	JB/CP	3 Mar. 2015		
CHECK	CM	3 Mar. 2015		
REVIEW	GWS	3 Mar. 2015		

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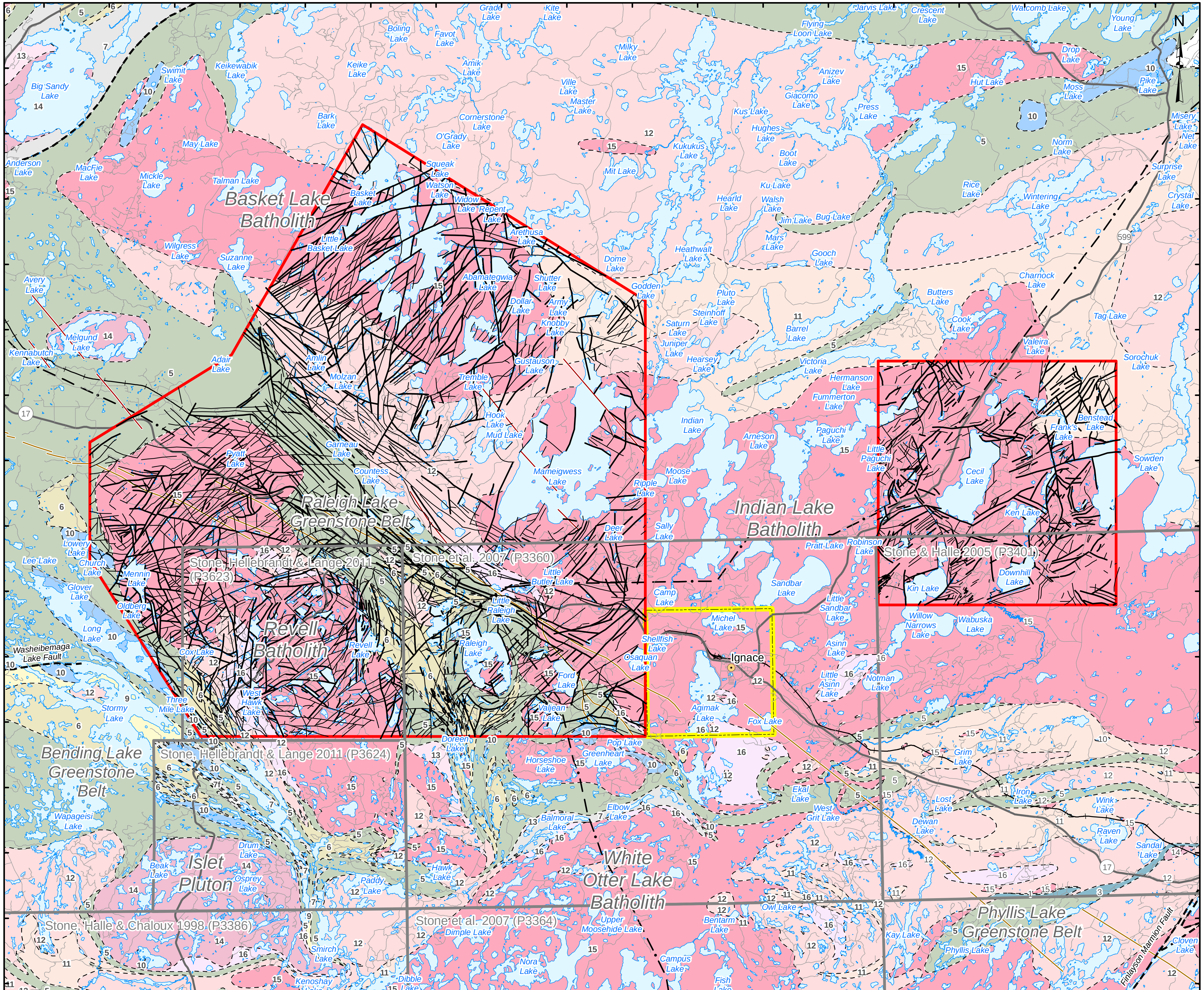

LEGEND

- Airborne Survey Block
- Ignace
- Main Road
- Local Road
- Railway
- Transmission Line
- Municipal Boundary (Township of Ignace)
- Waterbody
- Detailed Geology Extents
- Fault

Dykes

- Kenora-Fort Frances Dyke
- Wabigoon Dyke

Surficial Lineaments

- Medium Certainty
- High Certainty

Bedrock Geology

- Bedrock Geology Outline
- 31 Sibley Gp.
- 23 Mafic and related intrusive rocks
- 16 Hornblendite - nepheline syenite suite
- 15 Massive granodiorite to granite
- 14-Diorite-monzodiorite-granodiorite suite
- 13 Muscovite-bearing granitic rock
- 12 Foliated tonalite suite
- 11 Gneissic tonalite suite
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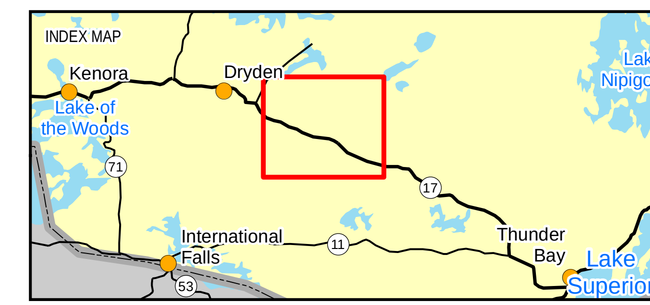
- 9 Coarse clastic metasedimentary rocks
- 7 Metasedimentary rocks
- 7c Marble, chert, iron formation, minor metavolcanic rocks
- 6 Felsic to intermediate metavolcanic rocks
- 5 Mafic to intermediate metavolcanic rocks
- 4 Mafic to ultramafic metavolcanic rocks
- 3 Mafic metavolcanic and metasedimentary rocks
- 1 Metasedimentary rocks and mafic to ultramafic metavolcanic rocks



REFERENCE

Base Data - MNR LIO, obtained 2009-2015, CANMAP v2006.4
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OGS MRD126 - Revision 1
Lineaments: SRK 2015
Natural Earth 2015
Projection: Universal Transverse Mercator
Datum: NAD 83 Coordinate System: UTM Zone 15N

Stone et al. 2007 (P3360)
Stone et al. 2007 (P3364)
Stone, Halle & Chaloux 1998 (P3386)
Stone, Hellebrandt & Lange 2011 (P3623)
Stone, Hellebrandt & Lange 2011 (P3624)
Stone & Halle 2005 (P3401)

SCALE 1:300,000 KILOMETRES (4 2 0 4 8 12)

PROJECT
PHASE 2 GEOSCIENTIFIC PRELIMINARY ASSESSMENT
FINDINGS FROM INITIAL FIELD STUDIES
THE TOWNSHIP OF IGNACE, ONTARIO

TITLE
Surficial Lineaments in the Airborne Survey Blocks with Medium and High Certainty

Golder Associates, Mississauga, Ontario

PROJECT NO. 12-1152-0026			SCALE AS SHOWN	REV. 0.0
DESIGN	CP	20 Feb. 2015		
GIS	JB/CP	2 Mar. 2015		
CHECK	CM	2 Mar. 2015		
REVIEW	GWS	2 Mar. 2015		

FIGURE: 4-6

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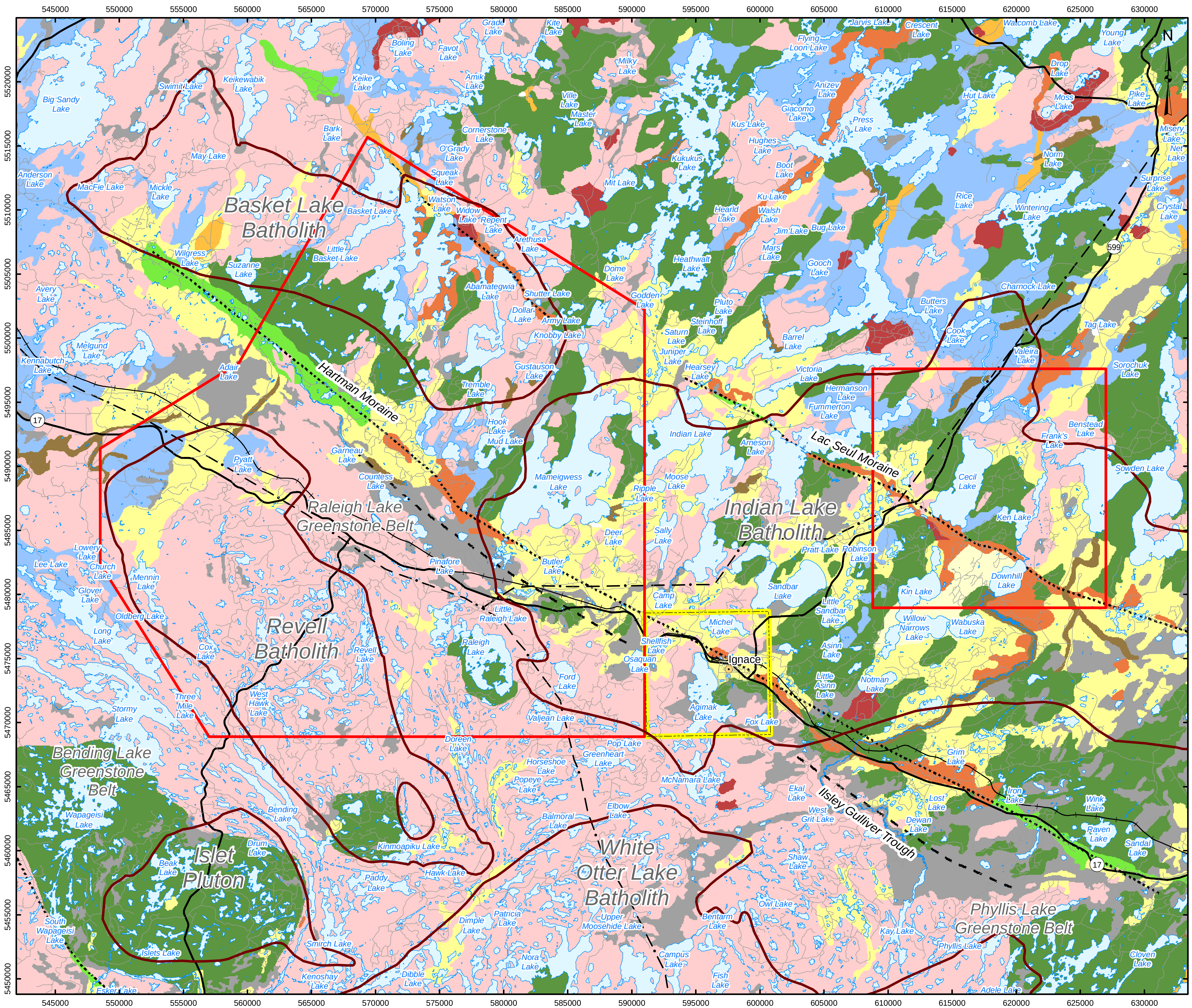
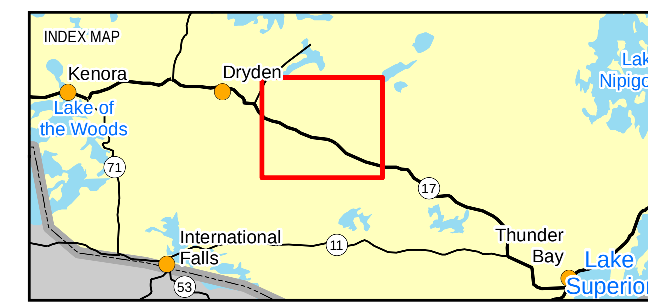


