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LAKE-SEDIMENT AND WATER-SAMPLING SURVEY IN THE FRASER LAKE REGION, WESTERN LABRADOR

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ABSTRACT

The 2010 federal–provincial Geo-mapping for Energy and Minerals (GEM) Program included a lake-sediment and water-sampling survey over western Labrador. The survey area encompassed two complete and four partial NTS map sheets, over which a total of 769 sites were sampled at a density of one sample per 4.3 km^2. Results for the analysis of 48 elements in sediment samples and 29 elements in water samples will be available later in 2011.

The study area is partly underlain by Archean and/or Paleoproterozoic granite, tonalite and gneiss. Late Paleoproterozoic and early Mesoproterozoic gabbro–syenite and granite–charnockite complexes in the region show indications of enrichment in rare-earth and rare-metal elements. The dominant unit, an early Mesoproterozoic mafic intrusive complex that underlies the central portion of study area, is the focus of historical exploration for magmatic Ni–Cu mineralization.

INTRODUCTION

This report summarizes a helicopter-supported lake-sediment and water-sampling program, carried out over an area of approximately 3300 km^2 in the Fraser Lake area of western Labrador, in July and August 2010 (Figures 1 and 2). This study is a component of the larger Geo-mapping for Energy and Minerals (GEM) Program that focuses on areas north of the 60th parallel but also includes ‘activity locations’ in northwest Manitoba and northern Saskatchewan (Percival, 2009). The GEM program also supports geophysical and geological mapping studies that are complementary to geochemical sampling initiatives in these regions. The study area covers 1:50 000 NTS map areas 13L/05, 13L/06, 13L/12, 13L/13, 23I/08 and 23I/09 (Figure 3).

GEOLOGY AND MINERALIZATION

The survey area is covered by three bedrock geological maps. NTS map areas 13L/05 and 13L/06, and 13L/12 and 13L/13 were mapped by Nunn (1993, 1994a, b), while NTS map areas 23I/08 and 23I/09 form part of the area mapped by James (1994). The information contained in these maps was subsequently compiled into a geological map of Labrador (Wardle *et al*., 1997) from which the information in Figure 4 was extracted.

Bedrock units underlying the region include Archean and/or Paleoproterozoic granite and gneiss that occur to the north and southwest (A-Pg, A-Pggn and A-Psgn; NTS map areas 13L/12, 13L/13 and 23I/09; Figure 4). Neoarchean metatonalite and tonalite gneiss units (ANtgn) crop out in the east of the study area (NTS map areas 13L/05, 13L/06, 13L/12 and 13L/13). Mid-Paleoproterozoic granite and gra-

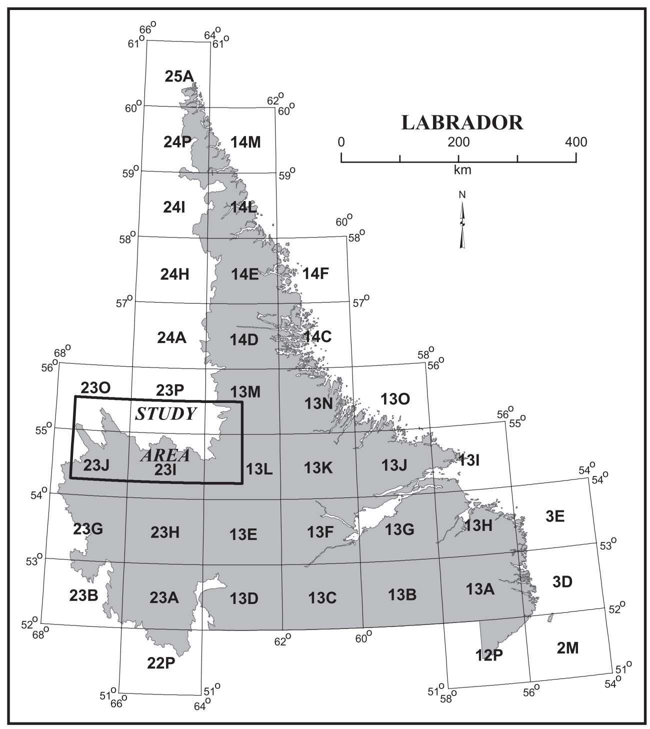

Figure 1. *Area of coverage of the GEM program in the Schefferville area of Labrador and Québec.*

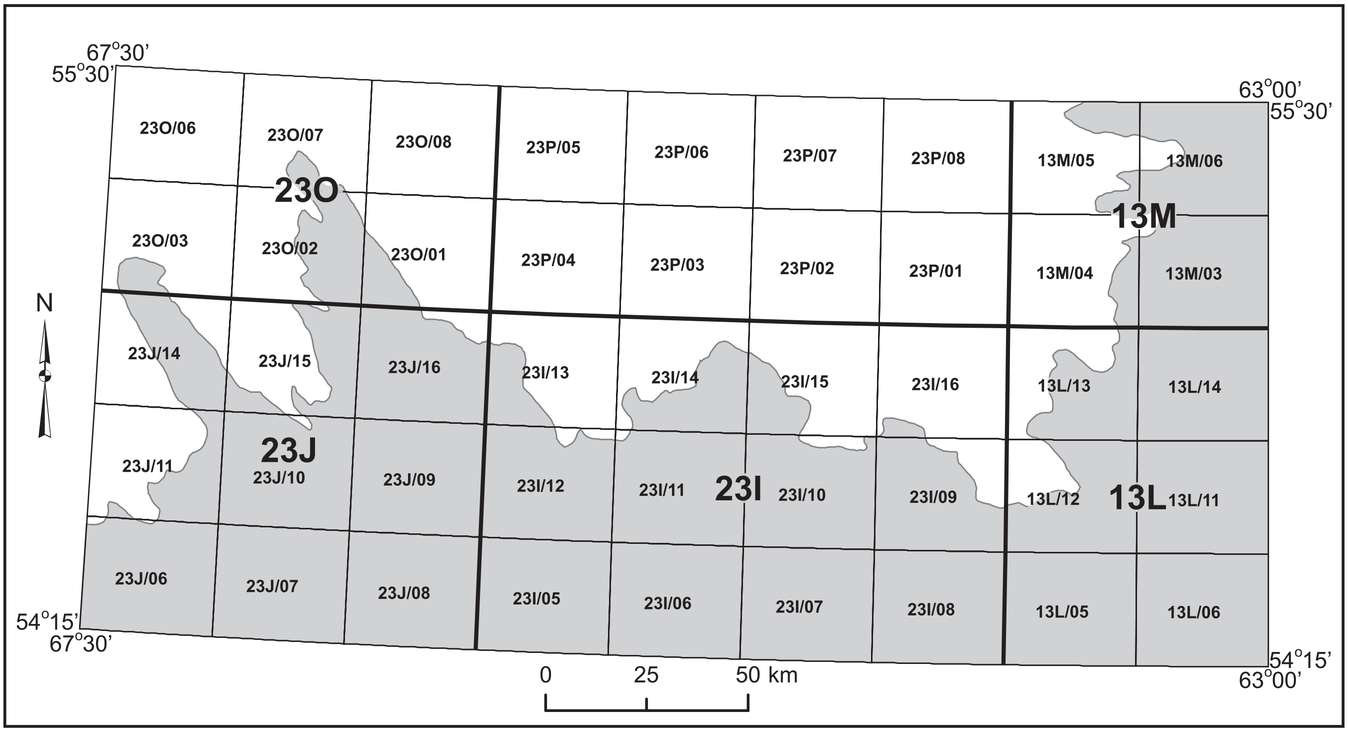

Figure 2. *NTS 1:50 000 map sheets comprising the GEM program in the Schefferville area of Labrador and Québec.*

nodiorite units (P2g; NTS map areas 23I/08 and of 23I/09) occur to the west of the extensive early Mesoproterozoic Michikamau Intrusion (M1a; NTS map areas 13L/06, 13L/12, 23I/08 and 23I/09). The Michikamau Intrusion, composed of leuconorite, leucogabbro, leucotroctolite and anorthosite, underlies the Smallwood Reservoir in the southwestern corner of the sampling area. The early Mesoproterozoic Michikamats intrusion of monzonite, charnockite and granite (M1g; NTS map areas 23I/09) crops out along the western boundary of the map area and to the east of the survey area. An unnamed late Paleoproterozoic complex of gabbronorite, amphibolite and mafic granulite (P3ga) and granite, quartz monzonite, granodiorite and syenite (P3gr) occurs in the southeast corner of the map area. The youngest rocks in the sampled region are the mid Mesoproterozoic Seal Lake Group arkose and quartzite units (M2aq) exposed in the east of map area 13L/06, and the north-central and south-central portions of NTS map areas 23I/08 and 23L/09.

