

The Evolution of the Geological Survey of Canada's Regional Reconnaissance Geochemical Drainage Sediment and Water Surveys

Introduction

As a result of the 1973 international energy crisis, the Canadian government introduced the Federal-Provincial Uranium Reconnaissance (URP) Program in 1974. The objectives of this program included establishing and maintaining high-quality databases of field observations and geochemical data for stream and lake sediments and waters, and airborne gamma-ray survey data, to aid uranium exploration. Technological advances in analytical methods and computing since then have led to improvements in efficiency, presentation, and the amount of information derived from each site. Counterbalancing these improvements have been steady decreases in funding and staff. Large-scale regional surveys managed by the Geological Survey of Canada (GSC) and carried out by contractors as stand-alone projects for mineral exploration, ceased in 2004. Since then, regional geochemical surveys have been undertaken within larger projects with multiple objectives including environmental evaluation and surficial and bedrock mapping, in addition to supporting mineral exploration.

A Brief Summary of Past Work

The exposed Canadian Shield (Fig. 1), with an area of 4.4 million km² and rich in mineral resources, occupies a little less than half of Canada's surface area of 10.0 million km² (Bostock 1967). Prior to 1970 conventional methods of geochemical exploration (stream sediments), soils and bedrock were employed mostly in the Canadian Cordillera and the Appalachian Mountains physiographic

regions (Fig. 1) (Brunner *et al.* 1987). Attempts to transfer sediment and soil methods and techniques to the Canadian Shield generally had poor success, and by 1970 exploration geochemistry on the Shield had acquired an unflattering reputation (Hansuld 1971). The problems facing exploration companies were and still are daunting: the area is vast and for the most part remote, bedrock is overlain by a variety of glacial sediments, and as a result of low relief and relatively recent de-glaciation, swamp, muskeg and indefinite and disorganized drainages are common (Coker & Nichol 1975). However, one notable feature of the Shield is a multitude of lakes. Beginning in 1970, research at the GSC began to focus on near-shore lake sediments, including inflow stream deltas and shoreline sediment deposits, as a sample medium for mineral exploration (Allan 1971). This led to the first large-scale reconnaissance survey of near-shore, predominantly clastic, lake sediments, including submerged frost/mud boils, carried out in 1972. Investigations by Hornbrook and Gleeson in 1971-1972 in the Abitibi Greenstone Belt (Hornbrook 1972) into the utility of centre-bottom lake sediments did not lead to encouraging results due to the presence of thick cover of glaciolacustrine clay. Studies continued in 1972 in Newfoundland with encouraging results (Hornbrook *et al.* 1975), and as a result organic-rich centre-lake bottom sediment sampling was adopted by the GSC as a regional reconnaissance tool in 1974. Research at Queen's University by Coker (1974) indicated that the best place to sample true 'lake sediments' was in the centre of the lake where the most organic-rich *gyttja* was found. This material has the highest and most homogeneous organic carbon content, and hence maximum metal levels for the lake most indicative of the average metal levels within the lake catchment basin. Near-shore materials, heterogeneous mixtures of materials from cobble to clay in size, are subaqueous equivalents of glacial and postglacial sediments and are not produced by the normal processes of lacustrine sedimentation (Coker *et al.* 1979).

In 1974, the Canadian government announced the initiation of the Uranium Reconnaissance Program (URP), a national program of mineral exploration for uranium (Darnley *et al.* 1975) which included regional reconnaissance surveys of organic-rich centre-lake bottom sediments as a major component. The term 'National Geochemical Reconnaissance' (NGR) program was first coined by Cameron (1976) in a paper that outlined the importance of having consistent protocols for sample

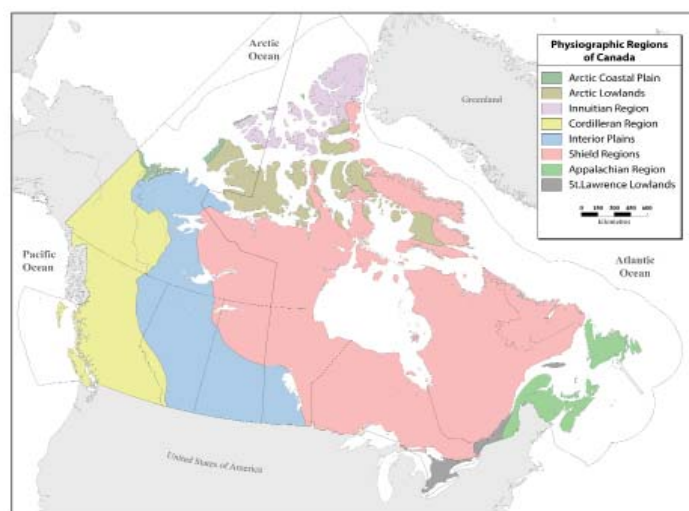


Figure 1. Physiographic regions of Canada.