LEGEND

- Airborne Survey Block
- Ignace
- Main Road
- Local Road
- Railway
- Transmission Line
- Municipal Boundary (Township of Ignace)
- Waterbody
- Outline of Major Batholith/Pluton
- Ilsley Gulliver Trough
- Moraine Trend

Landforms

- Ground moraine
- End moraine
- Outwash
- Glaciolacustrine esker
- Kame
- Ice-contact delta
- Glaciolacustrine plain
- Alluvial plain
- Aeolian dune
- Organic terrain
- Bedrock terrain



REFERENCE

Base Data - MNR LIO, obtained 2009-2015, CANMAP v2006.4
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Landforms: NOEGTS MRD160
Natural Earth 2015
Projection: Universal Transverse Mercator
Datum: NAD 83 Coordinate System: UTM Zone 15N

4 2 0 4 8 12
SCALE 1:300,000 KILOMETRES

PROJECT
PHASE 2 GEOSCIENTIFIC PRELIMINARY ASSESSMENT
FINDINGS FROM INITIAL FIELD STUDIES
THE TOWNSHIP OF IGNACE, ONTARIO

TITLE
Terrain Features of the Ignace Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 12-1152-0026			SCALE AS SHOWN	REV. 0.0
DESIGN	CP	20 Feb. 2015	FIGURE: 4-7	
GIS	JB/CP	2 Mar. 2015		
CHECK	CM	2 Mar. 2015		
REVIEW	GWS	2 Mar. 2015		

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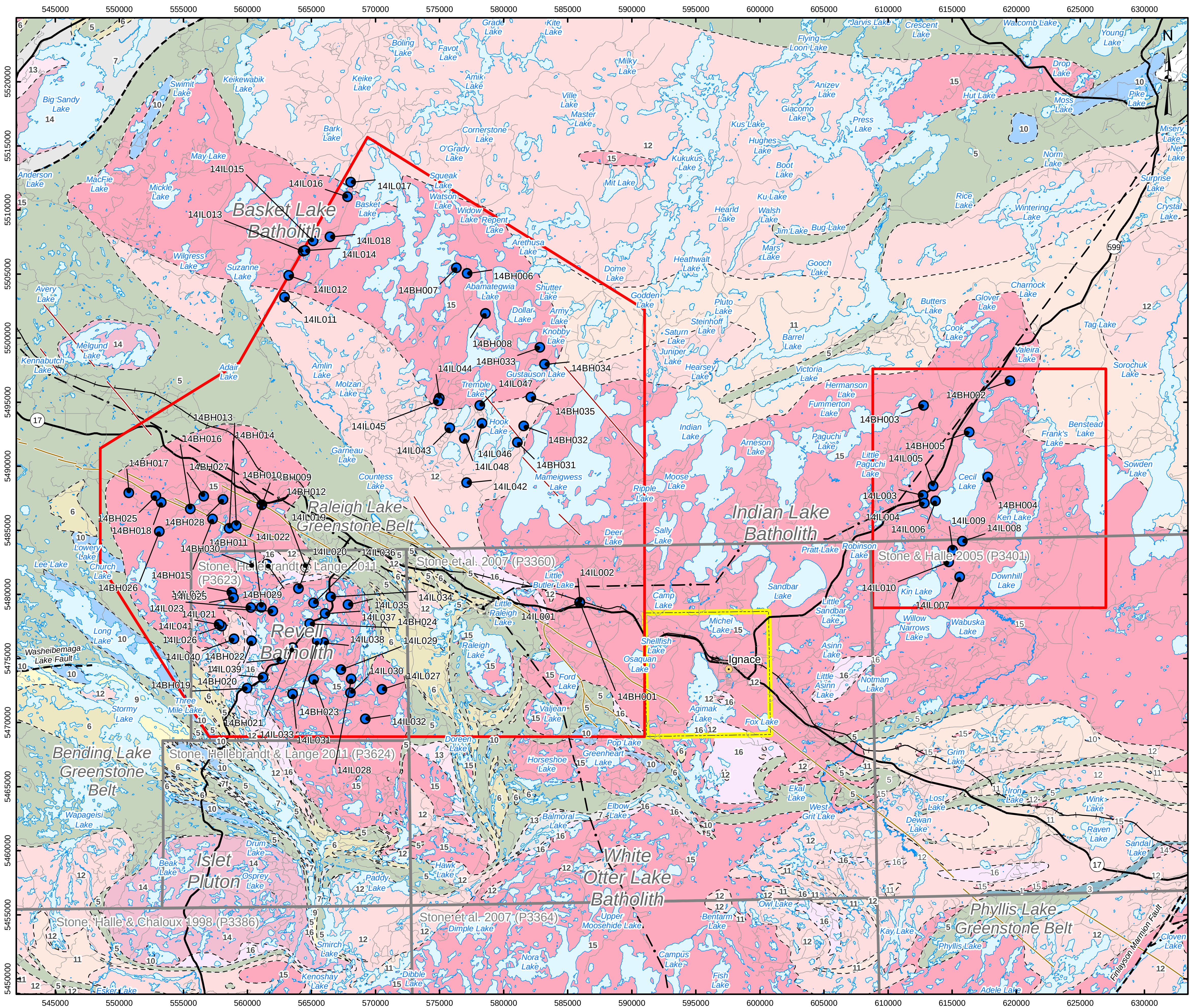

LEGEND

- Outcrop Mapping Location
- Airborne Survey Block
- Ignace
- Main Road
- Local Road
- Railway
- Transmission Line
- Municipal Boundary (Township of Ignace)
- Waterbody
- Detailed Geology Extents
- Fault

Dykes

- Kenora-Fort Frances Dyke
- Wabigoon Dyke

Bedrock Geology

- Bedrock Geology Outline
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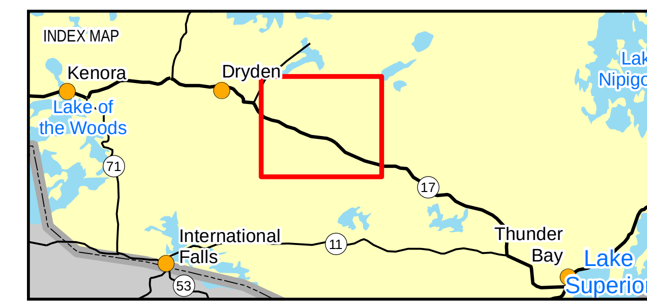
- 4 Mafic to ultramafic metavolcanic rocks
- 3 Mafic metavolcanic and metasedimentary rocks
- 1 Metasedimentary rocks and mafic to ultramafic metavolcanic rocks

INDEX MAP



REFERENCE

Base Data - MNR LIO, obtained 2009-2015, CANMAP v2006.4
Produced by Golder Associates Ltd under license from
Ontario Ministry of Natural Resources, © Queens Printer 2012
OGS MRD126 - Revision 1
Mapping Locations: SRK and Golder 2015
Natural Earth 2015
Projection: Universal Transverse Mercator
Datum: NAD 83 Coordinate System: UTM Zone 15N

Stone et al. 2007 (P3360)
Stone et al. 2007 (P3364)
Stone, Halle & Chaloux 1998 (P3386)
Stone, Hellebrandt & Lange 2011 (P3623)
Stone, Hellebrandt & Lange 2011 (P3624)
Stone & Halle 2005 (P3401)

4 2 0 4 8 12
SCALE 1:300,000 KILOMETRES

PROJECT
PHASE 2 GEOSCIENTIFIC PRELIMINARY ASSESSMENT
FINDINGS FROM INITIAL FIELD STUDIES
THE TOWNSHIP OF IGNACE, ONTARIO

TITLE
Outcrop Mapping Locations in the Airborne Survey Blocks in the Ignace Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 12-1152-0026			SCALE AS SHOWN	REV. 0.0
DESIGN	CP	20 Feb. 2015		
GIS	JB/CP	2 Mar. 2015		
CHECK	CM	2 Mar. 2015		
REVIEW	GWS	2 Mar. 2015		

FIGURE: 4-8

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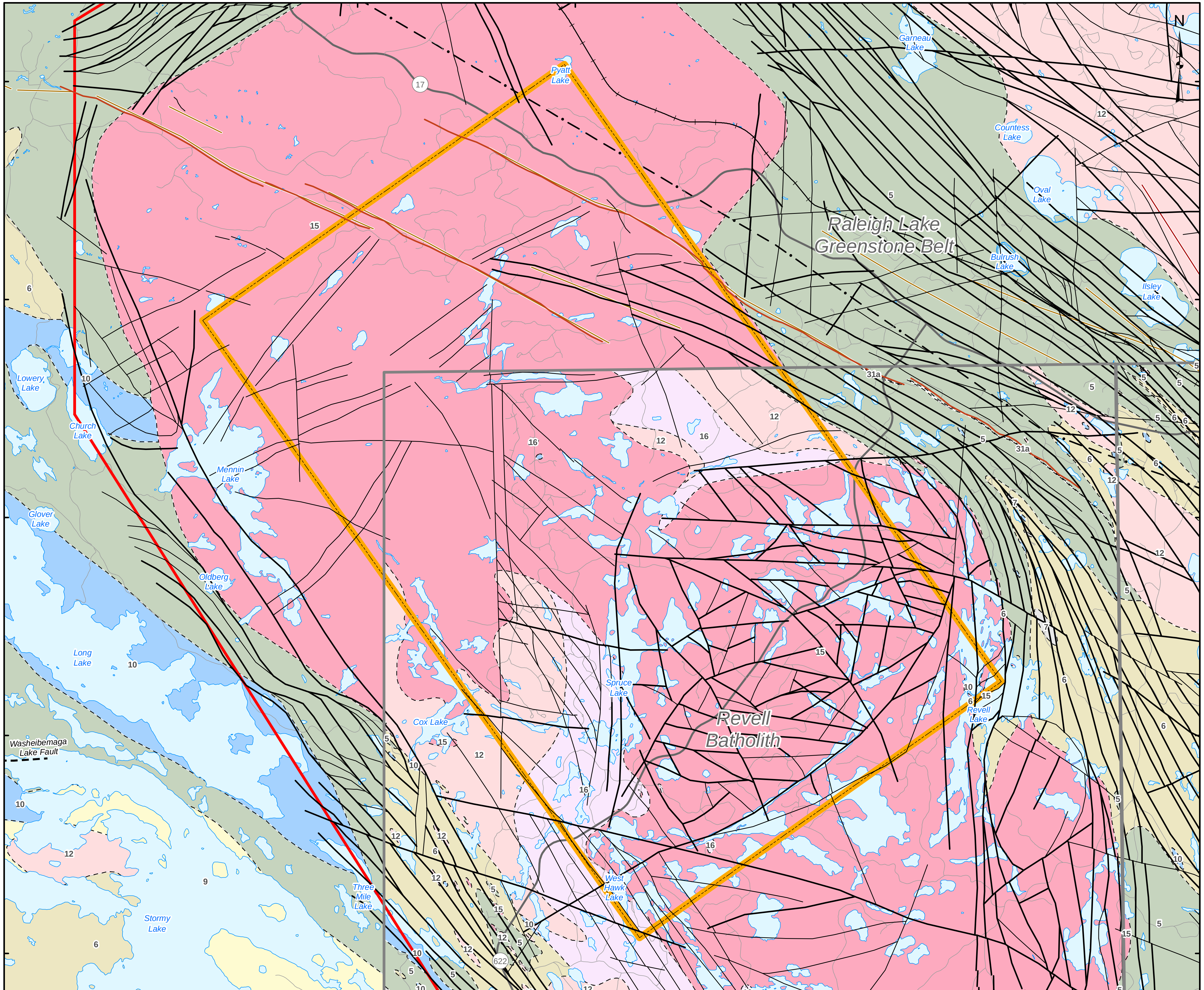