Minor units include Archean anorthosite and leucogabbro (Aa), gabbro, metabasalt and metasediment (Amv), Neoarchean granitic gneiss (ANggn), mid Paleoproterozoic gabbro and leucogabbro (P2ga), pillow basalt and mafic pyroclastic rocks (P2pmv) and pelitic schist and pelitic phyllite (P2ss).

The Michikamau (mafic) Intrusion (M1a; Figure 4), particularly its eastern contact with Neoarchean metatonalite and tonalite gneiss units (ANtgn), is a prospecting target for magmatic Ni–Cu–Co mineralization. This has resulted in the discovery of the Fraser Lake prospect (63.8313ºW, 54.3276ºN; MODS, 2009) that consists of pyrrhotite, chalcopyrite and pentlandite hosted in melatroctolite and olivine norite (Dyke *et al*., 2004). Two additional Ni–Cu showings that occur within the Michikamau Intrusion are the Juno Grid and Sword Far North occurrences; both are farther from the intrusion's eastern contact with Unit ANtgn than the Fraser Lake prospect. At the Juno Grid showing (63.9679ºW, 54.2945ºN), one diamond-drill hole intersected an interval of 10.5 m averaging 0.36% Ni and 0.31% Cu, while a second intersected 3.1 m at 0.46% Ni and 0.40% Cu and 1.5 m at 0.52% Ni and 0.16% Cu (Brilliant Mining Corporation press release, September 24, 2006). At Sword Far North (63.9564ºW, 54.2945ºN), grab samples collected from an outcropping rusty zone in a creek bed assayed up to 1.28% Ni and 1.62% Cu (Brilliant Mining Corporation press release, August 30, 2007).

There are three further documented mineral occurrences within the Michikamau Intrusion (Figure 4). The Fraser Lake North Ti indication (63.6994ºW, 54.4961ºN) occurs as veinlets and disseminations of massive ilmenite approximately 22 km northeast of the Fraser Lake prospect (Emslie, 1964). Two indications of Fe mineralization occur near the intrusion's western, faulted contact in the Upper Border Zone. At Michikamau Lake Northwest No. 1 (64.3801ºW, 54.3985ºN) and Michikamau Lake Northwest No. 2 (64.2868ºW, 54.2872ºN), small magnetite-rich bands

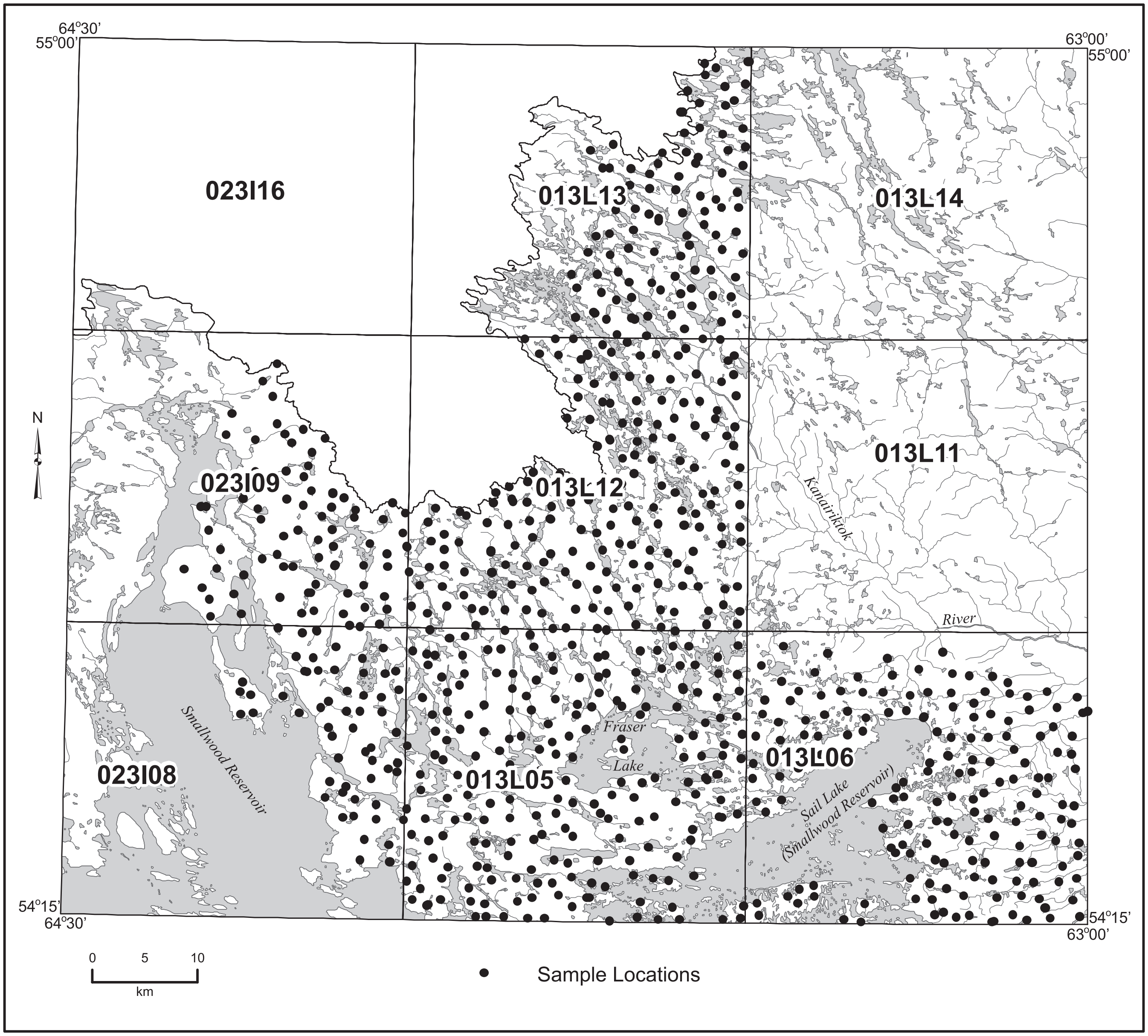

Figure 3. *Location of 2010 lake samples.*

and zones present in leucogabbro or gabbro may contain titanium (Emslie, 1964).

PREVIOUS WORK – GOVERNMENT

The geology of the study area has been mapped and described by Nunn (1993, 1994a, b), James (1994) and Wardle *et al.* (1997).