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collection, preparation and analysis as well as effective quality control procedures so that data can be compared from year to year. Hornbrook & Garrett (1976) described the first centre-lake bottom regional reconnaissance survey undertaken in 1974 in east-central Saskatchewan. This survey was to serve as the template for all future regional reconnaissance lake and stream sediment surveys managed by the GSC.

The first regional stream sediment and water surveys under the federal URP program were carried out in 1976 in British Columbia and Yukon Territory. The URP was terminated in 1978, but NGR surveys continued to be carried out most years under two Mineral Development Agreements (1984-1990 and 1990-1995) between the federal, provincial, and territorial governments.

In 1978, the Geological Survey of Canada and partner provincial surveys collected 9,969 stream sediment and water samples and 9,976 lake sediment and water samples across Canada (Fig. 2). This marked the high point of regional government drainage sediment and water surveys in Canada using a model that incorporated federal funding, and federal ownership of data and standard methods of collection and analysis. The introduction of personal computers, Geographic Information Systems (GIS), and Global Positioning Systems (GPS) into the production of

geochemical maps and reports for publication gradually reduced or eliminated most of the manual cartographic and data entry tasks, so that despite reductions in staff, output was maintained.

Present State of Affairs

Regional geochemical surveys carried out by the GSC, many in partnership with Provinces and Territories, now extend over approximately 20% of the Canadian landmass (Fig. 3). In addition, Quebec has made available lake or stream sediment survey geochemical data for the entire province, and the province of Newfoundland and Labrador has published lake sediment geochemical data for the Island of Newfoundland and most of Labrador. Although no new regional lake sediment surveys have been carried out by the GSC since 1993, stream sediment and water surveys continue to play an important role in larger GSC regional mapping projects. The integration of current technologies and the new uses for geochemical data described below have combined to make regional geochemical surveys even more relevant for resource assessment, environmental applications, and land-use planning.

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Reanalysis

One of the unique characteristics of the NGR program has been the commitment of resources to maintaining an archive of dried sediment samples for future reanalysis (water samples are discarded after one year). In Ottawa, over 200,000 dried sediment samples are organized and stored in fire-resistant cabinets or on industrial metal shelving. An additional 22,000 samples collected by the province of British Columbia are part of the GSC's archive.

Reanalysis of existing samples, at around 5% of the cost of new surveys, has become the first option for both the mineral exploration industry and government scientists currently working in areas previously covered during the NGR program. The availability of low-cost, multi-element analytical packages and constantly changing international markets for different metals has resulted in demand for new data for up to 60 or more elements in lake and stream sediments from areas with high mineral potential. Under the Geo-Mapping for Energy and Minerals (GEM-1) Program, a 5-year (2009-2013) investment by the Government of Canada in geoscience information to help discover new energy and mineral resources in Canada, most lake sediment samples collected from sites in Nunavut and Northwest Territories between 1974 and 1979 were re-analyzed. Access to archive samples can be arranged

by contacting Ann Therriault (Ann.Therriault@NRCan-RNCan.gc.ca). All published data NGR data are available at no cost at <http://geochem.nrcan.gc.ca>.

Partnerships

Funding for new surveys has traditionally been provided to stimulate mineral exploration activity, however, an increasing proportion of monies are being provided to carry out NGR-style surveys to generate a layer of geochemical data critical in evaluating the mineral potential of an area. Regardless of the objectives of the funding sources for the survey, the resulting data are published in a timely manner to be used by the public and other government agencies.

In 2002, after nearly two decades of no new large government drainage geochemical surveys in the Northwest Territories, the Northwest Territories Geoscience Office (NTGO) requested the expertise of NGR geochemists to co-operatively manage what would become a series of new stream sediment and water surveys along the western margins of the Territory. The majority of the funding was provided by NTGO, and GSC involvement has helped to establish and maintain high quality data, which are compatible with existing NGR and other provincial/territorial drainage geochemical datasets. An increase in mineral exploration, claims staked, prospecting permits and