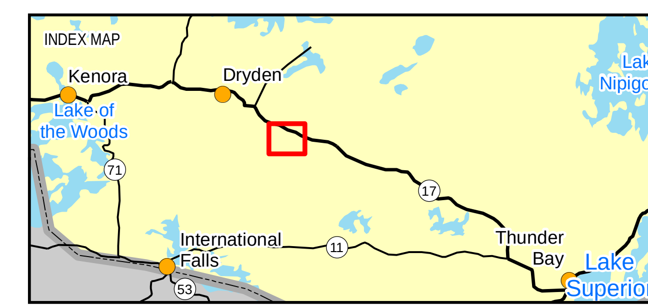

REFERENCE

Base Data - MNR LIO, obtained 2009-2015, CANMAP v2006.4
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OGS MRD126 - Revision 1
Lineaments: SRK 2015
Natural Earth 2015
Projection: Universal Transverse Mercator
Datum: NAD 83 Coordinate System: UTM Zone 15N

Stone et al. 2007 (P3360)
Stone, Hellebrandt & Lange 2011 (P3623)

PROJECT
PHASE 2 GEOSCIENTIFIC PRELIMINARY ASSESSMENT
FINDINGS FROM INITIAL FIELD STUDIES
THE TOWNSHIP OF IGNACE, ONTARIO

TITLE
Magnetic Lineaments with High and Medium Certainty for the Northern Portion of the Revell Batholith

Golder Associates
Mississauga, Ontario

PROJECT NO. 12-1152-0026			SCALE AS SHOWN	REV. 0.0
DESIGN	CP	20 Feb. 2015	FIGURE: 5-1	
GIS	JB/CP	3 Mar. 2015		
CHECK	CM	3 Mar. 2015		
REVIEW	GWS	3 Mar. 2015		

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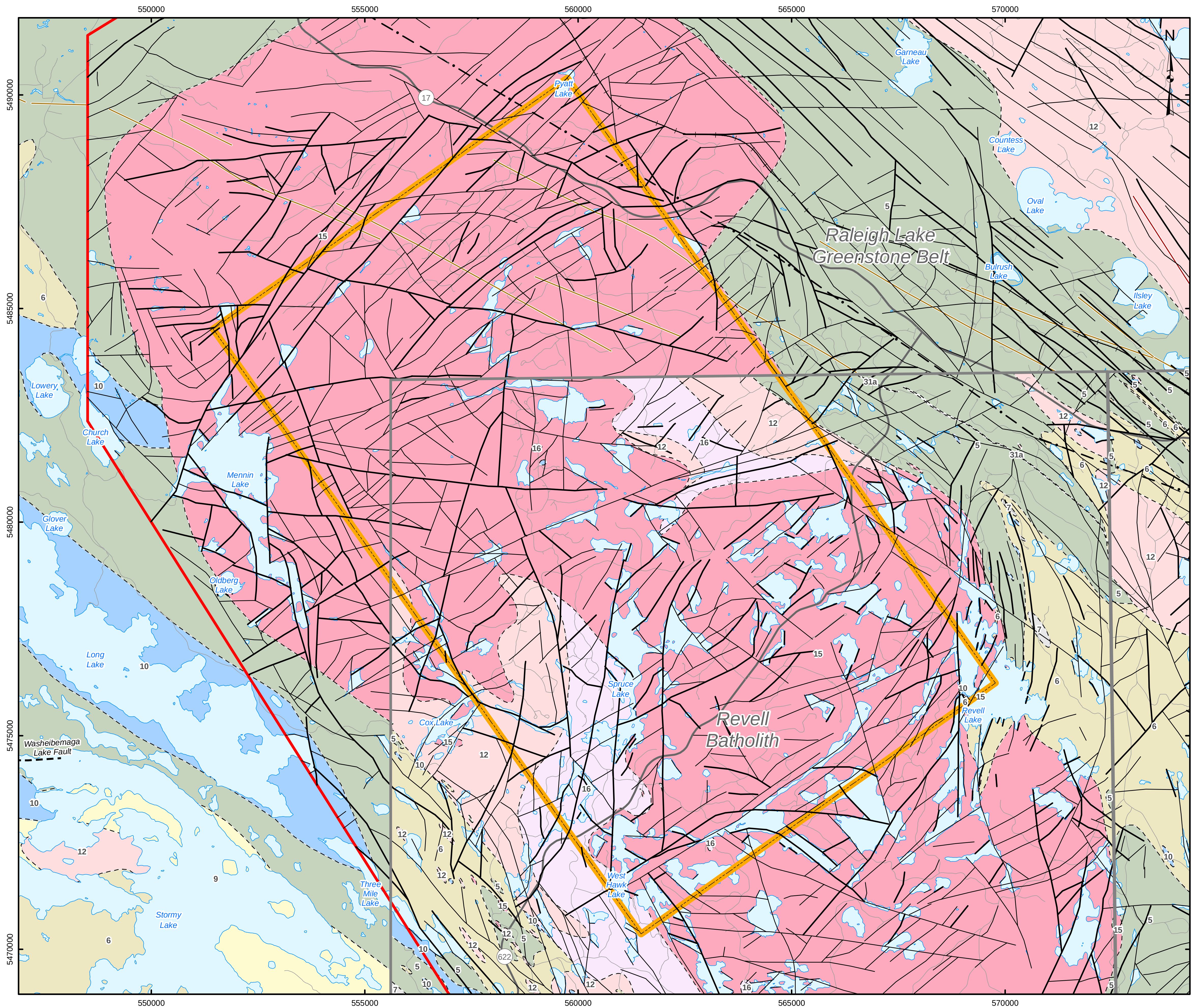


LEGEND

- Withdrawn Area
- Airborne Survey Block
- Main Road
- Local Road
- Railway
- Transmission Line
- Waterbody
- Detailed Geology Extents
- Fault

Dykes

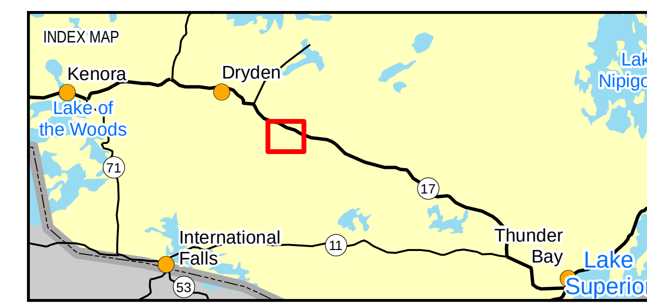
- Kenora-Fort Frances Dyke
- Wabigoon Dyke

Surficial Lineaments

- Medium Certainty
- High Certainty

Bedrock Geology

- Bedrock Geology Outline
- 31 Sibley Gp.
- 23 Mafic and related intrusive rocks
- 16 Hornblendite - nepheline syenite suite
- 15 Massive granodiorite to granite
- 14-Diorite-monzodiorite-granodiorite 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
- 4 Mafic to ultramafic metavolcanic rocks
- 3 Mafic metavolcanic and metasedimentary rocks
- 1 Metasedimentary rocks and mafic to ultramafic metavolcanic rocks



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OGS MRD126 - Revision 1
Lineaments: SRK 2015
Natural Earth 2015
Projection: Universal Transverse Mercator
Datum: NAD 83 Coordinate System: UTM Zone 15N

Stone et al. 2007 (P3360)
Stone, Hellebrandt & Lange 2011 (P3623)

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SCALE 1:90,000 KILOMETRES

PROJECT
PHASE 2 GEOSCIENTIFIC PRELIMINARY ASSESSMENT
FINDINGS FROM INITIAL FIELD STUDIES
THE TOWNSHIP OF IGNACE, ONTARIO

TITLE
Surficial Lineaments with High and Medium Certainty for the Northern Portion of the Revell Batholith

Golder Associates
Mississauga, Ontario

PROJECT NO. 12-1152-0026			SCALE AS SHOWN	REV. 0.0
DESIGN	CP	20 Feb. 2015	FIGURE: 5-2	
GIS	JB/CP	2 Mar. 2015		
CHECK	CM	2 Mar. 2015		
REVIEW	GWS	2 Mar. 2015		

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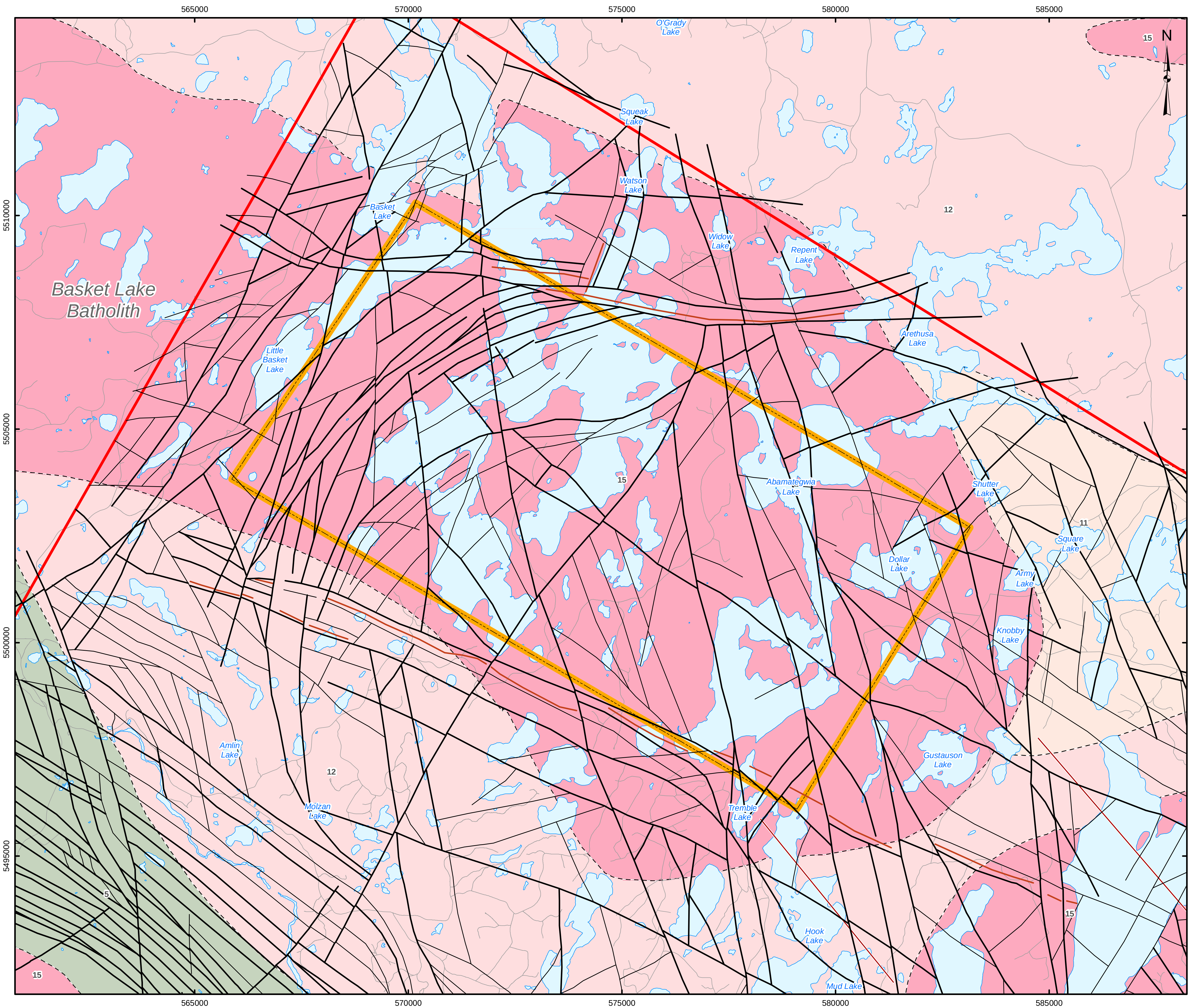