Lakes in the area were sampled at regional scale (one sample per 16 km^2) as part of the federal National Geochemical Reconnaissance (NGR) Program (Boyle *et al.*, 1981). The sediments were initially analyzed for Ag, As, Cd, Co, Cu, Fe, Mn, Mo, Ni, Pb, V and Zn using Atomic-Absorption Spectrophotometry (AAS); F, by Ion-Specific Electrode (ISE) analysis; Hg, by cold-vapour-AAS; U, by Neutron Activation/Delayed Neutron counting, and Loss-on-Ignition by gravimetry. The water samples were analyzed for fluoride ion by ISE, and for U by fluorimetry. The lake-sediment samples were subsequently recovered from the archives in the mid-1980s and analyzed by Instrumental Neutron-Activation Analysis (INAA) for Au, Ba, Ce, Co, Cr, Cs, Eu, Fe, Hf, La, Lu, Mo, Na, Ni, Rb, Sb, Sc, Sm, Ta, Tb, Th, U, W, Yb and Zn (Hornbrook and Friske, 1989).

Results of the NGR program indicate a strong fluoride anomaly in water over the Michikamats intrusion in the western portion of NTS map areas 23I/08 and 23I/09 (Fig-

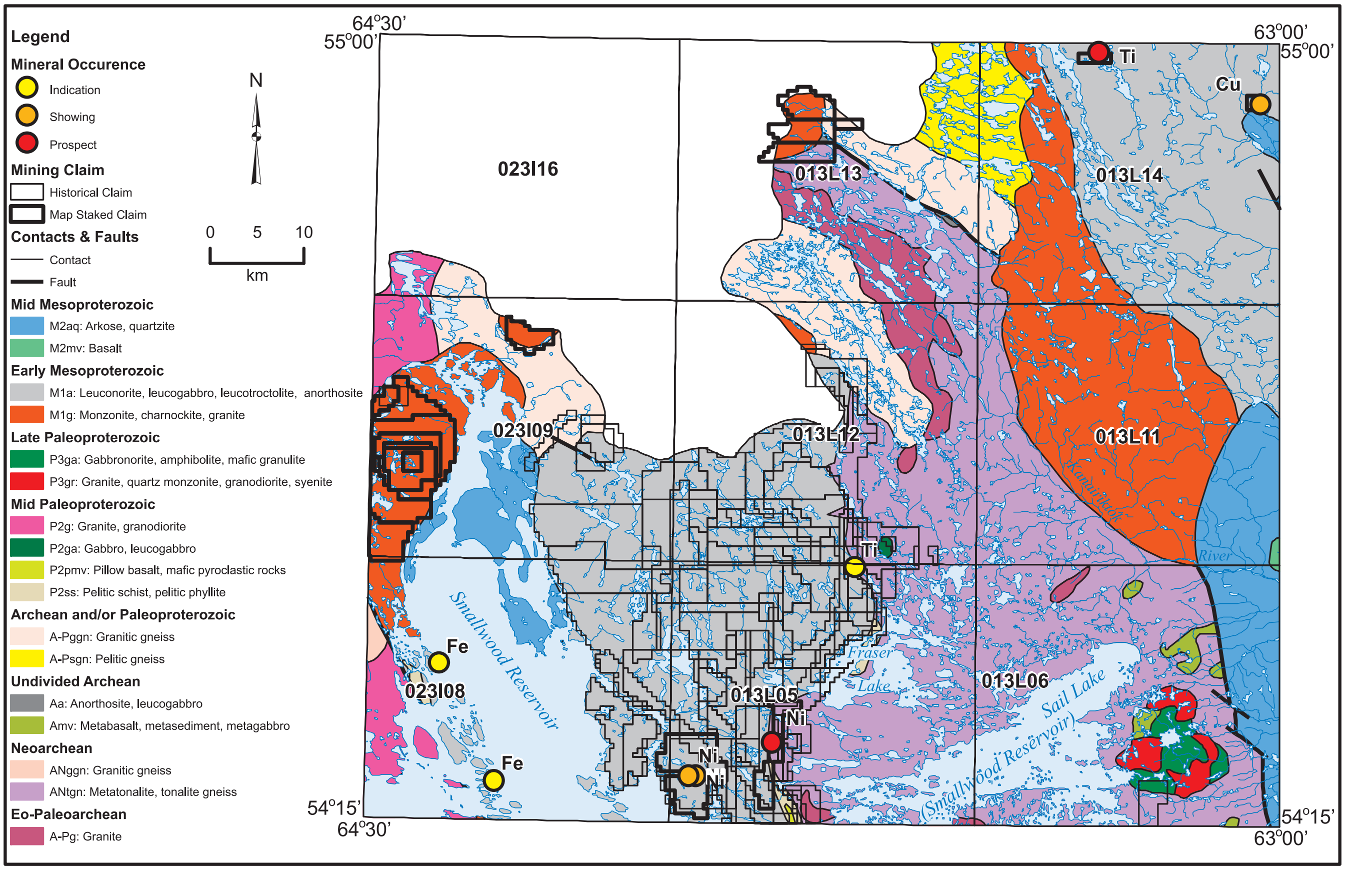

Figure 4. *Geological map of sampled area (A-Pg, A-Pggn, ANggn: Archean and/or Proterozoic granite and gneiss; ANtgn: Neoarchean metatonalite and tonalite gneiss; P2g: mid Paleoproterozoic granite and granodiorite; M1a: early Mesoproterozoic Michikamau Intrusion; M1g: early Mesoproterozoic Michikamats intrusion; P3a and P3gr: unnamed late Paleoproterozoic intrusive complex; M2aq: Mesoproterozoic Seal Lake Group arkose and quartzite; Aa: Archean anorthosite and leucogabbro; Amv: Archean metabasalt and metasediment; ANggn: Neoarchean granitic gneiss; P2ga: Paleoproterozoic gabbro and leucogabbro; P2pmv: Paleoproterozoic pillow basalt and mafic pyroclastic rocks; P2ss: Paleoproterozoic pelitic schist and pelitic phyllite). Expired (narrow borders) and current (thick borders) claims, as well as indications, showings, and prospects are shown.*

ure 3). This area was re-sampled in detail by McConnell (1989; *see* below). Well-defined lake-sediment and water anomalies, as defined by the NGR samples, are scarce within the study area. A sample collected over Unit P3ga (number 823079; NTS map area 13L/05) returned values in the uppermost 2.5-percentile for all of Labrador for Cd, Ce, Eu, La, Lu, Sm, Tb and Yb in lake sediment, as well as values between the 90- and 97.5-percentile for Ag, Au, Br, Fe, Hf, Mo, U and Zn in sediment and F^- in water. Most of the adjacent samples are not anomalous, although the southern part of the same, unnamed plutonic complex is marked by elevated values of fluoride in lake water. Fluoride anomalies in lake water are accompanied by anomalous Mo in lake sediment over the Michikamats intrusion in the west of NTS map area 23I/08 (Figure 4). Over a similar intrusion on the Québec border, in the north of NTS map area 13L/13, an anomaly of fluoride in water is accompanied by anomalous Lu, Sm, Tb, U and Yb in lake sediment. These anomalies have attracted recent attention from the mining industry.

A well-defined Zn anomaly, situated over the Michikamau Intrusion on NTS map area 13L/12, extends to the Québec border but does not continue into Québec (Maurice and Labbé, 2009).

The known Ni–Cu mineralization within the Michikamau Intrusion is not associated with a well-defined regional lake-sediment anomaly in these elements. However, two samples in its vicinity show anomalous or elevated values of Ni, Fe, Co, Ag, Cd, Ce, Mn and Zn. The results from the more detailed 2010 sampling program should determine if these anomalous values constitute random noise, or if a greater sampling density will define dispersion patterns for this type of mineralization.

