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

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ABSTRACT

A lake-sediment and water-sampling survey over the area of Labrador covered by the Federal–Provincial GEM Program commenced in 2009 with the coverage of seven NTS map areas, and partial coverage of one, at an overall density of one sample per 4.7 km^2. The area is mostly underlain by Archean and Paleoproterozoic granitic and gneissic rocks, although the volcano-sedimentary succession of the Labrador Trough, and associated mafic and ultramafic intrusions, crop out on the western flank, and a Mesoproterozoic granite–syenite complex, apparently enriched in rare-earth and rare-metal elements, impinges in the east. A total of 1018 sites were sampled, from which the sediment will be analyzed for 48 elements and the water samples for 29 elements. Results are expected in early 2010, and continued sampling of an expanded coverage area is also planned to resume.

INTRODUCTION

This report summarizes a helicopter-supported lake-sediment and water-sampling program carried out over an area of approximately 4800 km^2 in the Knox Lake area of southwestern Labrador in July and August 2009.

The program is a component of the Geo-mapping for Energy and Minerals (GEM) Program (Percival, 2009), which focusses mainly on areas north of the 60th parallel; the program also includes 'activity locations' for northwest Manitoba, northern Saskatchewan and the Schefferville area of Québec and Newfoundland and Labrador. The last-named area (Figures 1 and 2), is the focus of the current study. It comprises a geophysical component (airborne magnetic and radiometric surveys), a geological mapping component, and a geochemical component, which is the subject of this report. As part of the geological component, detailed mapping was carried out on NTS map areas 23I/14 and the northern half of 23I/11, and limited mapping on 23I/10 and the remainder of 23I/11 (Valley, *this volume*).

In the 2009 lake-sampling program, attention was focussed on NTS 1:50 000-scale map areas 23I/06, 23I/07, 23I/10, 23I/11, 23I/14 and 23I/15. Coverage was also completed for the portion of NTS map area 23I/13 that lies within Newfoundland and Labrador, and part of NTS map area 23I/12.

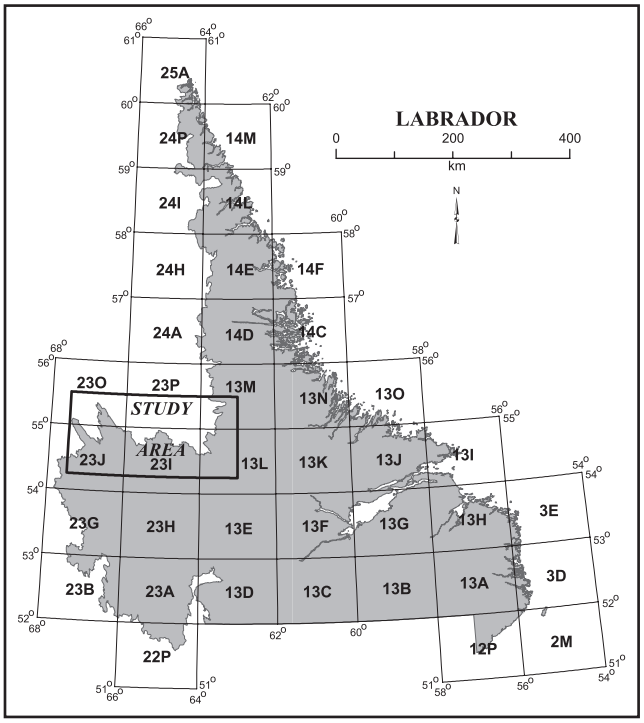

Figure 1. *Area of coverage of the GEM Program in the Schefferville area of Labrador and Québec.*

GEOLOGY AND MINERALIZATION

The area covered by the 2009 sampling program is underlain in the northwest (NTS map areas 23I/12 and 23I/13) by supracrustal rocks of the Mesoproterozoic Labrador Trough, striking northwesterly and comprising units of pillow basalt and mafic pyroclastic rocks (Unit P2pmv) intruded by gabbro (Unit P2ga) and peridotite (Unit