LEGEND

- Withdrawn Area
- Airborne Survey Block
- Local Road
- Waterbody

Dykes

- Kenora-Fort Frances Dyke

Magnetic Lineaments

- Medium Certainty
- High Certainty

Dyke Lineaments

- High Certainty

Bedrock Geology

- Bedrock Geology Outline
- 31 Sibley Gp.
- 23 Mafic and related intrusive rocks
- 16 Hornblendite - nepheline syenite suite
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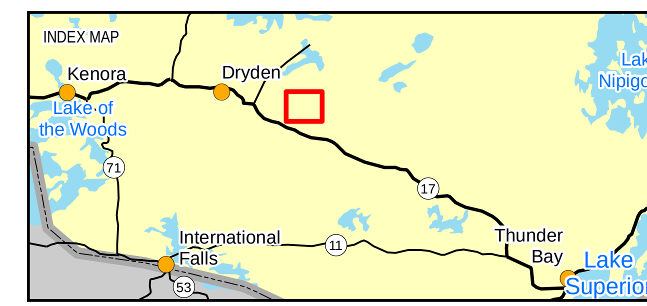
- 3 Mafic metavolcanic and metasedimentary rocks
- 1 Metasedimentary rocks and mafic to ultramafic metavolcanic rocks

INDEX MAP



REFERENCE

Base Data - MNR LIO, obtained 2009-2015, CANMAP v2006.4
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Lineaments: SRK 2015
Natural Earth 2015
Projection: Universal Transverse Mercator
Datum: NAD 83 Coordinate System: UTM Zone 15N

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SCALE 1:90,000 KILOMETRES

PROJECT

PHASE 2 GEOSCIENTIFIC PRELIMINARY ASSESSMENT
FINDINGS FROM INITIAL FIELD STUDIES
THE TOWNSHIP OF IGNACE, ONTARIO

TITLE

Magnetic Lineaments with High and Medium Certainty for the Southern Portion of the Basket Lake Batholith

Golder Associates
Mississauga, Ontario

PROJECT NO. 12-1152-0026			SCALE AS SHOWN	REV. 0.0
DESIGN	CP	20 Feb. 2015	FIGURE: 5-3	
GIS	JB/CP	3 Mar. 2015		
CHECK	CM	3 Mar. 2015		
REVIEW	GWS	3 Mar. 2015		

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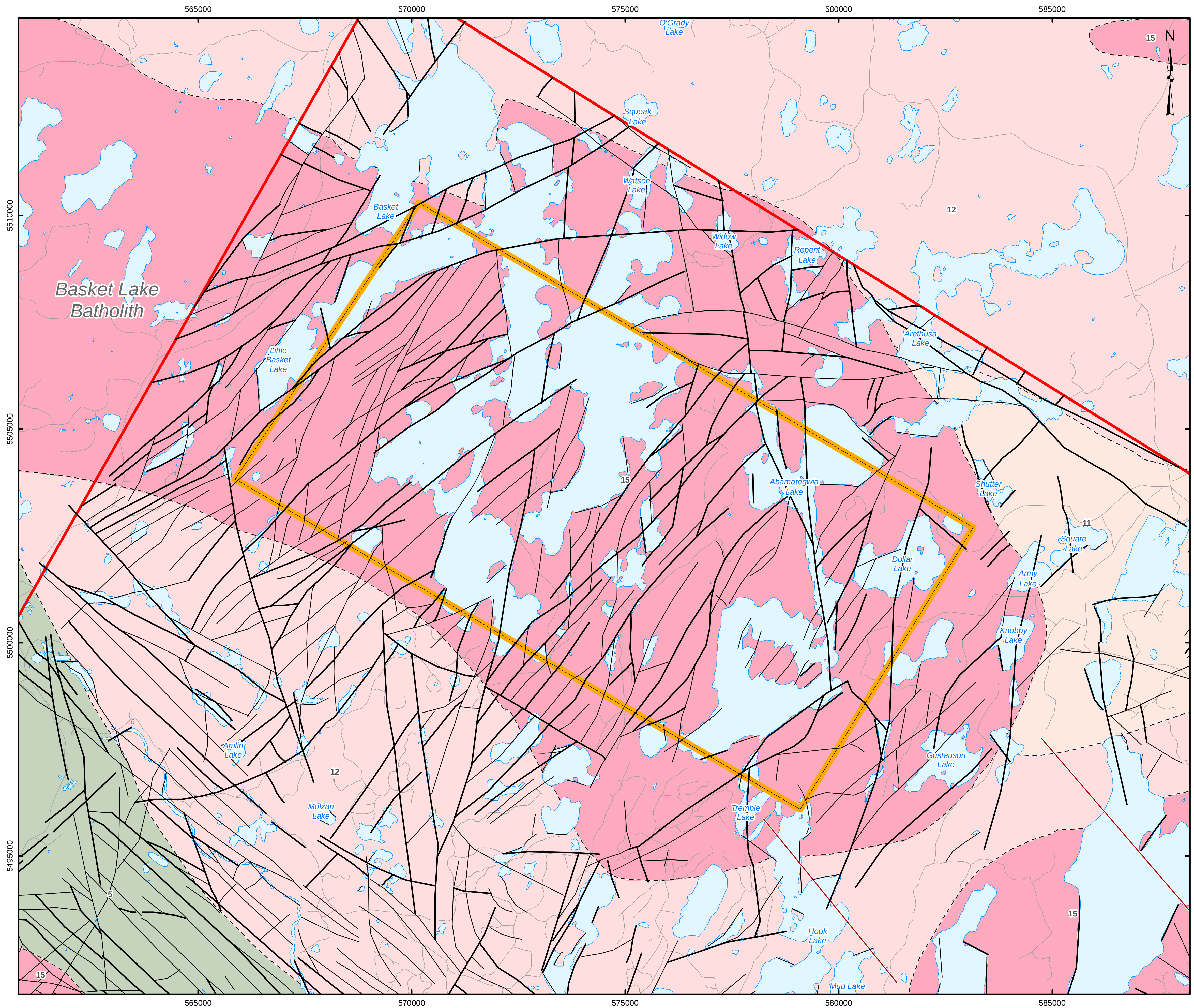

LEGEND

- Withdrawn Area
- Airborne Survey Block
- Local Road
- Waterbody

Dykes

- Kenora-Fort Frances Dyke

Surficial Lineaments

- Medium Certainty
- High Certainty

Bedrock Geology

- Bedrock Geology Outline
- 31 Sibley Gp.
- 23 Mafic and related intrusive rocks
- 16 Hornblendite - nepheline syenite suite
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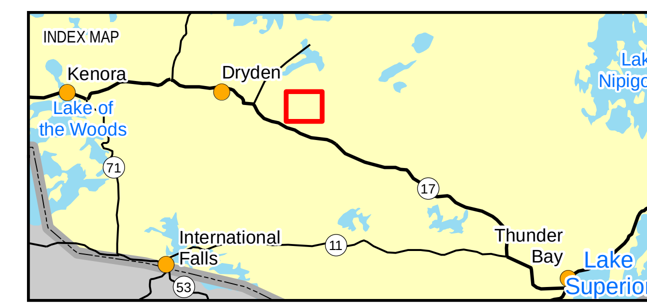

REFERENCE

Base Data - MNR LIO, obtained 2009-2015, CANMAP v2006.4
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OGS MRD126 - Revision 1
Lineaments: SRK 2015
Natural Earth 2015
Projection: Universal Transverse Mercator
Datum: NAD 83 Coordinate System: UTM Zone 15N

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PROJECT
PHASE 2 GEOSCIENTIFIC PRELIMINARY ASSESSMENT
FINDINGS FROM INITIAL FIELD STUDIES
THE TOWNSHIP OF IGNACE, ONTARIO

TITLE
Surficial Lineaments with High and Medium Certainty for the Southern Portion of the Basket Lake Batholith

Golder Associates
Mississauga, Ontario

PROJECT NO. 12-1152-0026			SCALE AS SHOWN	REV. 0.0
DESIGN	CP	20 Feb. 2015	FIGURE: 5-4	
GIS	JB/CP	2 Mar. 2015		
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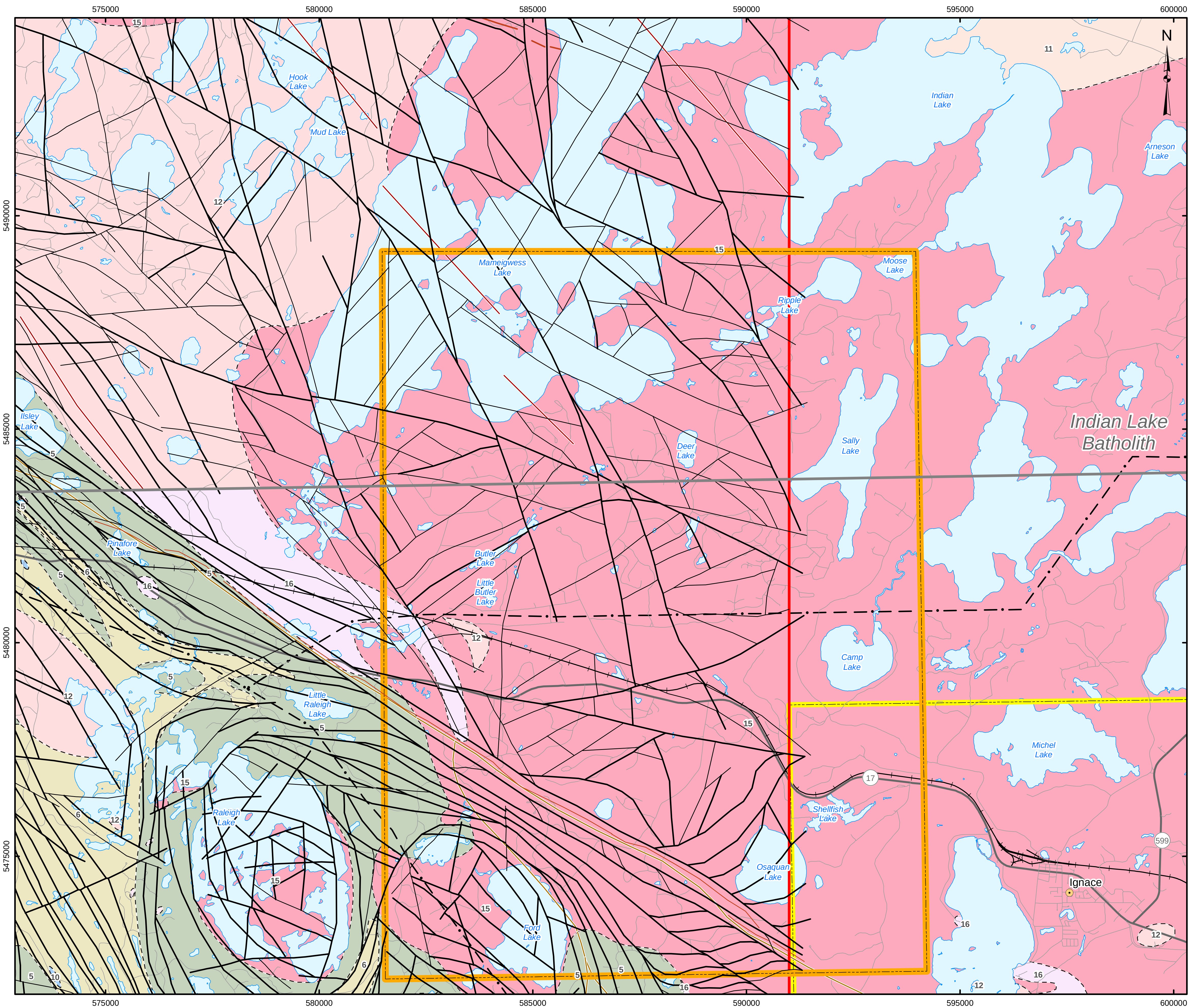