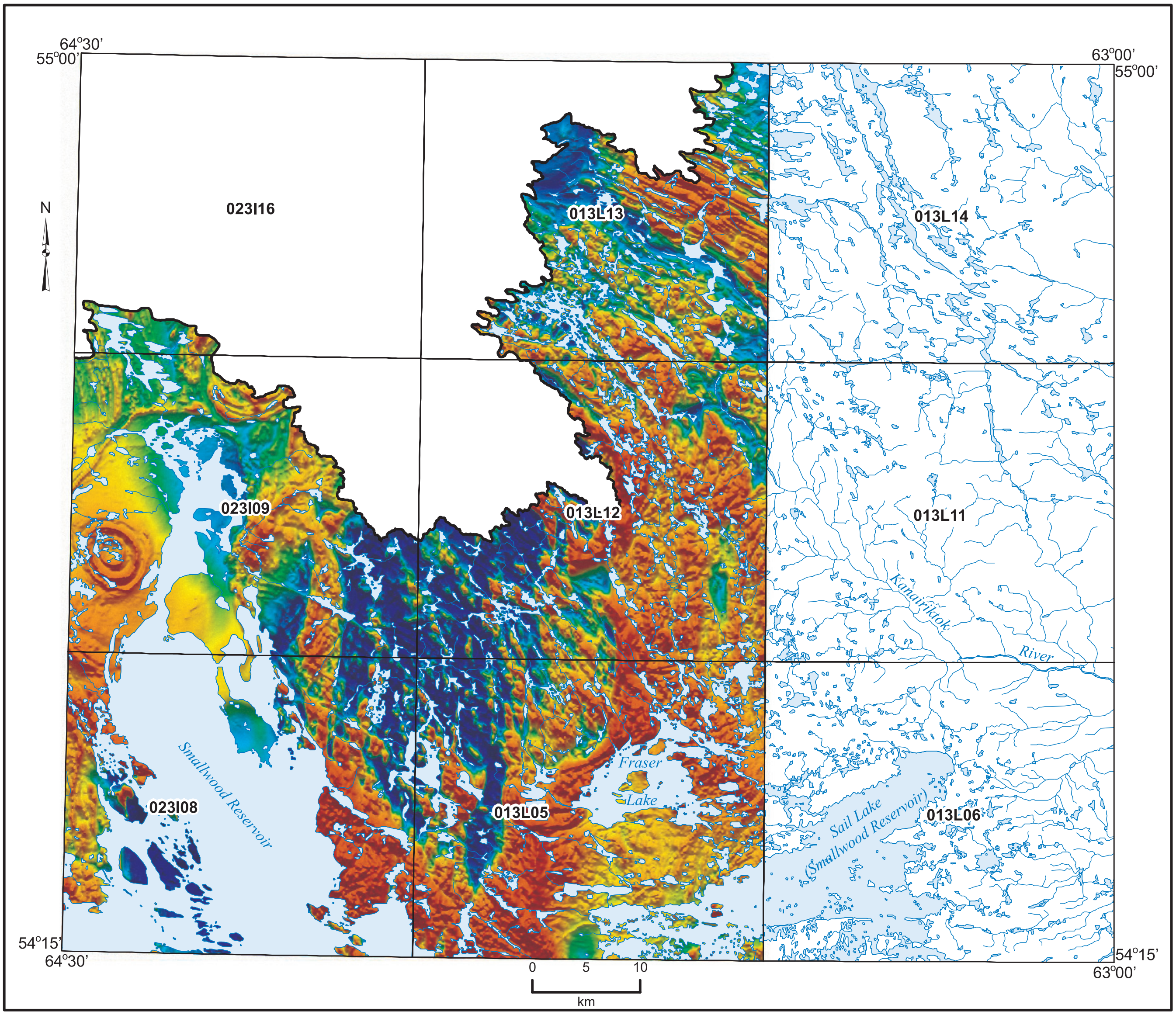

Figure 5. *Residual Total Magnetic Field over sampled area (from Dumont* et al.*, 2010). These data show the distinctive 'dart-board' anomaly associated with the Michikamats intrusion in the west, and the relatively low response of the Fraser Lake anorthosite (*see *Figure 4).*

McConnell (1989) carried out a more detailed lake-sediment and water-sampling program, at one sample per 4 km^2, over both the Michikamats and the NTS map area 13L fluoride anomalies. Analyses of samples collected over the Michikamats anomaly confirmed the fluoride ion response indicated in the NGR program, and returned anomalous or elevated lake-sediment values of Ba, Be, Ce, F, Hf, La, Na, Nb, Sc, Se, Sm, Sr, Ta, Tb, W, Y, Yb and Zn. Over the NTS map area 13L anomaly, strong, spatially clustered anomalous responses were reported for Be, F, Tb, Y and Yb in lake sediment and fluoride ion in water, with elevated or scattered anomalous responses in lake sediment for Ce, La, Lu, Sm, Th, U and Zn.

Detailed airborne radiometric and magnetic maps of the Schefferville region were released in March of 2010 (Dumont *et al.*, 2010) as a component of the GEM program. The coverage of airborne data extends eastward as far as NTS map areas 13L/05, 13L/12 and 13L/13 (Figures 5 and 6). The Residual Total Magnetic Field and First Vertical Derivative of the magnetic field data provide important new insights into the geology of the area. In particular, there is a concentric 'bulls-eye' anomaly that corresponds to the Michikamats geochemical anomaly (*see* above) and strongly resembles a feature at Quest Minerals Inc.'s Misery Lake rare-earth prospect in Québec.