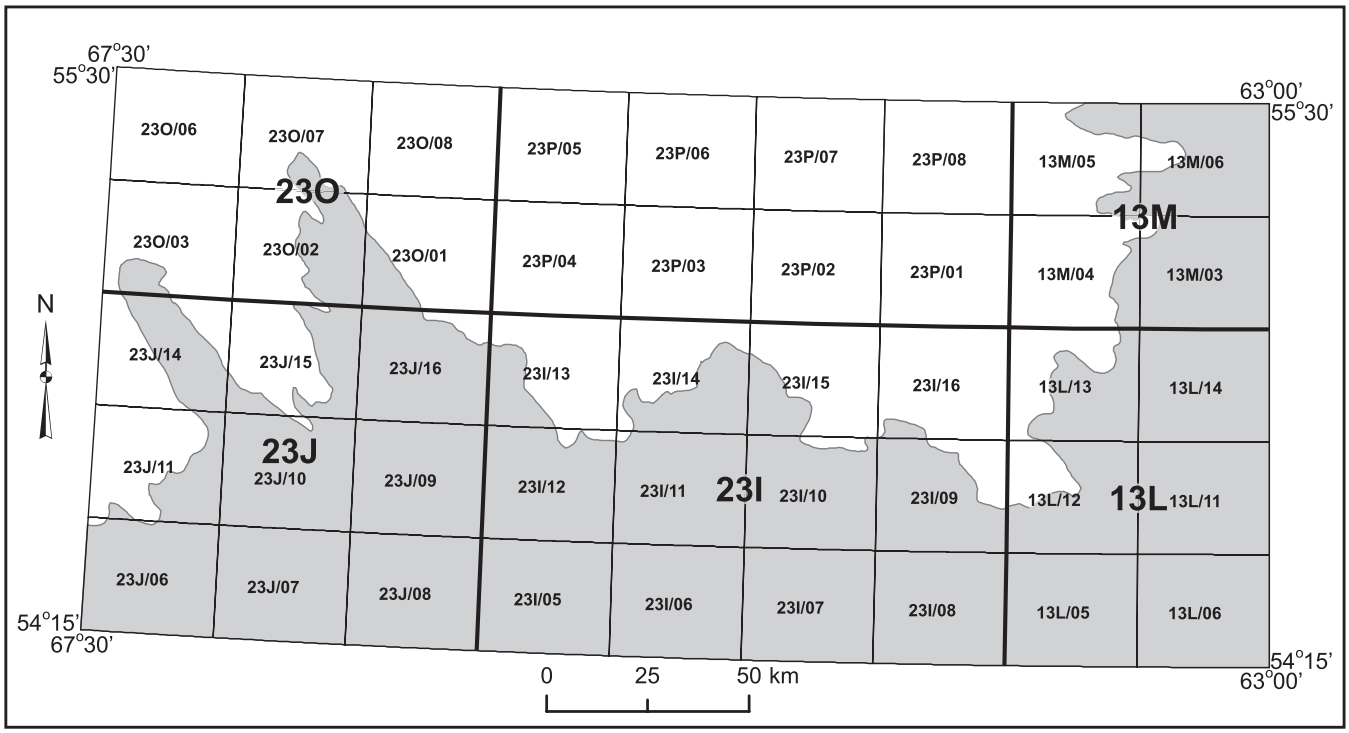

Figure 2. *NTS 1:50 000-map sheets comprising the GEM Program in the Schefferville area of Labrador and Québec.*

P2u); rhyolite and felsic pyroclastic rocks (Unit P2fv); clastic sediments containing some coal (Unit P2st); dolomite and chert (Unit P2d); and iron formation (Unit P2i). The six map sheets that comprised the original sampling program (NTS map areas 23I/06, 23I/07, 23I/10, 23I/11, 23I/14 and 23I/15) are underlain by Neoarchean metatonalite and tonalite gneiss (Unit ANtgn), intruded by mid-Paleoproterozoic gabbro (Unit P2ga); Neoarchean granitic gneiss (Unit ANggn) intruded by mid-Paleoproterozoic tonalite, quartz diorite, granodiorite and granite (Unit P2cg); mid-Paleoproterozoic granite and granodiorite; and early Mesoproterozoic monzonite, granite and charnockite (Unit M1g) (Wardle *et al.*, 1997). A geological map of the area is shown in Figure 3.

MINERALIZATION

There are no developed prospects or producers (past or present) within the area of 2009 coverage. One mineral occurrence on NTS map area 23I/12 (Montgomery Lake Cu/Au) has the status of prospect (Figure 3). This was discovered by prospectors in 1942 and drilled in the mid-1960s. It comprises stringers and disseminations of chalcopyrite and pyrrhotite, locally enriched in Au, hosted by clastic sedimentary rocks (including shale, sandstone and pebbly conglomerate), and has been interpreted as being of mesothermal origin (Swinden and Santaguida, 1995). Of the other mineral occurrences, 13 have the status of showing and 13 have the status of occurrence.