LEGEND

- Withdrawn Area
- Airborne Survey Block
- Ignace
- Main Road
- Local Road
- Railway
- Transmission Line
- Municipal Boundary (Township of Ignace)
- Waterbody
- Detailed Geology Extents

Dykes

- Kenora-Fort Frances Dyke
- Wabigoon Dyke

Magnetic Lineaments

- Medium Certainty
- High Certainty

Dyke Lineaments

- Medium Certainty
- High Certainty

Bedrock Geology

- Bedrock Geology Outline
- 31 Sibley Gp.
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- 3 Mafic metavolcanic and metasedimentary rocks
- 1 Metasedimentary rocks and mafic to ultramafic metavolcanic rocks

INDEX MAP

REFERENCE

Base Data - MNR LIO, obtained 2009-2015, CANMAP v2006.4
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Lineaments: SRK 2015
Natural Earth 2015
Projection: Universal Transverse Mercator
Datum: NAD 83 Coordinate System: UTM Zone 15N

Stone et al. 2007 (P3360)

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SCALE 1:90,000 KILOMETRES

PROJECT

PHASE 2 GEOSCIENTIFIC PRELIMINARY ASSESSMENT
FINDINGS FROM INITIAL FIELD STUDIES
THE TOWNSHIP OF IGNACE, ONTARIO

TITLE

Magnetic Lineaments with High and Medium Certainty for the Western Portion of the Indian Lake Batholith

Golder Associates
Mississauga, Ontario

PROJECT NO. 12-1152-0026			SCALE AS SHOWN	REV. 0.0
DESIGN	CP	20 Feb. 2015	FIGURE: 5-5	
GIS	JB/CP	3 Mar. 2015		
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REVIEW	GWS	3 Mar. 2015		

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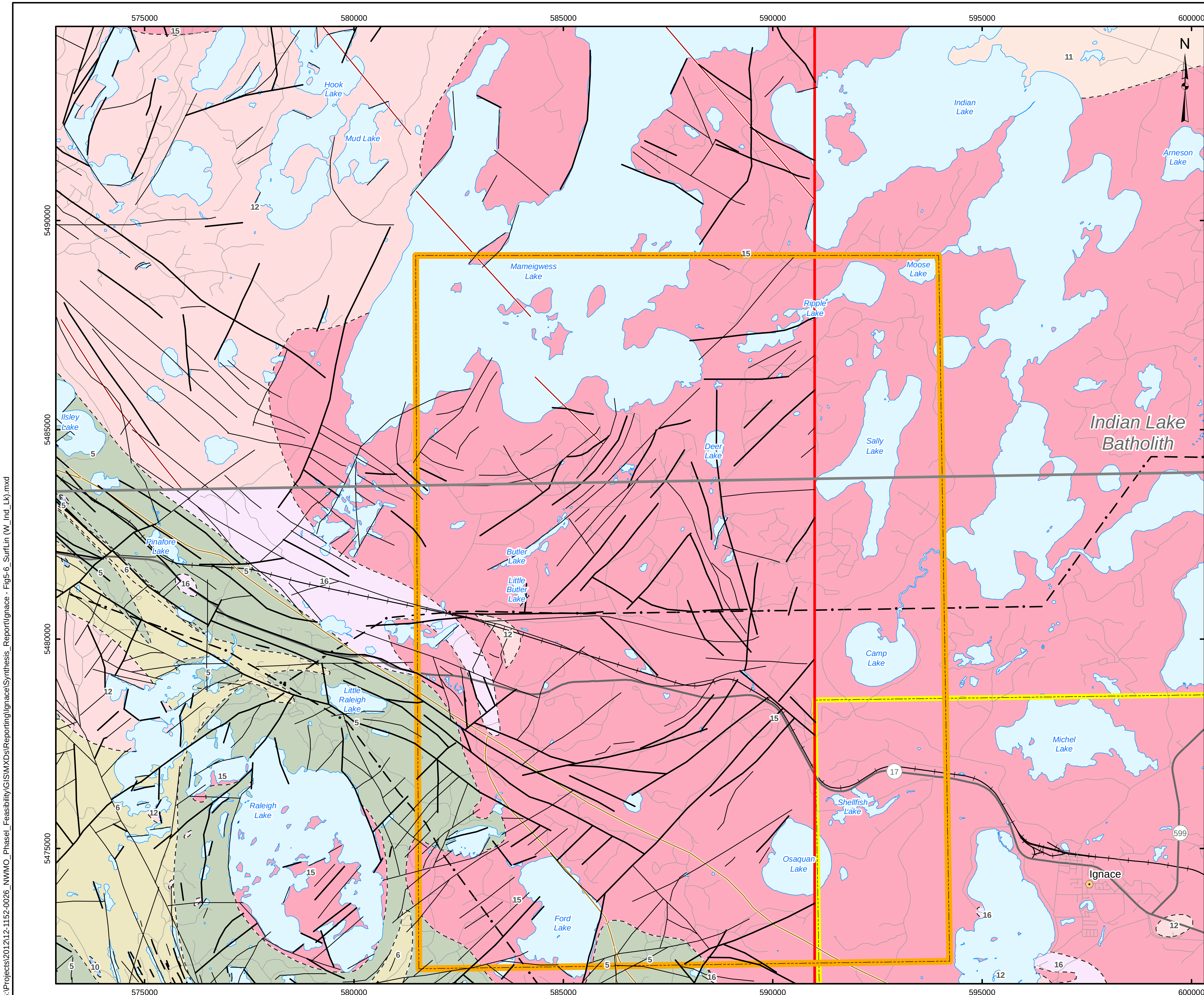

LEGEND

- Withdrawn Area
- Airborne Survey Block
- Ignace
- Main Road
- Local Road
- Railway
- Transmission Line
- Municipal Boundary (Township of Ignace)
- Waterbody
- Detailed Geology Extents

Dykes

- Kenora-Fort Frances Dyke
- Wabigoon Dyke

Surficial Lineaments

- Medium Certainty
- High Certainty

Bedrock Geology

- Bedrock Geology Outline
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Lineaments: SRK 2015
Natural Earth 2015
Projection: Universal Transverse Mercator
Datum: NAD 83 Coordinate System: UTM Zone 15N

Stone et al. 2007 (P3360)

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PROJECT
PHASE 2 GEOSCIENTIFIC PRELIMINARY ASSESSMENT
FINDINGS FROM INITIAL FIELD STUDIES
THE TOWNSHIP OF IGNACE, ONTARIO

TITLE
Surficial Lineaments with High and Medium Certainty for the Western Portion of the Indian Lake Batholith

Golder Associates
Mississauga, Ontario

PROJECT NO. 12-1152-0026			SCALE AS SHOWN	REV. 0.0
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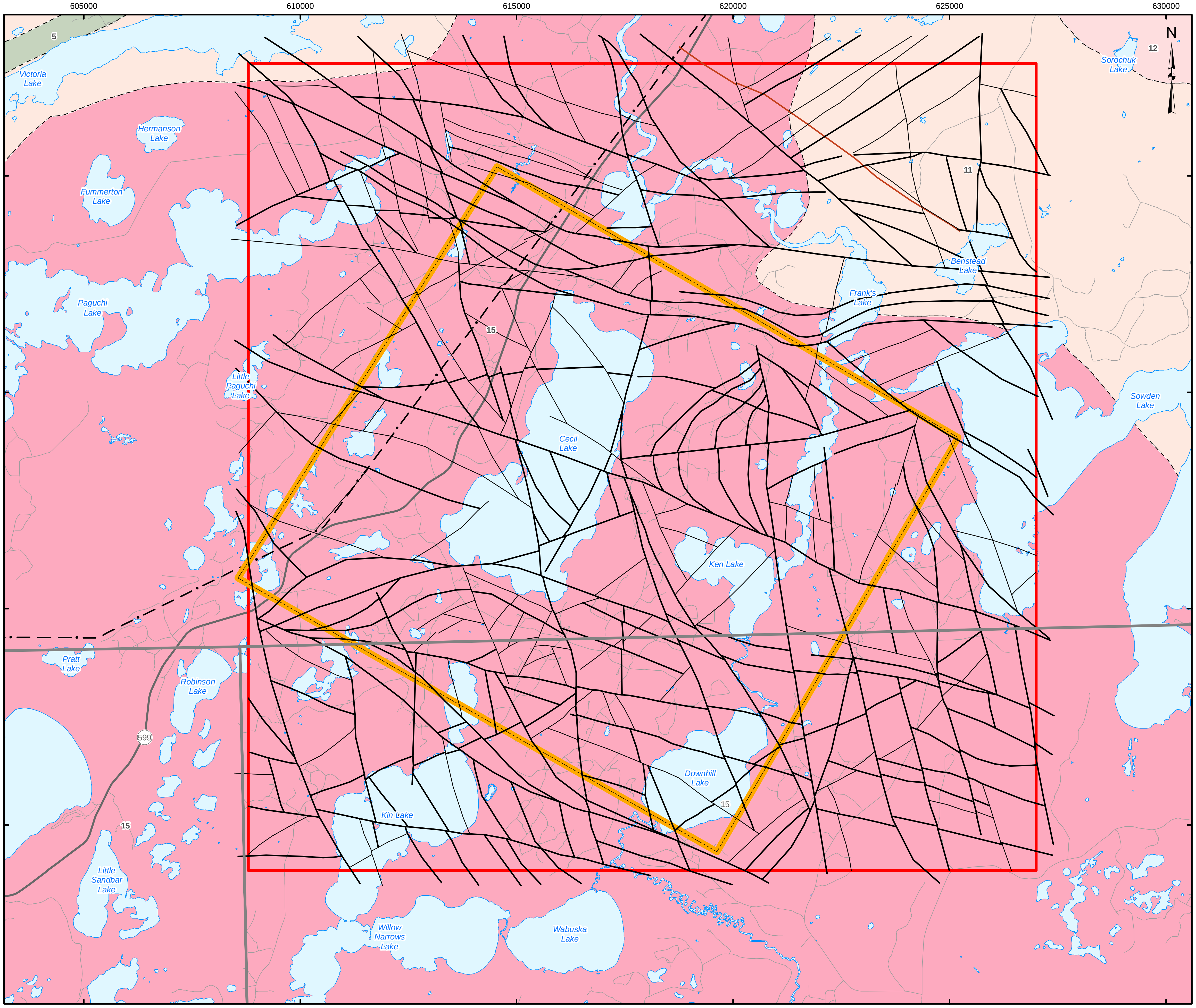