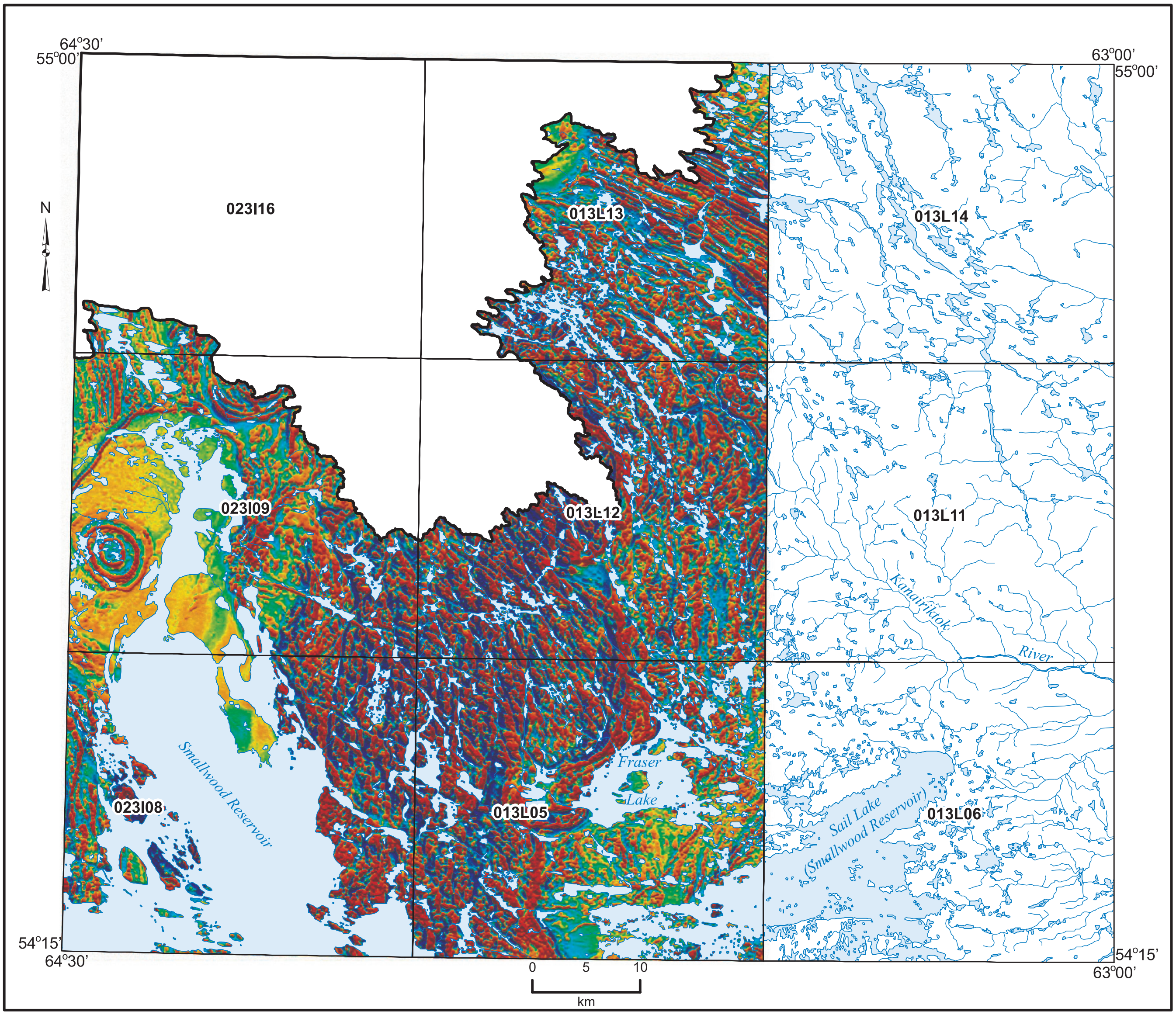

Figure 6. *First Vertical Derivative of Magnetic Field over sampled area (from Dumont* et al.*, 2010).*

The Michikamau Intrusion is generally characterized by a magnetic low (Figure 5). However, toward the southern portion of the study area, the intrusion underlies a magnetic high, as indicated in the residual total magnetic field map. This is less apparent in the First Vertical Derivative map (Figure 6). A magnetic high occurs along the eastern contact of the Michikamau Intrusion with the Neoarchean metatonalite and tonalite gneiss units (ANtgn). Both of these areas are in the vicinity of Brilliant Mining Corp's discoveries and are underlain by mafic and ultramafic rocks. The lower magnetic susceptibilities may be associated with anorthosite.

PREVIOUS WORK – INDUSTRY

The Michikamau Intrusion has been the focus of considerable exploration activity, mainly directed at magmatic Ni–Cu (plus Co and platinum group metals) mineralization. The distribution of all current claims, as well as expired claims for which assessment reports have been filed with the Newfoundland and Labrador Department of Natural Resources, is shown in Figure 4.

The most advanced exploration has been carried out by three companies: Kennecott Canada in joint venture with

Noranda Exploration (1992 and 1993); Teck-Cominco (2005 and 2006); and Brilliant Mining Corp. (2005 and 2006). All three companies carried out diamond-drilling programs, with Kennecott's work leading to the discovery of the Fraser Lake prospect. Basing its approach on a new model, Brilliant Mining Corp. concentrated exploration efforts on an area away from the intrusion's eastern contact (Finnigan, 2006). This resulted in the discovery of the Juno Grid and Sword Far North showings.

SURFICIAL GEOLOGY AND ENVIRONMENT

Elevations in the study area vary from 471 m above sea level, at the Smallwood Reservoir, to 648 m near the border with Québec (NTS map area 13L/12). The only major watercourse is the Kanairiktok River, which flows in a southeasterly direction across NTS map areas 13L/13 and the northeastern corner of 13L/12.

The GEM study area is close to an ice centre and as a result, within an area of complicated ice-flow pattern, compared to much of the rest of Labrador. It is also the area of last ice in the Province, at approximately 7500 years BP. Inferred ice-flow directions indicate at least four events (Klassen and Thompson, 1990):

Event 1: Northeastward flow
Event 2: Northeastward flow
Event 3: South-southeastward flow
Event 4: Northeastward flow

Despite the later effects of glaciation on the morphology of the present-day landscape, there is a strong geological control on topography. Rugged terrain is associated with the Michikamau Intrusion and the early Mesoproterozoic granitic intrusions of monzonite, charnockite and granite (M1g) in the east and west. Topography over metatonalite and tonalite gneiss (Unit ANtgn), in the south of NTS map areas 3L/05 and 13L/06, is relatively flat, low-lying and swampy.

Surficial deposits are dominated by undifferentiated till consisting of silty to sandy diamicton, with some glaciofluvial, glaciolacustrine and fluvial deposits (Figure 7). There is minor glacial drift cover in the northeast of NTS map area 23I/08 and the southeast of 23I/09; and ablation drift is present to the northwest of Sail Lake in the western portion of NTS map area 13L/06 and in the southeast area of 13L/05. Drumlin or fluting orientations are predominantly north–south (Klassen *et al*., 1992). The majority of eskers have a generally southeastward orientation.

SAMPLE COLLECTION

Sampling was carried out from a float-equipped Bell 206-BL helicopter. A wooden platform was attached to the port side of the helicopter to facilitate sample retrieval but a winch was not used. Both sediment and water sampling followed procedures developed and described by McConnell (2009). Sample sites were selected by laying a 2-km grid over the area to be sampled and selecting one lake or pond within each cell for sampling. Generally, smaller bodies of water were selected in preference to larger ones. The presence of larger lakes in which few or no samples were collected (*i.e.*, the Smallwood Reservoir), decreased the overall sampling density from the theoretical one per 4 km^2 to approximately one per 4.3 km^2. Figure 3 shows the sample coverage and Table 1 summarizes the sampling statistics, with corresponding 2009 figures for comparison.

Table 1. Sampling statistics

	2010	2009
Duration of program (days)	18	18
Days lost to bad weather	3.5	3
Total helicopter hours	98.1	108.5
Sites sampled	769	1018
Field duplicate sites	42	51
Water-only sites	108	32
Minimum sampled lake depth (m)	0.3	0.2
Median sampled lake depth (m)	1.5	2.0
Maximum sampled lake depth (m)	15	14
Median lake area (km^2)	0.03	0.1

Two duplicate sample sites were selected randomly from every sequence of 20 sample locations. The two duplicate sites were typically separated by a distance of 50 to 100 m. The following field parameters are recorded at each site: UTM coordinates, sample depth, nature of vegetation surrounding the lake, sample colour, water colour, sample composition, potential sources of contamination and duplicate status. The NTS 1:50 000-map sheet number, lake area and lithological classification of the upstream drainage cell are also documented.

Lake-sediment samples were collected using a tubular steel sampler, fitted with a butterfly valve that opens on impact with the sediment and closes as the sample is retrieved. The sampler is designed so that once retrieved, it can be inverted and the contained sediment poured into a plastic container and thence into the sample bag. The rope used for retrieving the sampler is marked at 1 m intervals to estimate water depth at the point of sampling. Samples were