PREVIOUS WORK – GOVERNMENT

The area sampled during 2009 was previously sampled as part of the federal National Geochemical Reconnaissance (NGR) Program (Boyle *et al*., 1981). Samples of lake sediment and water were collected at a density of one per 16 km^2. 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 Nneutron-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).

Within the GEM activity area, anomalous values were reported for a large number of elements (Ag, As, Au, Cd, Co, Cs, Cu, Fe, Hg, Mn, Ni, Sb and Zn) over rocks of the Labrador Trough, in the west. More noteworthy, from the point of view of the area of 2009 coverage, was a strong anomaly of fluoride ion in water, accompanied by elevated values of Mo (the Michikamats Anomaly; McConnell, 1989), over an intrusion of monzonite, granite and charnockite straddling the boundary between NTS map areas 23I/09 and 23I/10 (Figure 4). Additionally, a strong

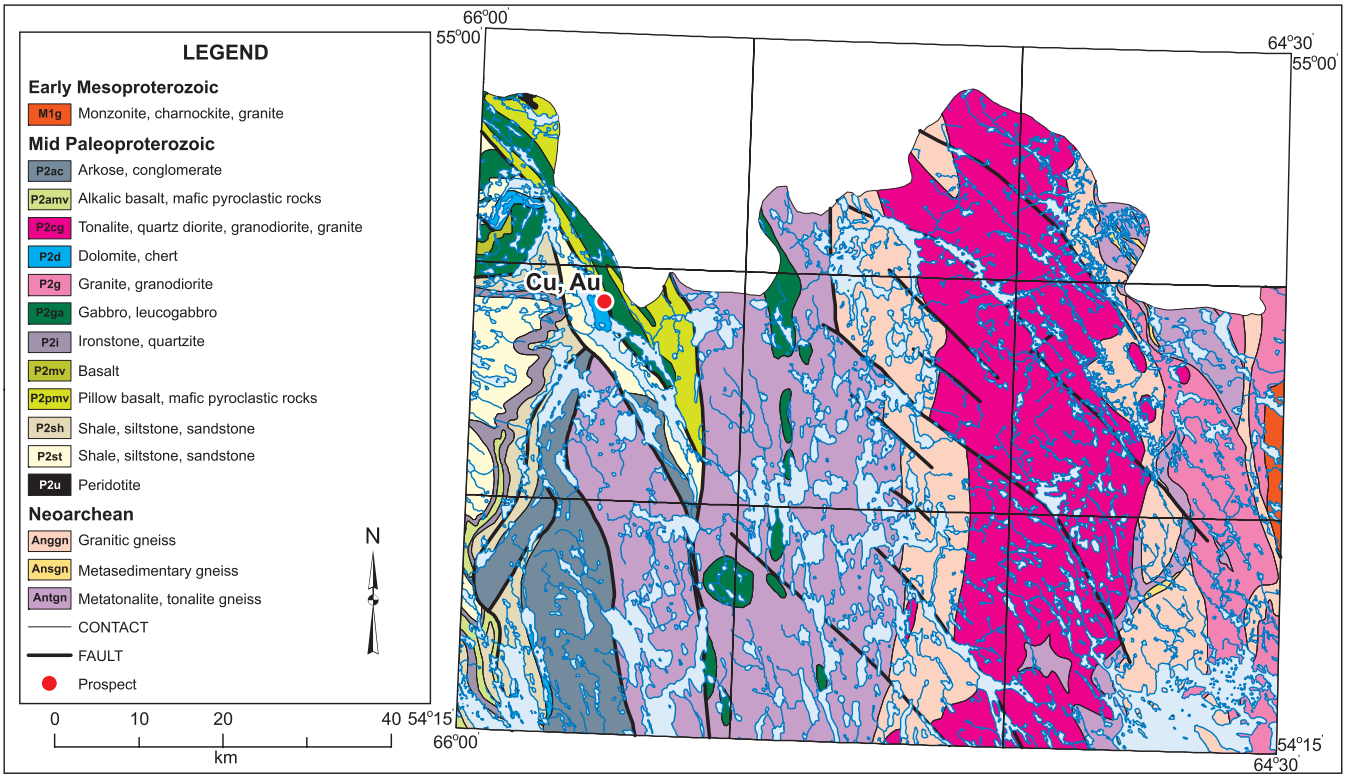

Figure 3. *Geology of the area covered by the 2009 sampling program (from Wardle* et al.*, 1997).*