LEGEND

- Withdrawn Area
- Airborne Survey Block
- Main Road
- Local Road
- Transmission Line
- Waterbody
- Detailed Geology Extents

Magnetic Lineaments

- Medium Certainty
- High Certainty

Dyke Lineaments

- High Certainty

Bedrock Geology

- Bedrock Geology Outline
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- 16 Hornblendite - nepheline syenite suite
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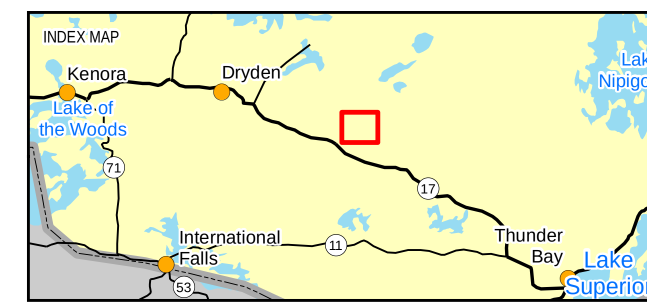
- 3 Mafic metavolcanic and metasedimentary rocks
- 1 Metasedimentary rocks and mafic to ultramafic metavolcanic rocks

INDEX MAP



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Projection: Universal Transverse Mercator
Datum: NAD 83 Coordinate System: UTM Zone 15N

Stone et al. 2007 (P3360)
Stone & Halle 2005 (P3401)

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SCALE 1:90,000 KILOMETRES

PROJECT

PHASE 2 GEOSCIENTIFIC PRELIMINARY ASSESSMENT
FINDINGS FROM INITIAL FIELD STUDIES
THE TOWNSHIP OF IGNACE, ONTARIO

TITLE

Magnetic Lineaments with High and Medium Certainty for the Eastern Portion of the Indian Lake Batholith

Golder Associates
Mississauga, Ontario

PROJECT NO. 12-1152-0026			SCALE AS SHOWN	REV. 0.0
DESIGN	CP	20 Feb. 2015		
GIS	JB/CP	3 Mar. 2015		
CHECK	CM	3 Mar. 2015		
REVIEW	GWS	3 Mar. 2015		

FIGURE: 5-7

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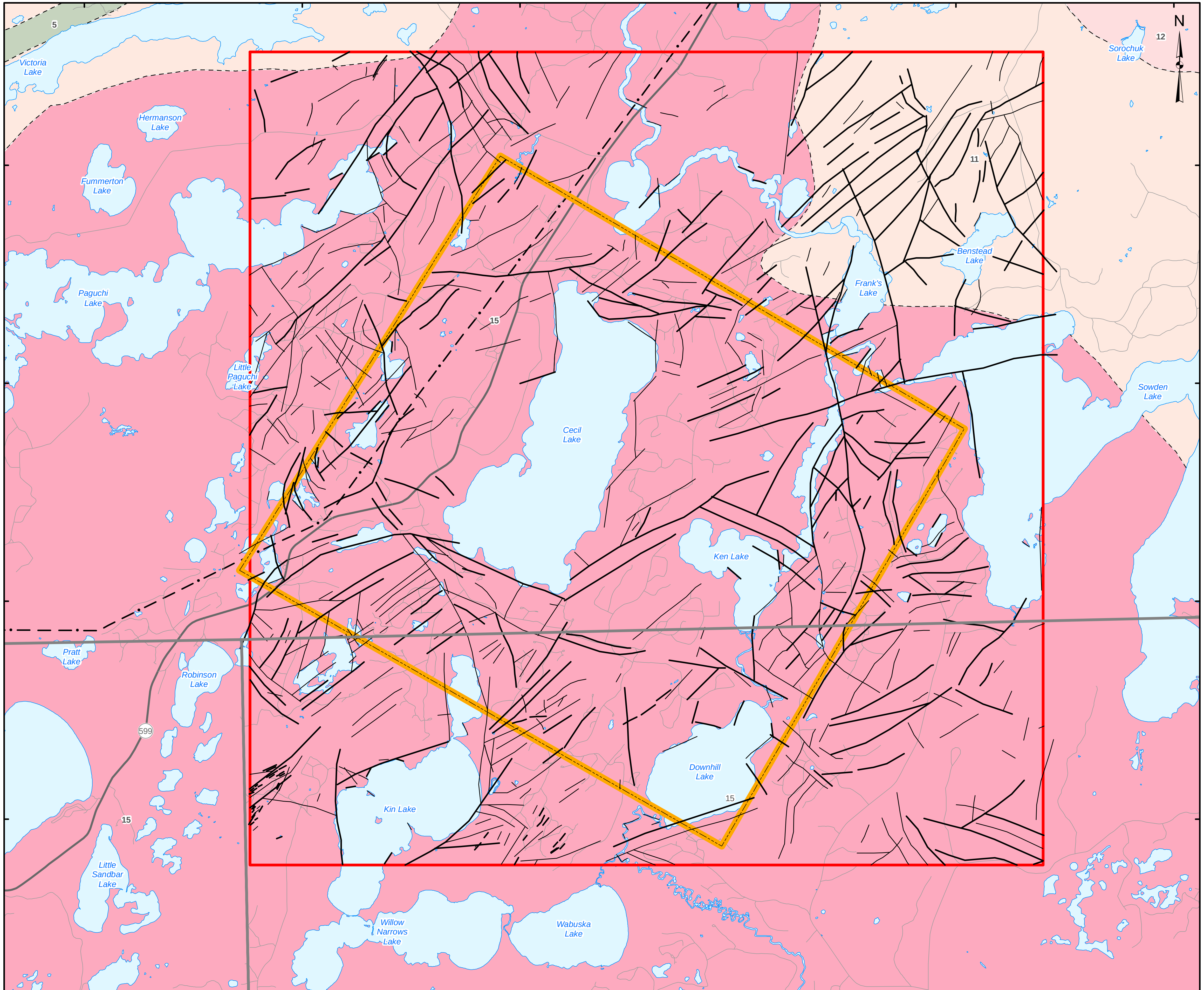

LEGEND

- Withdrawn Area
- Airborne Survey Block
- Main Road
- Local Road
- Transmission Line
- Waterbody
- Detailed Geology Extents

Surficial Lineaments

- Medium Certainty
- High Certainty

Bedrock Geology

- Bedrock Geology Outline
- 31 Sibley Gp.
- 23 Mafic and related intrusive rocks
- 16 Hornblendite - nepheline syenite suite
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INDEX MAP

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Projection: Universal Transverse Mercator
Datum: NAD 83 Coordinate System: UTM Zone 15N

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Stone & Halle 2005 (P3401)

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SCALE 1:90,000 KILOMETRES

PROJECT

PHASE 2 GEOSCIENTIFIC PRELIMINARY ASSESSMENT
FINDINGS FROM INITIAL FIELD STUDIES
THE TOWNSHIP OF IGNACE, ONTARIO

TITLE

Surficial Lineaments with High and Medium Certainty for the Eastern Portion of the Indian Lake Batholith

Golder Associates
Mississauga, Ontario

PROJECT NO. 12-1152-0026			SCALE AS SHOWN	REV. 0.0
DESIGN	CP	20 Feb. 2015	FIGURE: 5-8	
GIS	JB/CP	2 Mar. 2015		
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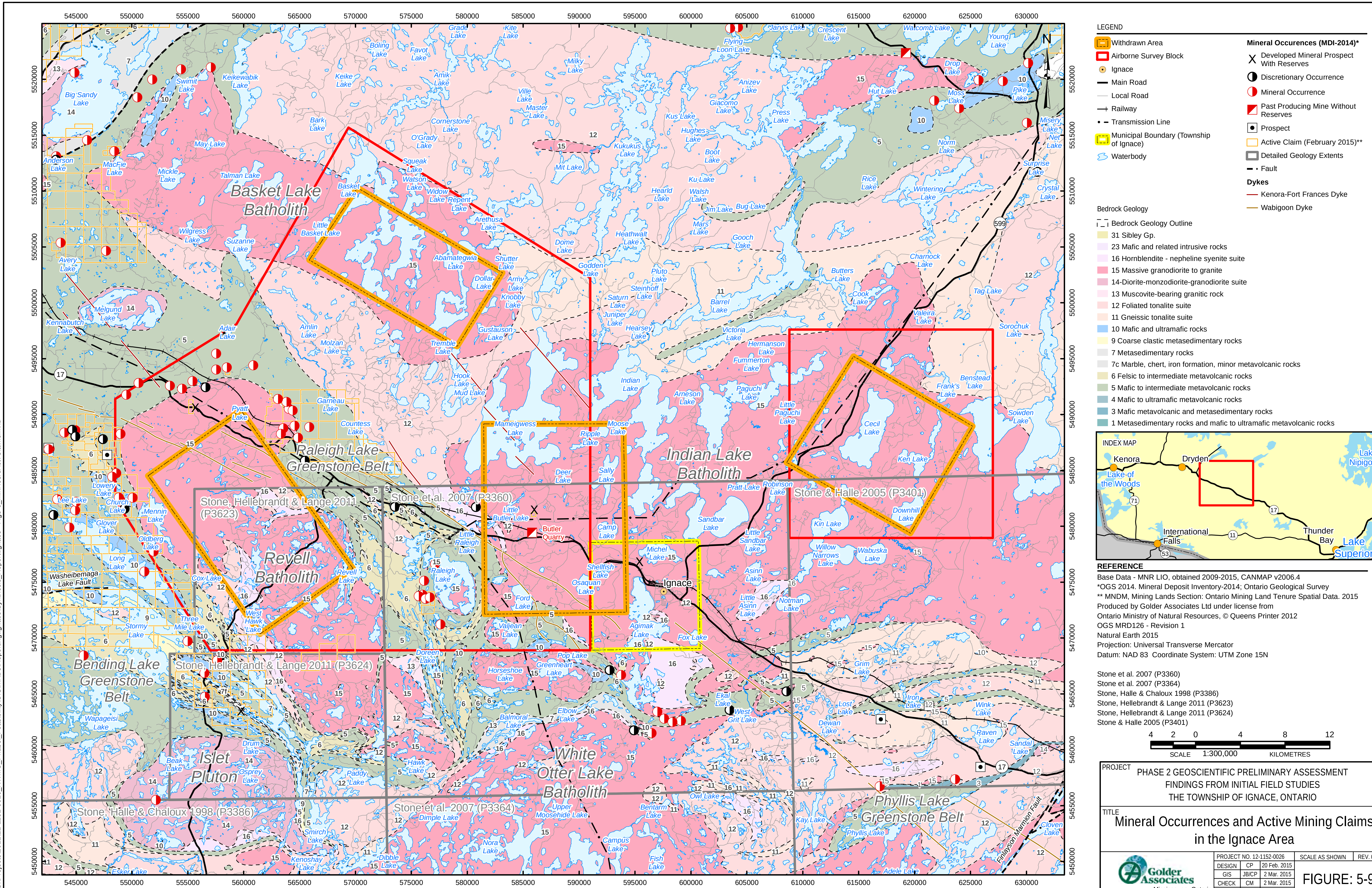