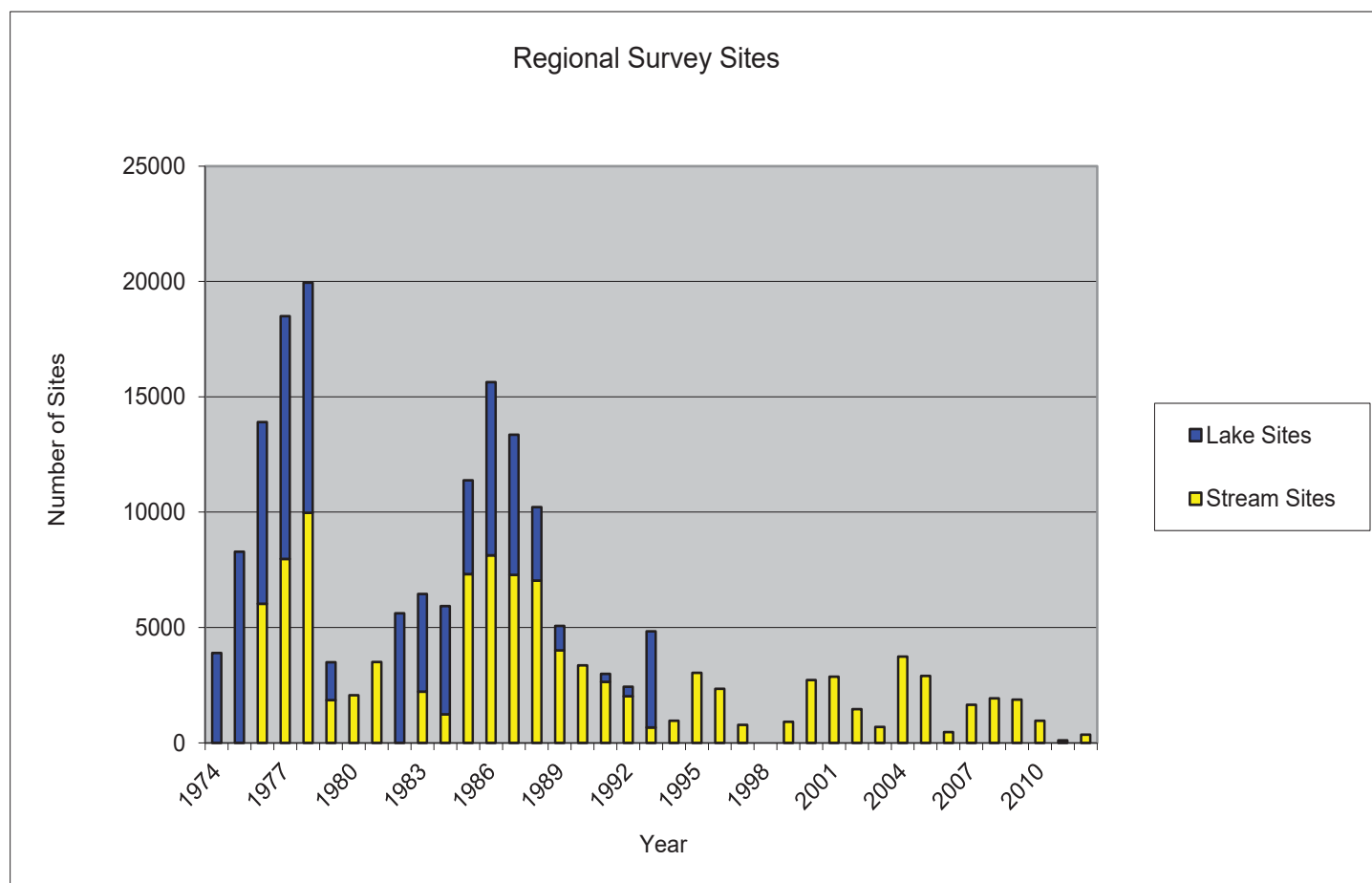


Figure 2. Total number of lake and stream sediment sites for the years 1974-2012.