anomaly of Lu, Sm, Tb and Yb, with some samples also returning elevated or anomalous F, La, Mo, Th and U (titled the 13L Anomaly, McConnell, 1989), is present over similar rocks on NTS map area 13L/13. This anomaly is surrounded on three sides by the Québec provincial border and is separated from the Michikamats Anomaly by Québec, within which the lake-sediment analyses are not anomalous (Maurice and Labbé, 2009). Therefore, the Michikamats and 13L anomalies are not contiguous. There is also an extensive anomaly of Zn, unaccompanied by anomalous values of any other elements, on NTS map area 13L/12 again bounded to the north by Québec.

McConnell (1989) carried out more detailed (one sample per 4 km^2) lake-sediment and water-sampling over both the Michikamats and NTS 13L anomalies. In the former case, as well as confirming the fluoride ion in water response indicated in the NGR Program, the survey 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 monzonite–granite–charnockite complex. Over the NTS 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.

PREVIOUS WORK – INDUSTRY

Figure 5 shows the number of assessment files covering each 1:50 000-map sheet in the area of GEM coverage. It is clear that while exploration has been intensive in the west where the area of coverage is underlain by rocks of the Labrador Trough, and modest in the east, there has been almost no activity in the central part, which was the focus of the 2009 program. The only work carried out on the ground over these six NTS map areas comprises ground geophysics and possibly soil geochemistry on NTS map area 23I/14 (Hogg, 1962), and soil geochemistry possibly covering NTS map area 23I/10 (Hogg, 1964). However, the assessment files contain insufficient information for the sampling grids to be located with any assurance. There has been considerably more activity on the two westernmost sheets sampled in 2009, with 34 and 22 assessment reports filed for NTS map areas 23I/12 and 23I/13, respectively. Prospecting has taken place for both ferrous and base metals.

SURFICIAL ENVIRONMENT

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.