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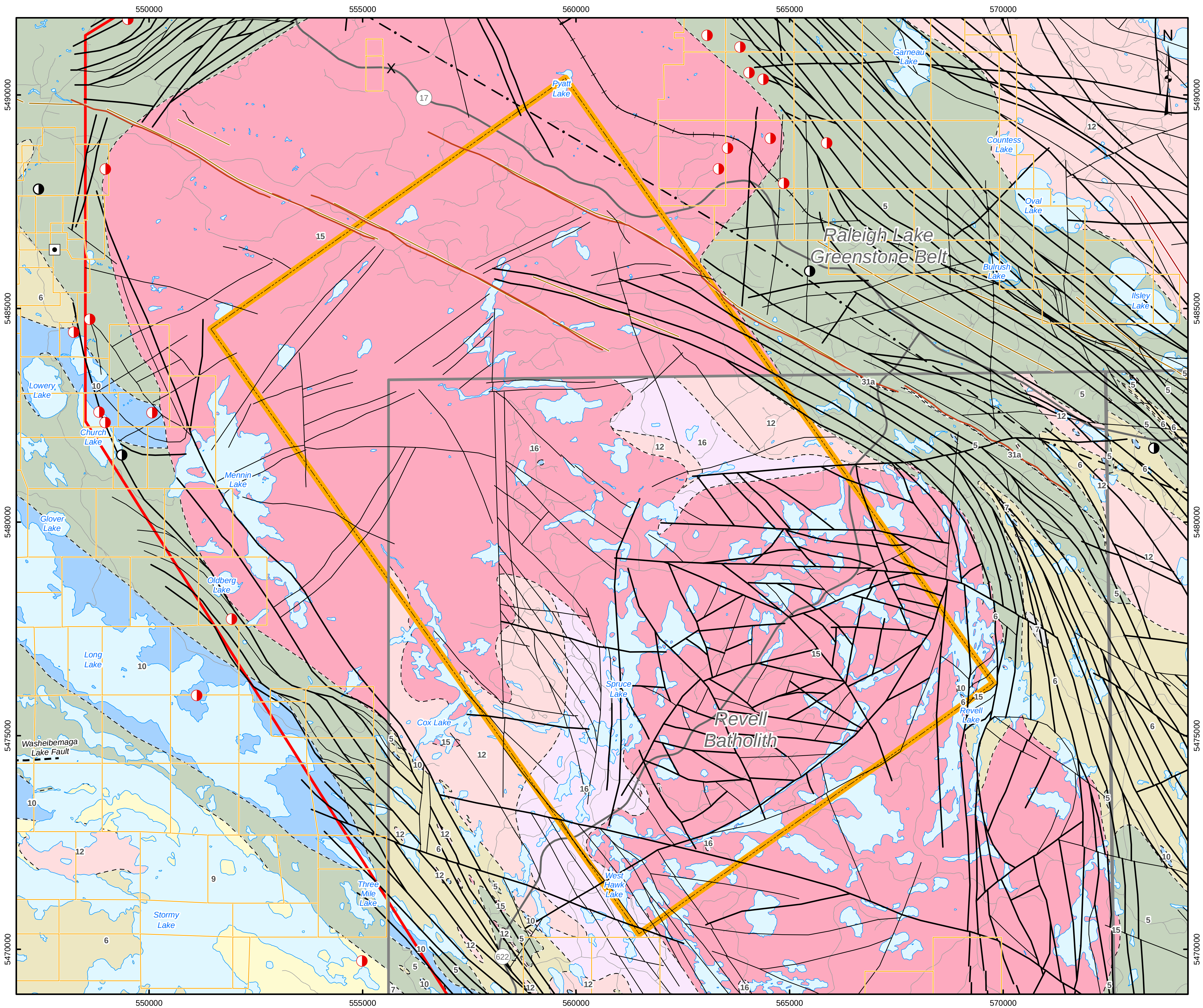

LEGEND

Withdrawn Area	**Mineral Occurences (MDI-2014)***
Airborne Survey Block	Developed Mineral Prospect With Reserves
Main Road	Discretionary Occurrence
Local Road	Mineral Occurrence
Railway	Prospect
Transmission Line	Active Claim (February 2015)**
Waterbody	Detailed Geology Extents
	Fault
	Dykes
	Kenora-Fort Frances Dyke
	Wabigoon Dyke
	Magnetic Lineaments
	Medium Certainty
	High Certainty
	Dyke Lineaments
	High Certainty

Bedrock Geology

- Bedrock Geology Outline
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Approximate Underground Repository Footprint (3 X 2 KM)

REFERENCE

Base Data - MNR LIO, obtained 2009-2015, CANMAP v2006.4
*OGS 2014. Mineral Deposit Inventory-2014; Ontario Geological Survey
** MNDM, Mining Lands Section: Ontario Mining Land Tenure Spatial Data. 2015
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Natural Earth 2015
Projection: Universal Transverse Mercator
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Stone, Hellebrandt & Lange 2011 (P3623)

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SCALE 1:90,000 KILOMETRES

PROJECT
PHASE 2 GEOSCIENTIFIC PRELIMINARY ASSESSMENT
FINDINGS FROM INITIAL FIELD STUDIES
THE TOWNSHIP OF IGNACE, ONTARIO

TITLE
Candidate Area in the Northern Part of the Revell Batholith with Magnetic Lineaments with High and Medium Certainty

Golder Associates
Mississauga, Ontario

PROJECT NO. 12-1152-0026			SCALE AS SHOWN	REV. 0.0
DESIGN	CP	20 Feb. 2015	FIGURE: 6-1	
GIS	JB/CP	3 Mar. 2015		
CHECK	CM	3 Mar. 2015		
REVIEW	GWS	3 Mar. 2015		

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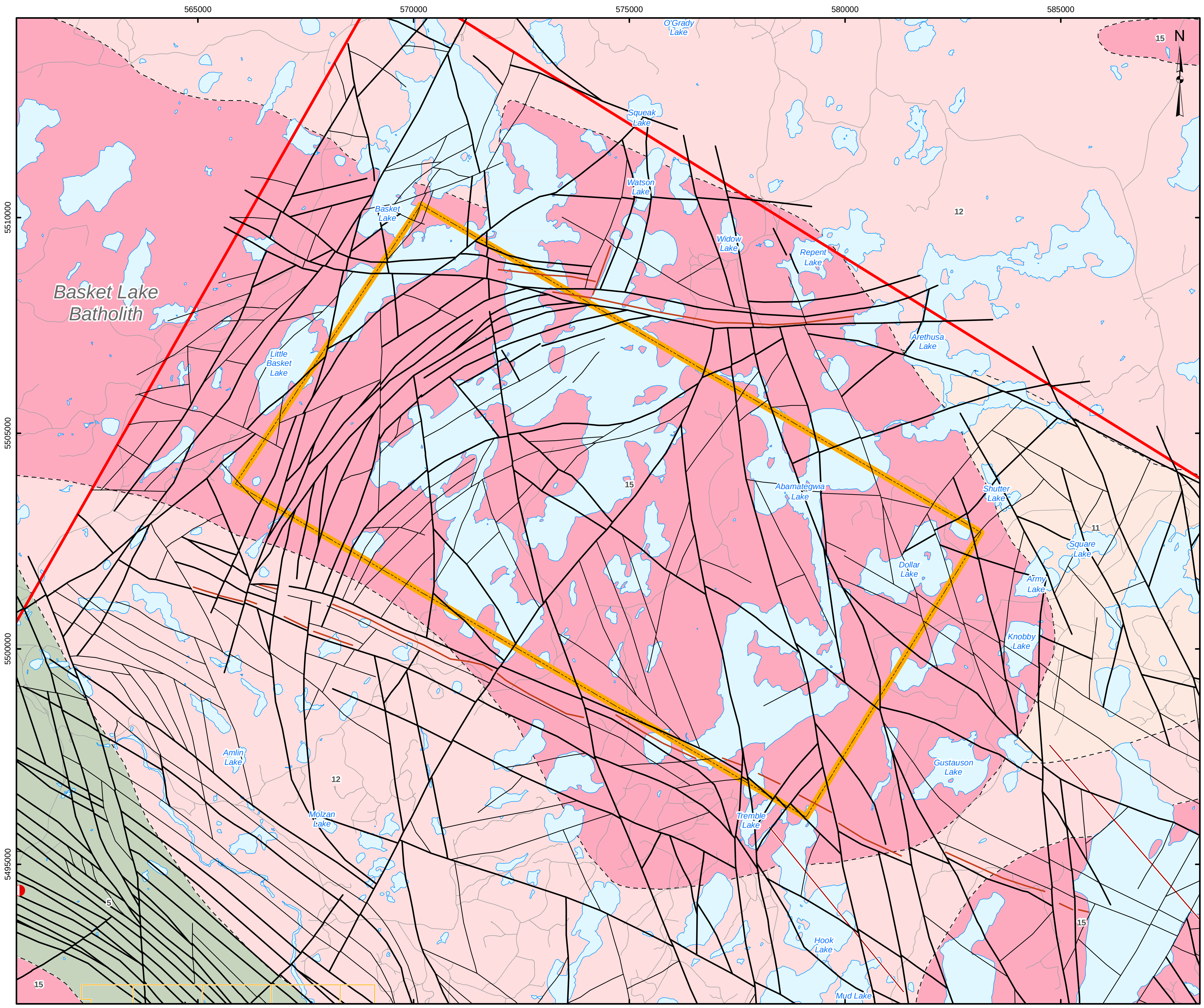

LEGEND

- Withdrawn Area
- Airborne Survey Block
- Local Road
- Waterbody

Mineral Occurences (MDI-2014)*

- Mineral Occurrence
- Active Claim (February 2015)**

Dykes

- Kenora-Fort Frances Dyke

Magnetic Lineaments

- Medium Certainty
- High Certainty

Dyke Lineaments

- High Certainty

Bedrock Geology

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Approximate Underground Repository Footprint (3 X 2 KM)

REFERENCE

Base Data - MNR LIO, obtained 2009-2015, CANMAP v2006.4
*OGS 2014. Mineral Deposit Inventory-2014; Ontario Geological Survey
** MNDM, Mining Lands Section: Ontario Mining Land Tenure Spatial Data. 2015
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OGS MRD126 - Revision 1
Natural Earth 2015
Projection: Universal Transverse Mercator
Datum: NAD 83 Coordinate System: UTM Zone 15N