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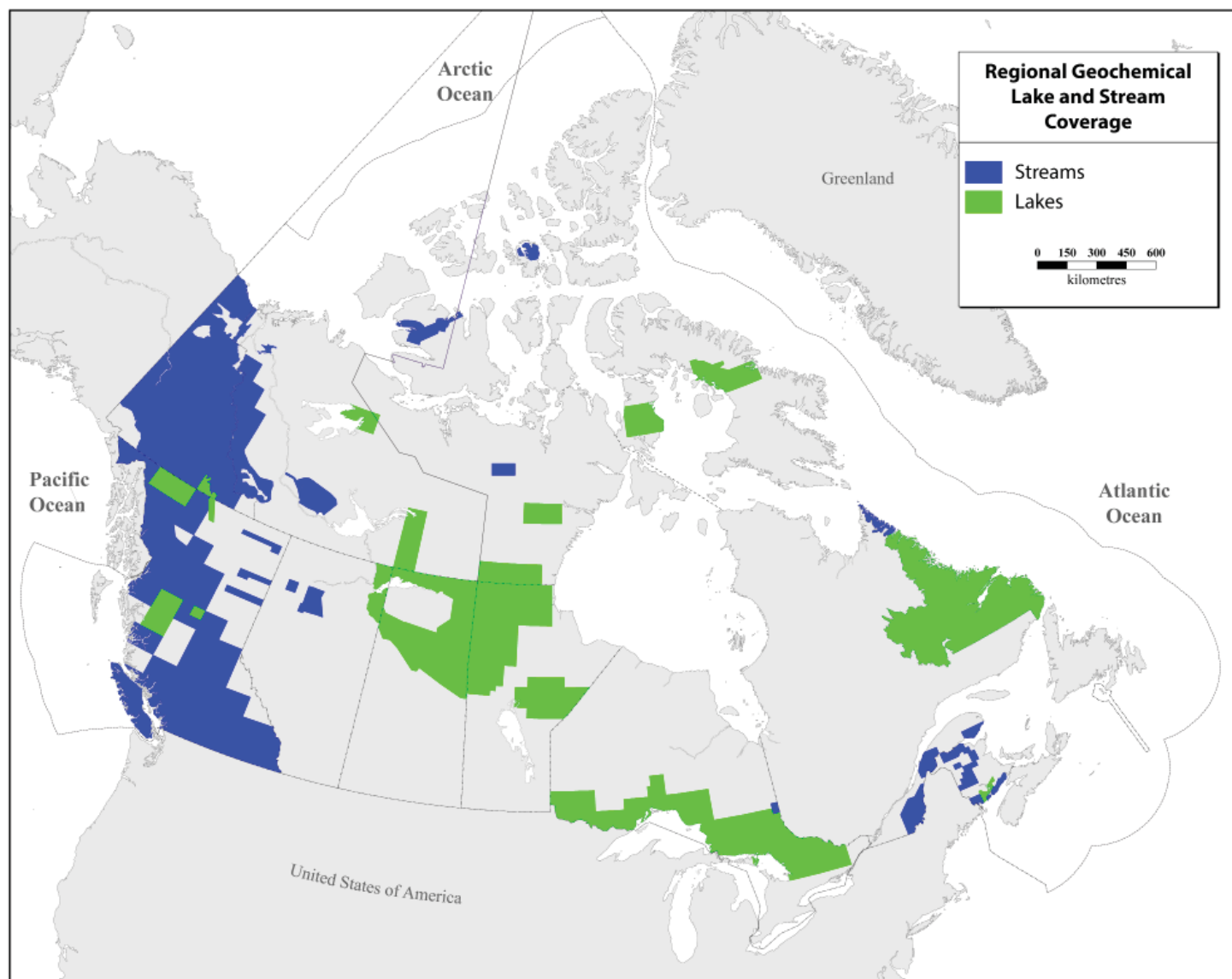


Figure 3. Regional drainage surveys to NGR standards in Canada.

informed land use planning decisions have resulted from this partnership.

Survey Design

The standard procedure developed at the GSC, and employed for recent stream sediment and water surveys carried out by the NTGO, is to select an area (usually a National Topographic System map sheet) and systematically sample one stream or lake within a 13 km² (5 mile²) grid. On average, approximately one thousand samples are collected from centre-lake basins or first or second order streams using helicopters. This model is efficient, thorough and expensive, with helicopter time accounting for 50-60% of the budget. Reduced funding at the GSC brought the need to reduce costs, where possible, for regional surveys. For streams, a strategy that incorporates the collection of indicator minerals from larger streams draining greater areas, in addition to silts

and waters, has been developed. The overall sampling density can be reduced to approximately two silt and water samples and one heavy mineral sample per 100 km², significantly reducing helicopter hours. Rather than sampling on a grid, sites are selected in order to effectively capture the geochemistry of sediments and waters by focussing on watersheds and the rock type underlying them.

Sample Media

Indicator Minerals

Although the cost of processing and analyzing heavy mineral concentrates is significant, identifying indicator minerals and interpreting their morphological characteristics provides a wealth of information about potential economic mineralization. Research at the GSC

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continues to expand the knowledge about indicator mineral methods that can be applied to stream sediments as well as glacial sediments for: gold and platinum group elements (McClenaghan & Cabri 2011); magmatic Ni-Cu-PGE (McClenaghan *et al.* 2013a); kimberlites (McClenaghan & Kjarsgaard 2007); W-Mo (McClenaghan *et al.* 2013b), volcanogenic massive sulphides (McClenaghan *et al.* 2012a,b; Hicken *et al.* 2013); Mississippi Valley Type Pb-Zn (McClenaghan *et al.* 2012c; Oviatt *et al.* 2013); and iron oxide copper gold deposits (McMartin *et al.* 2011).