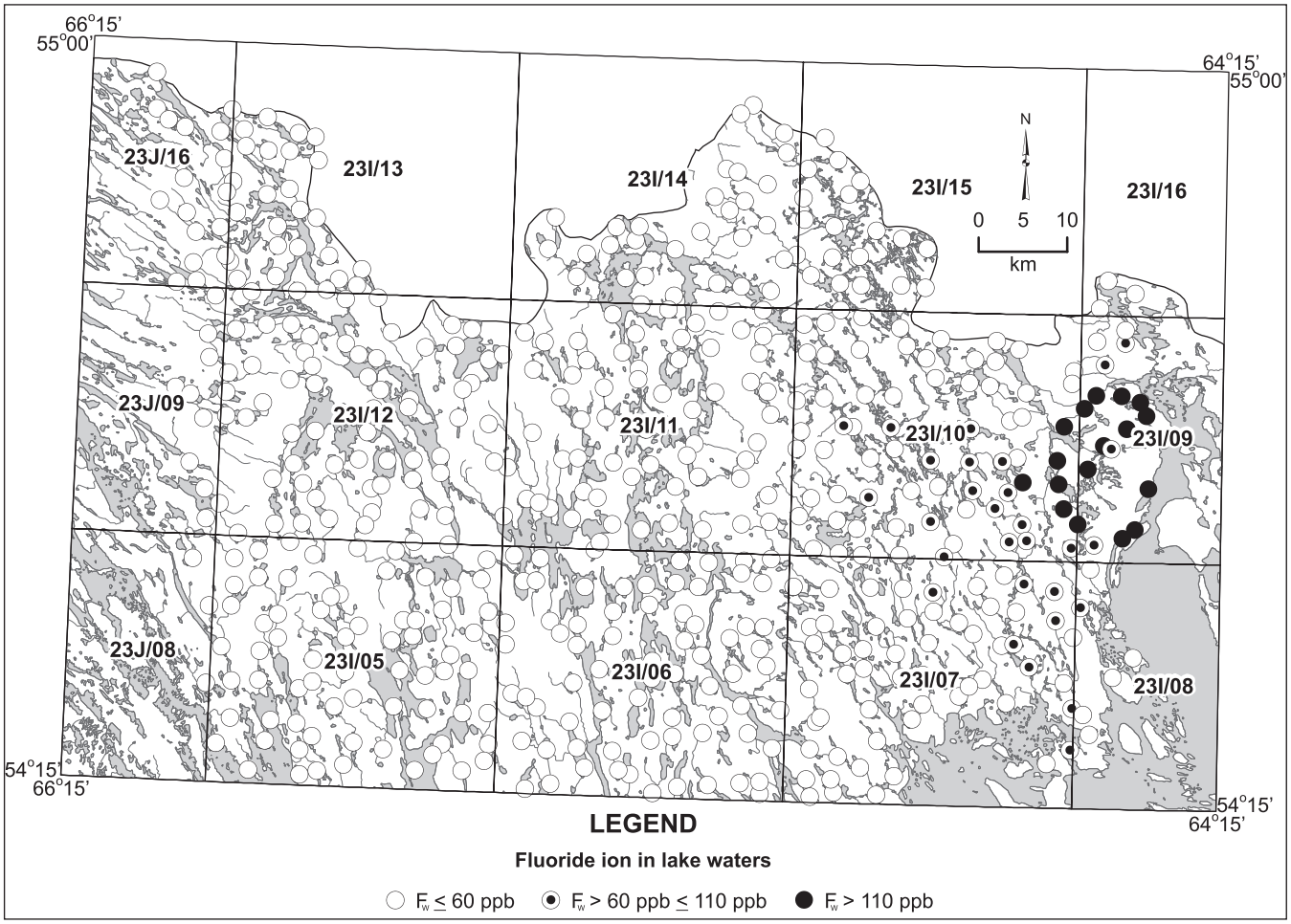

Figure 4. *Fluoride ion in lake waters, 2009 GEM area of coverage, as sampled during Federal National Geochemical Reconnaissance Program (data from Hornbrook and Friske, 1989). Open circles: $F_w \leq 60$ ppb; partly filled circles: $F_w > 60$ ppb ≤ 110 ppb; Filled circles: > 110 ppb. Cutpoints correspond to the 90- and 97.5-percentile for the NGR Labrador data set (18 641 samples).*

Inferred ice-flow directions indicate at least four events (Klassen and Thompson, 1990):

Event 1: Northeastward flow
Event 2: Northeastward flow
Event 3: North-northwestward and south-southeastward flow, with a divide striking east-northeastward from Schefferville through the northern part of the study area.
Event 4: Northeastward flow

The sampled area is characterized by rugged topography, with abundant outcrop, in the north, northwest and southeast, and flat, swampy ground and with abundant string bogs in the south and southwest. Surficial deposits are dominated by undifferentiated till consisting of silty to sandy diamicton, with minor glaciofluvial, glaciolacustrine and fluvial deposits. Drumlin or fluting orientations are predominantly north–south (Klassen *et al.*, 1992). There are several prominent eskers that have a generally southeastward orientation.

SAMPLE COLLECTION

Fieldwork was based in a camp on Crossroads Lake (54.7778°N, 65.1218°W) and sampling was carried out from a float-equipped Bell 206-B helicopter. A wooden platform was attached to the port side of the helicopter to facilitate sampling, but a winch was not used.

Sampling of both sediment and water 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. In general, smaller bodies of water were selected in preference to larger ones, although it was not always possible to apply this criterion rigorously. Furthermore, the presence of larger lakes (in particular, the Smallwood Reservoir), in which few samples were collected, served to lessen the overall sampling density from the theoretical one per 4 km^2 to approximately one per 4.7 km^2. Fig-