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SCALE 1:90,000 KILOMETRES

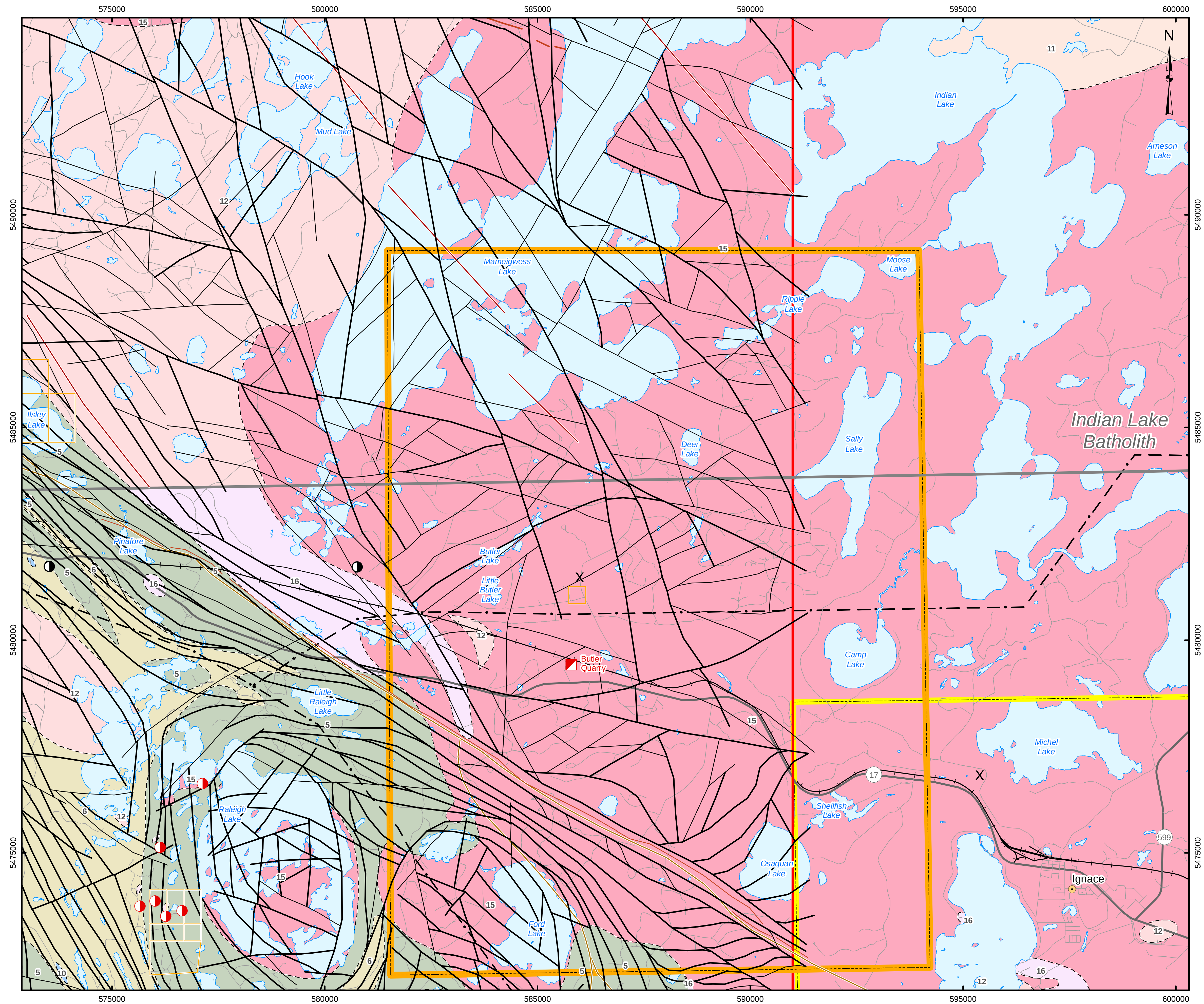
PROJECT
PHASE 2 GEOSCIENTIFIC PRELIMINARY ASSESSMENT
FINDINGS FROM INITIAL FIELD STUDIES
THE TOWNSHIP OF IGNACE, ONTARIO

TITLE
Candidate Area in the Basket Lake Batholith with Magnetic Lineaments with High and Medium Certainty

Golder Associates
Mississauga, Ontario

PROJECT NO. 12-1152-0026			SCALE AS SHOWN	REV. 0.0
DESIGN	CP	20 Feb. 2015	FIGURE: 6-2	
GIS	JB/CP	3 Mar. 2015		
CHECK	CM	3 Mar. 2015		
REVIEW	GWS	3 Mar. 2015		

G:\Projects\2012\12-1152-0026_NWMO_PhaseI_Feasibility\GIS\MXDs\Reporting\Ignace\Synthesis_Report\Ignace - Fig6-2_MagLinCandidate (Basket Lk).mxd



LEGEND

- Withdrawn Area
- Airborne Survey Block
- Ignace
- Main Road
- Local Road
- Railway
- Transmission Line
- Municipal Boundary (Township of Ignace)
- Waterbody

Mineral Occurences (MDI-2014)*

- Developed Mineral Prospect With Reserves
- Discretionary Occurrence
- Mineral Occurrence
- Past Producing Mine Without Reserves
- Active Claim (February 2015)**
- Detailed Geology Extents

Dykes

- Kenora-Fort Frances Dyke
- Wabigoon Dyke

Magnetic Lineaments

- Medium Certainty
- High Certainty

Dyke Lineaments

- Medium Certainty
- High Certainty

Bedrock Geology

- Bedrock Geology Outline
- 31 Sibley Gp.
- 23 Mafic and related intrusive rocks
- 16 Hornblendite - nepheline syenite suite
- 15 Massive granodiorite to granite
- 14-Diorite-monzodiorite-granodiorite 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
- 4 Mafic to ultramafic metavolcanic rocks
- 3 Mafic metavolcanic and metasedimentary rocks
- 1 Metasedimentary rocks and mafic to ultramafic metavolcanic rocks

Approximate Underground Repository Footprint (3 X 2 KM)

REFERENCE

Base Data - MNR LIO, obtained 2009-2015, CANMAP v2006.4
*OGS 2014. Mineral Deposit Inventory-2014; Ontario Geological Survey
** MNDM, Mining Lands Section: Ontario Mining Land Tenure Spatial Data. 2015
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OGS MRD126 - Revision 1
Natural Earth 2015
Projection: Universal Transverse Mercator
Datum: NAD 83 Coordinate System: UTM Zone 15N

Stone et al. 2007 (P3360)

1.5 0.75 0 1.5 3 4.5
SCALE 1:90,000 KILOMETRES

PROJECT
PHASE 2 GEOSCIENTIFIC PRELIMINARY ASSESSMENT
FINDINGS FROM INITIAL FIELD STUDIES
THE TOWNSHIP OF IGNACE, ONTARIO

TITLE
Candidate Area in the Western Portion of the Indian Lake Batholith with Magnetic Lineaments with High and Medium Certainty

Golder Associates
Mississauga, Ontario

PROJECT NO. 12-1152-0026			SCALE AS SHOWN	REV. 0.0
DESIGN	CP	20 Feb. 2015	FIGURE: 6-3	
GIS	JB/CP	3 Mar. 2015		
CHECK	CM	3 Mar. 2015		
REVIEW	GWS	3 Mar. 2015		

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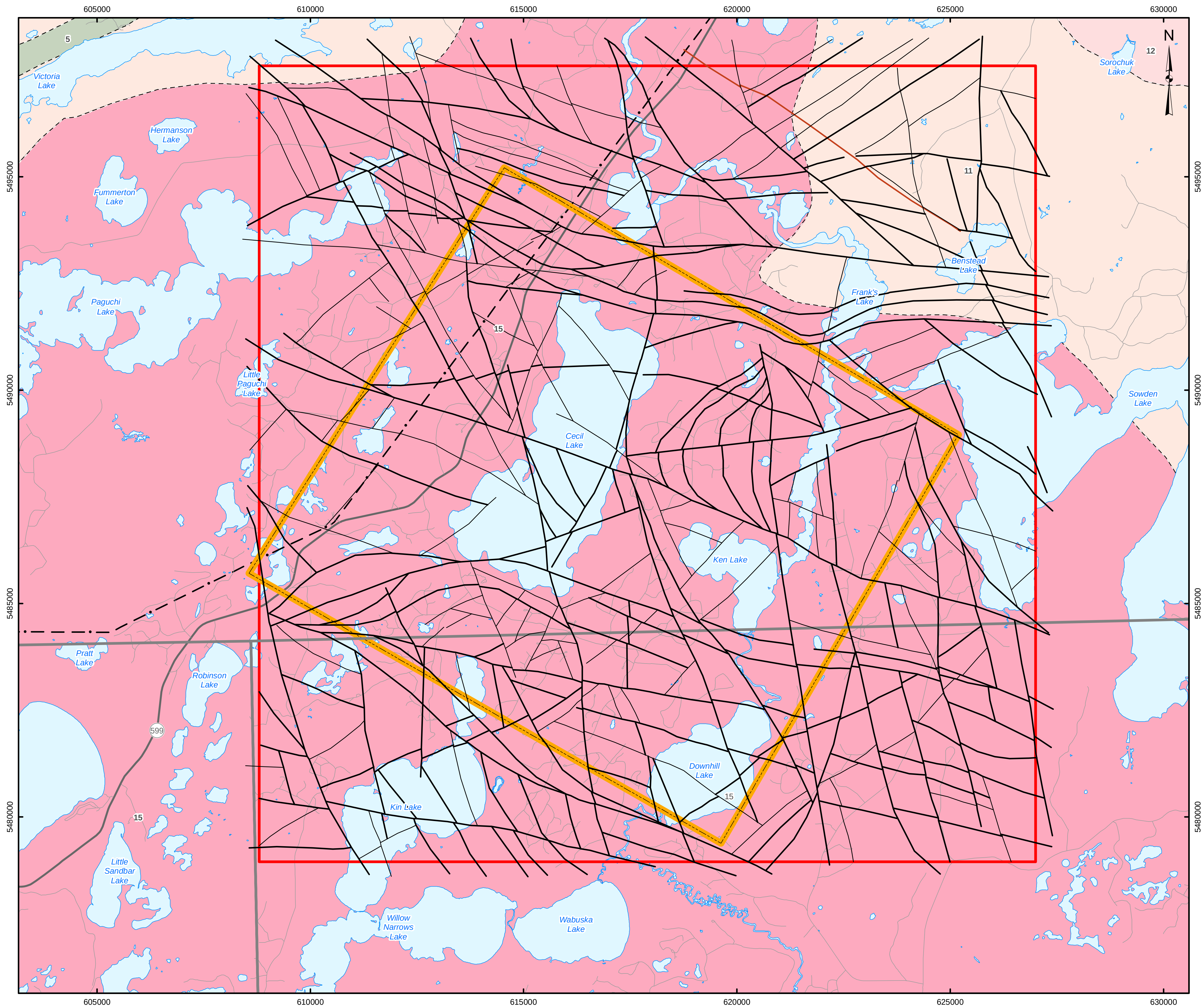

LEGEND

- Withdrawn Area
- Airborne Survey Block
- Main Road
- Local Road
- Transmission Line
- Waterbody
- Detailed Geology Extents

Magnetic Lineaments

- Medium Certainty
- High Certainty

Dyke Lineaments

- High Certainty

Bedrock Geology

- Bedrock Geology Outline
- 31 Sibley Gp.
- 23 Mafic and related intrusive rocks
- 16 Hornblendite - nepheline syenite suite
- 15 Massive granodiorite to granite
- 14-Diorite-monzodiorite-granodiorite 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
- 4 Mafic to ultramafic metavolcanic rocks
- 3 Mafic metavolcanic and metasedimentary rocks
- 1 Metasedimentary rocks and mafic to ultramafic metavolcanic rocks

Approximate Underground Repository Footprint (3 X 2 KM)

REFERENCE

Base Data - MNR LIO, obtained 2009-2015, CANMAP v2006.4
*OGS 2014. Mineral Deposit Inventory-2014; Ontario Geological Survey
** MNDM, Mining Lands Section: Ontario Mining Land Tenure Spatial Data. 2015
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OGS MRD126 - Revision 1
Natural Earth 2015
Projection: Universal Transverse Mercator
Datum: NAD 83 Coordinate System: UTM Zone 15N

Stone et al. 2007 (P3360)
Stone & Halle 2005 (P3401)

1.5 0.75 0 1.5 3 4.5
SCALE 1:90,000 KILOMETRES

PROJECT
PHASE 2 GEOSCIENTIFIC PRELIMINARY ASSESSMENT
FINDINGS FROM INITIAL FIELD STUDIES
THE TOWNSHIP OF IGNACE, ONTARIO

TITLE
Candidate Area in the Eastern portion of the Indian Lake Batholith with Magnetic Lineaments with High and Medium Certainty

Golder Associates
Mississauga, Ontario

PROJECT NO. 12-1152-0026			SCALE AS SHOWN	REV. 0.0
DESIGN	CP	20 Feb. 2015	FIGURE: 6-4	
GIS	JB/CP	3 Mar. 2015		
CHECK	CM	3 Mar. 2015		
REVIEW	GWS	3 Mar. 2015		

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