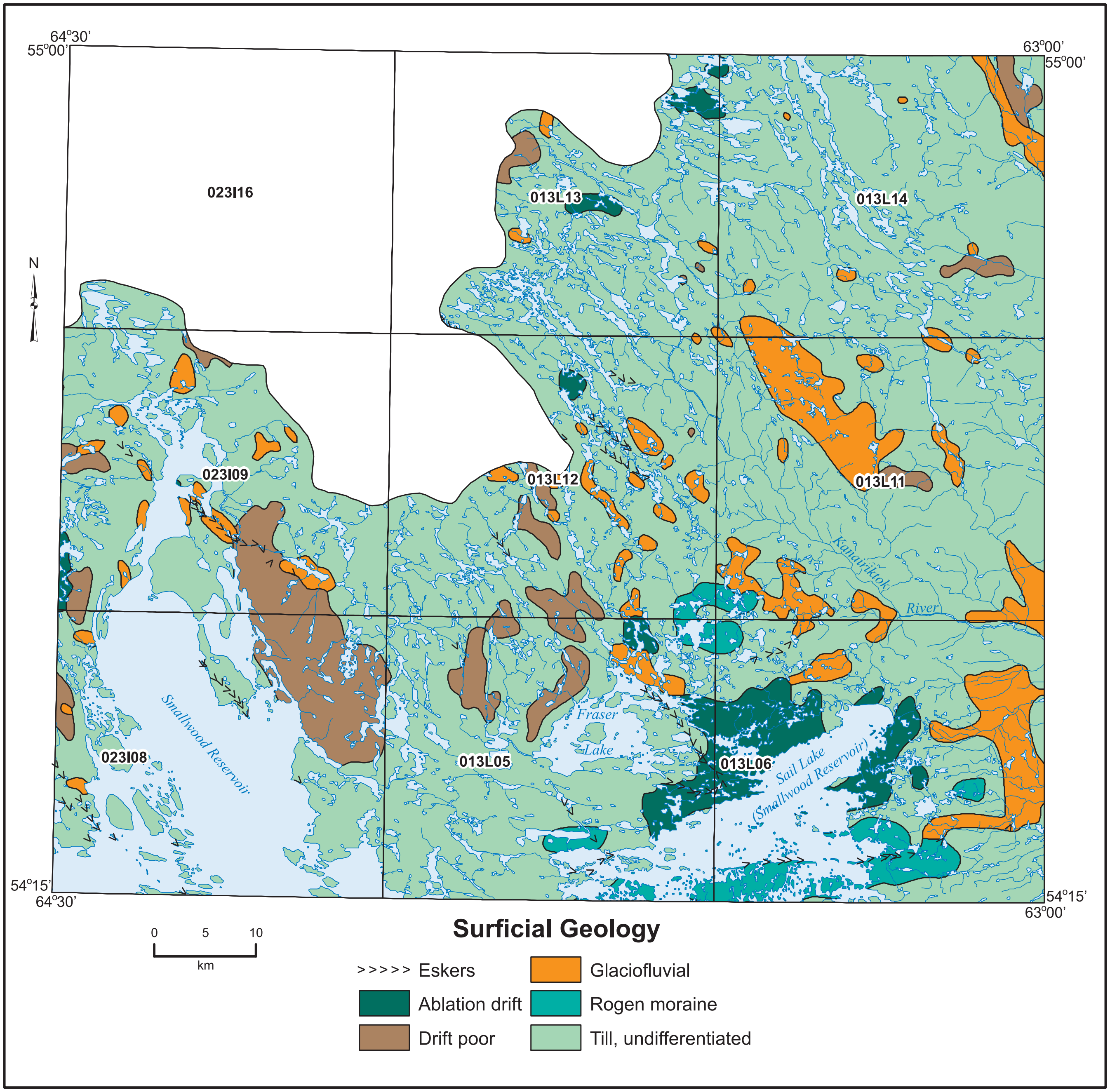

Figure 7. *Surficial geology of sampled area based on Klassen* et al. *(1992).*

stored in pre-numbered, water-resistant Kraft paper bags and air-dried at ambient temperatures for a few days before being shipped to the lab in steel pails.

Water samples were collected in purified Nalgene bottles, cleaned in the lab by leaching with acid and rinsing with distilled and de-ionized water. After collection, the sample bottles were stored in a buried metal chest before being shipped in coolers.

SAMPLE PREPARATION AND ANALYSES

Sediment samples were dried at 40º C, before being disaggregated using a mortar and pestle and screened through a 180 micron (80 mesh) stainless-steel sieve. Results from the analysis of the following parameters are expected during 2011:

- Ag, As, Au, Ba, Br, Ca, Ce, Co, Cr, Cs, Eu, Fe, Hf, La, Lu, Mo, Na, Nd, (Ni), (Rb), Sb, Sc, Sm, Sr, Ta, Tb, Th,

U, W, Yb, Zn and Zr by INAA
- Al, As, Ba, Be, Ca, Cd, Ce, Co, Cr, Cu, Dy, Fe, K, La, Li, Mg, Mn, Mo, Na, Nb, Ni, P, Pb, Rb, Sc, Sr, Ti, V, Y, Zn and Zr by ICP-ES after 'total' (HF-$HClO_4$-HNO_3) digestion
- Ag by AAS after HNO_3 digestion
- F by Fluoride-ion Specific Electrode after Na_2CO_3/KNO_3 fusion
- Loss-on-Ignition in muffle furnace (500º C), by gravimetric methods

With the exception of pH, conductivity and fluoride ion, all water analyses take place after 0.45 micron millipore filtration and HNO_3 acidification. The water samples will be analyzed for the following parameters:

- pH by Corning combination pH electrode
- Conductivity by Corning conductivity sensor
- F by Fluoride-ion Specific Electrode
- Ca, Fe, K, Mg, Mn, Na, Si, SO_4 by ICP-ES
- Al, Ba, Be, Co, Cr, Cu, Li, Mo, Ni, P, Pb, Sr, Ti, V, Y, Zn by ICP-ES/ultrasonic nebulizer
- U by ICP-mass spectrometry

SUMMARY OF FIELD SAMPLING DATA

The areal distribution and relative frequencies of sample depths, sample colours, sediment textural types and shoreline vegetation types are summarized in Figures 8–11.

Approximately three-quarters of the samples were collected at water depths of 2 m or less (Figure 8). The deepest sample was recovered at a water depth of 15 m in the northeast portion of NTS map area 23I/08, where there is a high concentration of deep lakes associated with the rugged terrain overlying the Michikamau Intrusion, particularly the latter's portion of low magnetic susceptibility and inferred anorthositic composition (Figures 4 and 8).

Sampled sediments were mostly reported as 'greenish brown' or 'brown – jelly-like' and these two types occur together over most of the study area (Figure 9). Exceptions include concentrations of 'Chocolate brown' samples in the centre of NTS map area 13L/05, and of 'green' samples along the northern boundary of the same map area.

Approximately three-quarters of the samples consisted of 'Organic Ooze' (Figure 10). An 'Organic Granular' sample composition is dominant over NTS map area 13L/13 and also the southeast part of 13L/12. Samples with a fine-grained, clastic composition are most common in the NTS map area 23I/09.

The most dominant shoreline vegetation types are 'Mixed Forest and Swamp' and 'Forest' (Figure 11). A mixture of these two vegetation types characterizes NTS map area 23I/08 in the southwest and NTS map areas 23I/09, 13L/12 and 13L/13 in the north. 'Mixed Forest and Swamp' covers most of 13L/05 and 13L/06, in the southeast of the study area. 'Swamp' vegetation is concentrated to the northwest of Sail Lake, while 'Rock and Forest' is focused in a conspicuous east–west-trending band near the northern border of NTS map area 13L/05. There is an extensive burned area in the southeast of NTS map area 13L/12.

CONCLUSIONS

The Geo-mapping for Energy and Minerals Program in the Schefferville activity centre was continued in the summer of 2010 with a helicopter-supported lake-sampling program in the Fraser Lake area. A total of 769 sites were sampled over a three-week period, at an overall density of one per 4.3 km^2. Sampled lake depths ranged from 0.3 to 15 m and the median area of the lakes sampled was 0.03 km^2.