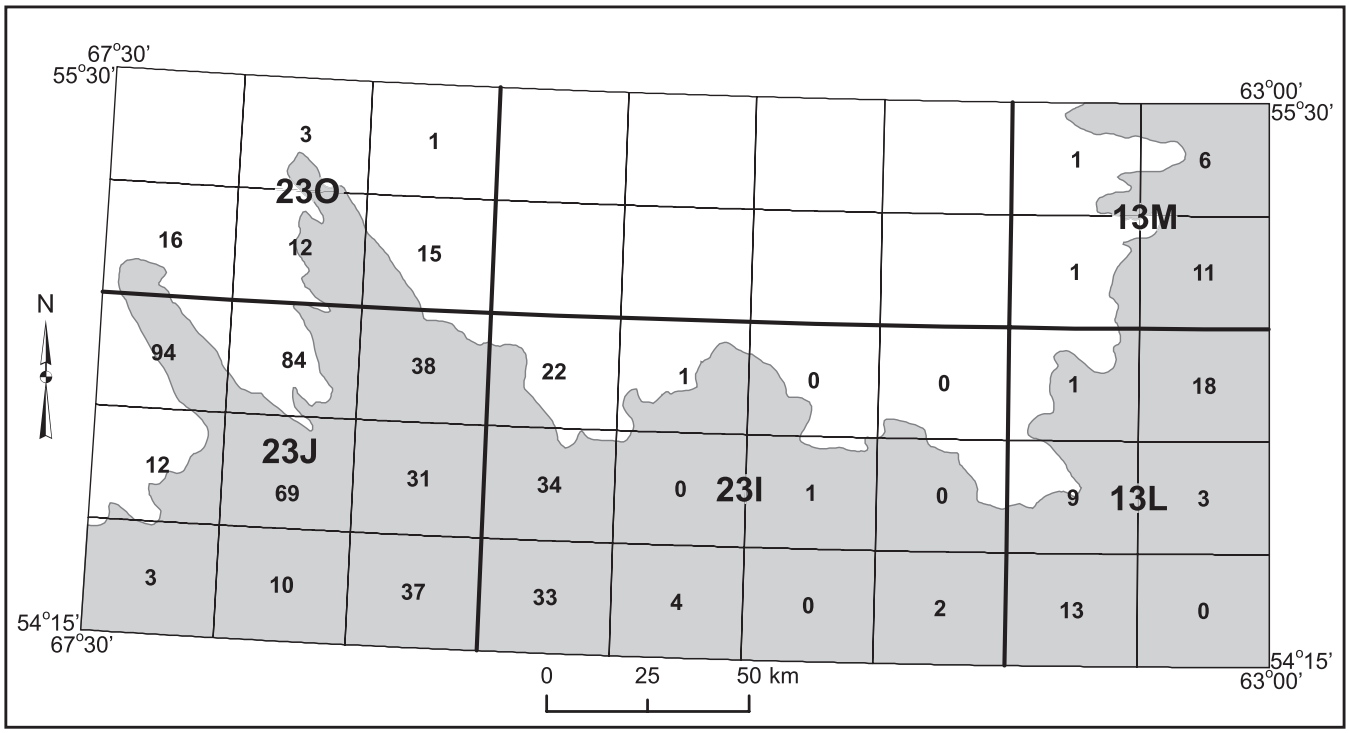

Figure 5. *Total assessment files in Newfoundland and Labrador Geofiles database for NTS sheets covered by GEM Program in the Schefferville area.*

ure 6 shows the sample coverage and Table 1 summarizes the sampling statistics.

Table 1. Sampling statistics

Duration of program (days)	18
Days lost to bad weather	3
Total helicopter hours	108.5
Sites sampled	1018
Field duplicate sites	51
Water-only sites	32
Minimum sampled lake depth (m)	0.2
Median sampled lake depth (m)	2.0
Maximum sampled lake depth (m)	14
Median lake area (km^2)	0.1

Two samples in every sequence of 20 consisted of a field duplicate pair, both of whose numbers (within the 20 sample sequence) were selected randomly, and the two duplicate sites were typically separated by a distance of 50 to 100 m. The following field parameters were 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 were added to the field cards later.

Samples of lake sediment were collected using a tubular steel Hornbrook Bomb, fitted with a butterfly valve that opens on impact with the sediment and closes as the sample is retrieved, trapping the contained sediment. The sampler is designed so that once retrieved, it can be inverted and the contained sediment poured into a plastic collection device and thence into a sample bag. The rope used for retrieving the sampler is marked at one-metre intervals to permit estimate of the lake depth at the point of sampling. Samples were stored in pre-numbered, water-resistant Kraft paper bags and air-dried at ambient temperatures for a few days before being shipped to St. John's 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 to St. John's in coolers.

SAMPLE PREPARATION AND ANALYSES

At the lab in St. John's, sediment samples were dried at 40ºC, before being disaggregated using a mortar and pestle and screened through a 180 micron (80 mesh) stainless-steel sieve. They will be analyzed for the following parameters:

- Ag, As, Au, Ba, Br, Ca, Ce, Co, Cr, Cs, Eu, Fe, Hf, La,

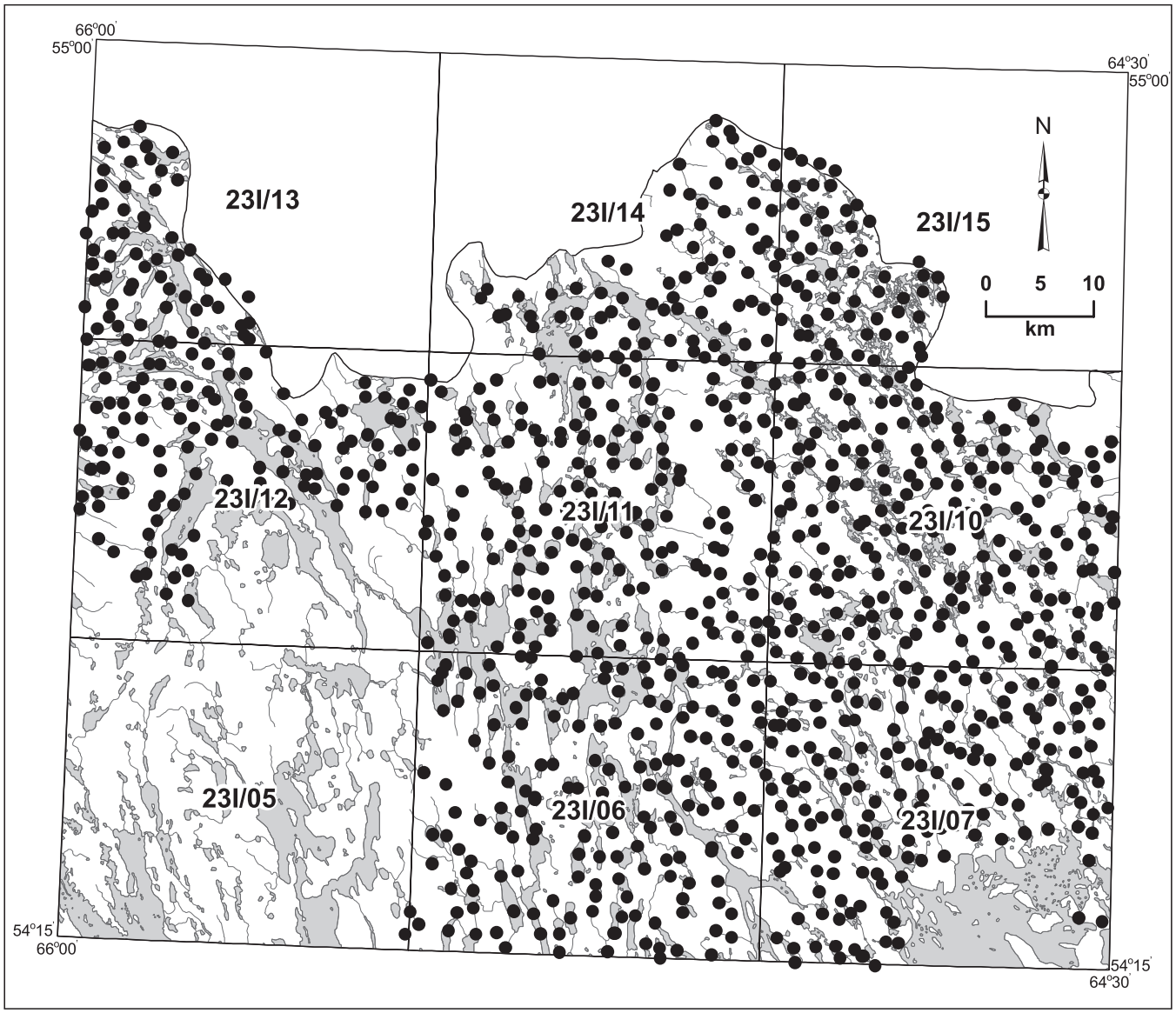

Figure 6. The 2009 lake-sampling coverage.

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 (500ºC), 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

It is expected that results will be received during the first quarter of 2010.

CONCLUSIONS

The Geo-mapping for Energy and Minerals (GEM) Program in the Schefferville activity centre was inaugurated in the summer of 2009 with a helicopter-supported lake-sampling program in the Knox Lake area, concurrent with geological mapping of selected areas. A total of 1018 sites were sampled over a three-week period, at an overall density of one per 4.7 km^2. Sampled lake depths ranged from 0.2 to 14 m, whereas the median area of the lakes sampled was 0.1 km^2.

ACKNOWLEDGMENTS

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