ACKNOWLEDGMENTS

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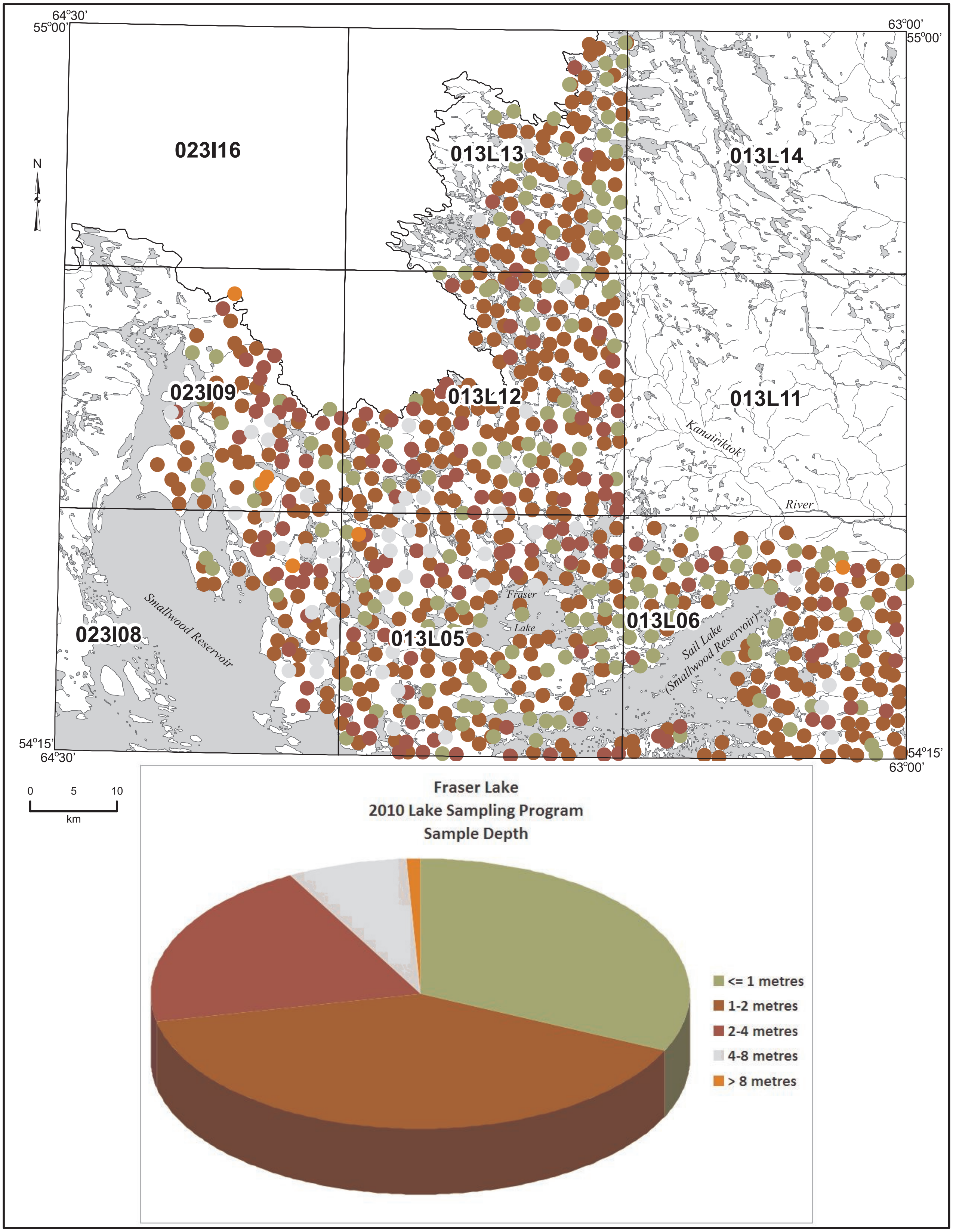

Figure 8. *Areal distribution of lake depths at sample locations and pie-chart showing frequency of sample depth classes in sampled lakes.*

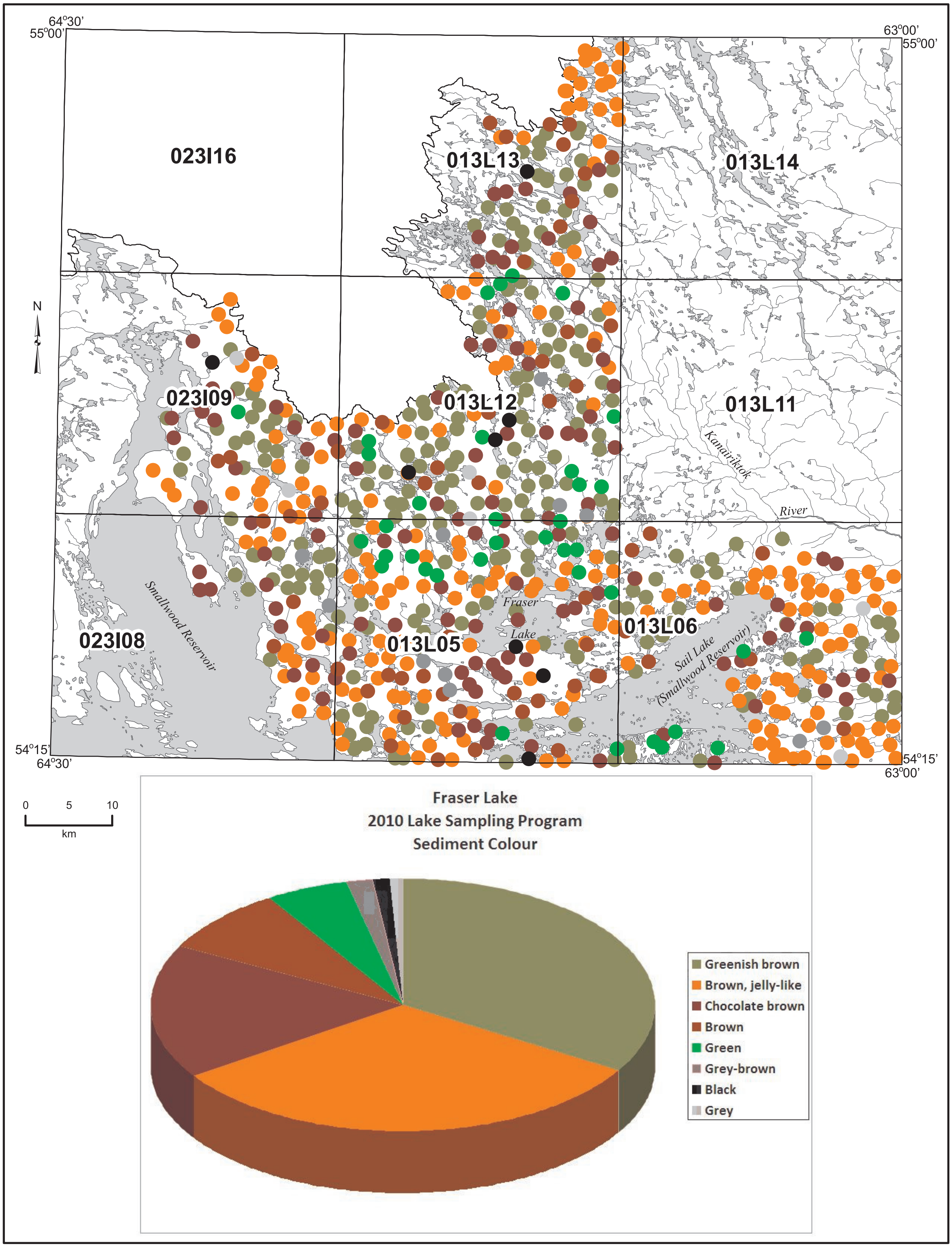

Figure 9. *Areal distribution of sediment colours at sample locations and pie-chart showing frequency of sediment colours sampled.*

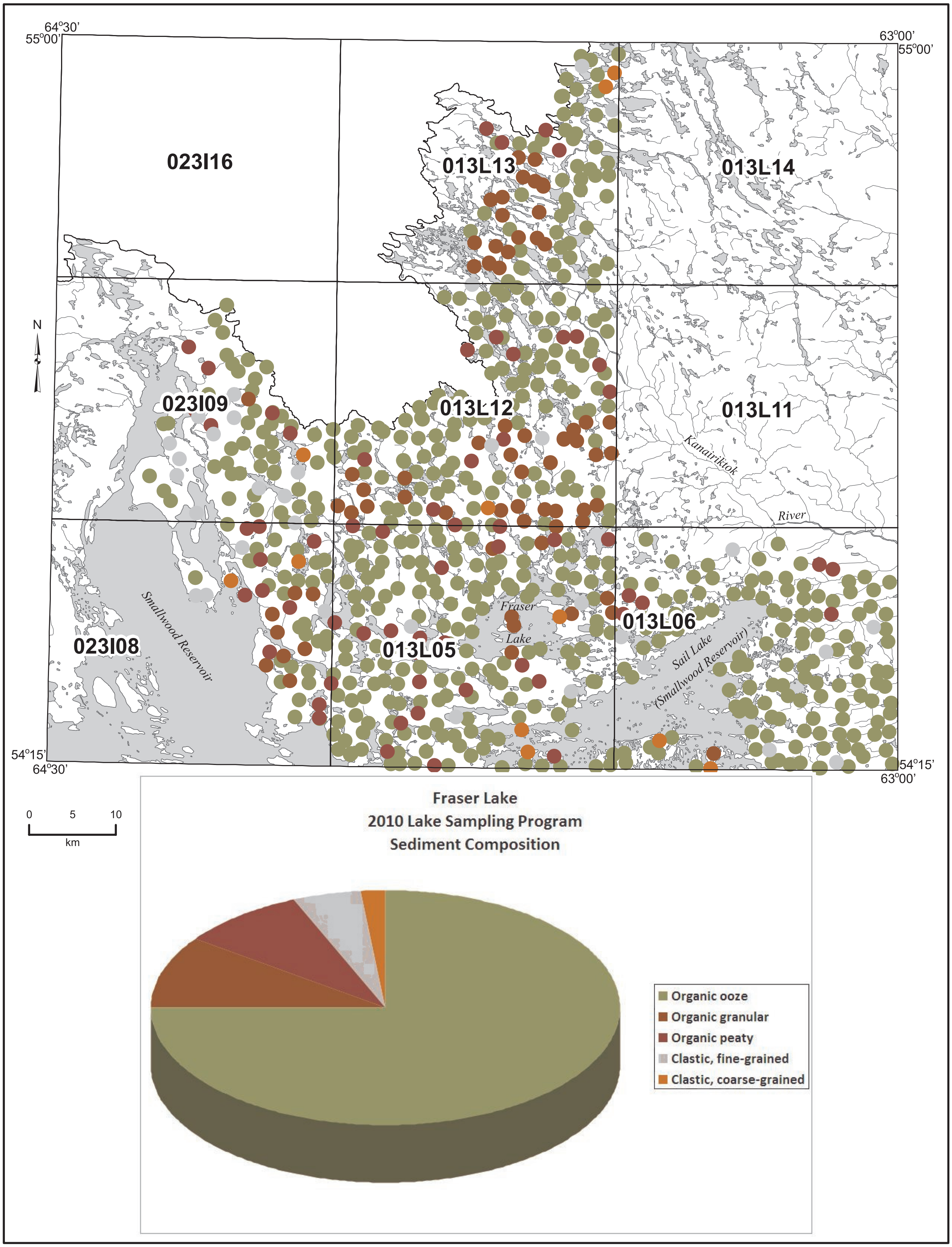

Figure 10. *Areal distribution of sediment textures at sample locations and pie-chart showing frequency of sediment textures sampled.*

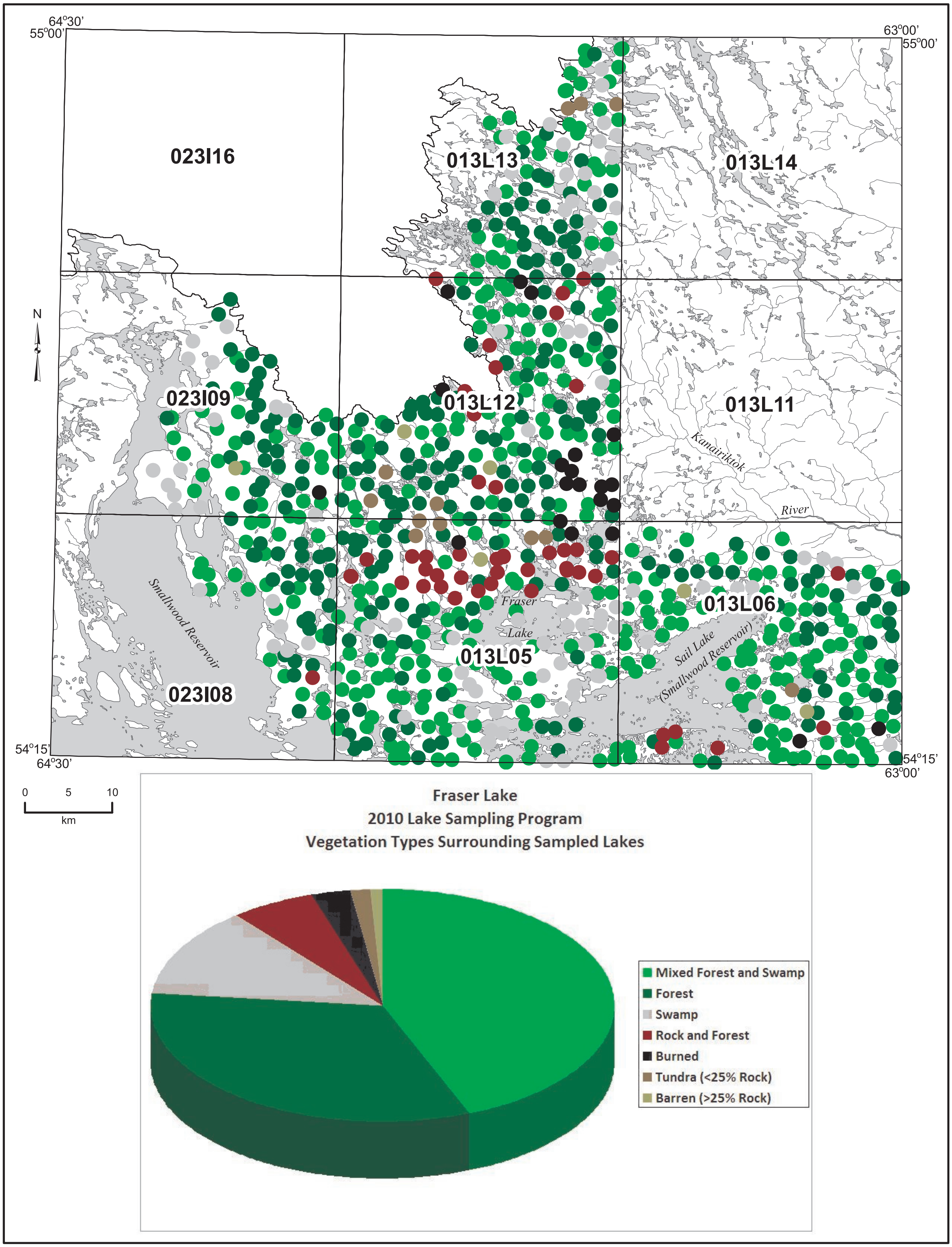

Figure 11: *Areal distribution of vegetation types at sample locations and pie-chart showing frequency of vegetation types surrounding sampled lakes.*

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