Waters

Until the year 2000, only uranium, fluoride, and pH were routinely determined in stream and lake waters. After 2000, up to 60 or more elements were determined in filtered and acidified waters from every fifth site by a combination of ICP-MS and ICP-AES methods. At present, water samples from all sites are filtered and acidified in the field and later analyzed.

Stream and Lake Sediments

Lake sediments collected in 1974 for the URP were analyzed for 11 elements by several different methods, including atomic absorption spectrometry, colourimetry, and fluorimetry. Results were accurate and precise, but the process was time-consuming and expensive. The commercial development of rapid and economical INAA and ICP-MS analytical methods for lake and stream sediments has resulted in the ability to determine up to 65 elements, from sample aliquots as small as 0.5 g for ICP-MS.

Targeted/Integrated Surveys

Drainage sediment surveys are now smaller, more focussed and integrated within larger projects, instead of being large stand-alone projects. GSC exploration geochemists adapted quickly to the changes and have played important roles in a number of projects. Recent surveys (since 2005) include stream sediments, waters and heavy minerals on Baffin Island, Nunavut (Utting *et al.* 2008), Victoria Island, Northwest Territories (McCurdy *et al.* 2012), Pine Point Pb-Zn MVT District, Northwest Territories (McClenaghan *et al.* 2012c), and the Sisson W-Mo deposit (McClenaghan *et al.* 2013b).

Resource Assessment and Environmental Applications

A new federal government policy was established in 1980 to guide the process of creating National Parks and under this policy it was mandated that an assessment of the non-renewable resources of an area be conducted prior to formal establishment of a National Park north of latitude 60° (Falck *et al.* 2007). Regional stream sediment surveys were an integral part of two park assessments, 1) northern Bathurst Island (Anglin & Harrison 1999), and 2) a proposed expansion of Nahanni National Park Reserve to include the Greater Nahanni Ecosystem (Wright *et al.* 2007). The Bathurst Island geochemical survey marked

the NGR's first significant use of heavy minerals in stream sediments to evaluate mineral potential.

Predictive Geochemical Mapping

The GSC is taking a leading role in the development of predictive geochemical mapping of Canada's North. Mapping with geochemical data involves a rigorous approach to validating the quality of the analytical data followed by a sequential investigation of process discovery and subsequent process validation. Through the application of data adjustment procedures, compositional data analysis, and the application of statistically-based classification procedures, geochemical data can be successfully used to predict lithology and estimate potential mineralization (Grunsky *et al.* 2012). Lake sediment samples collected up to 27 years ago have been reanalyzed for up to 60 elements and multivariate statistical procedures used to classify and predict lithologic variability, the location of mineral ore alteration zones, and zones of mineralization. These methods in combination with remote predictive mapping can be used to evaluate mineral potential over large areas of northern Canada.

Canadian Database of Geochemistry (CDoGS)

Geochemical data and metadata for NGR and other surveys are being stored in a sophisticated, general-purpose database, the Canadian Database of Geochemical Surveys (CDoGS) (Adcock *et al.* 2013). The public inter-face to CDoGS can be found at <http://geochem.nrcan.gc.ca> (Fig. 4). This web site provides high-level metadata for each catalogued survey and its associated publications. Links to raw data in their original published format are included where possible. Currently, there are over 1200 surveys stored in the database and 221 of them are NGR and NGR-style surveys. Links to published data for NGR surveys are available on the website and raw data in a standardized format are available for approximately 10% of them. Adding more surveys and standardizing the raw data for viewing in Google Earth™ is on-going, with the focus on loading raw data, in particular for NGR surveys. More details about how to use the CDoGS site are found in Spirito & Adcock (2010).

The Future of Regional Geochemical Surveys at the GSC

In August 2013, the Canadian government announced that \$100 million will be provided over seven years (2013-2020) to support increased exploration for natural resources in Canada's North, as a second phase of the GSC's GEM Program. Renewal of the GEM program was due in no small part to the output of high-quality maps and reports (over 700) produced during the first phase of the program. Over the previous five years much effort at the GSC has gone into developing new methods for collection, analysis, interpretation and dissemination of drainage sediment and water geochemistry. There is considerable scope for continued participation with the NTGO in lake sediment

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and water surveys in northern Canada. In areas of the Northwest Territories underlain by the Canadian Shield, over 400,000 km² are suitable for lake sediment and water sampling. Vast areas of Nunavut remain to be evaluated for mineral potential using geochemical surveys. Financial resources and expertise provided by the GSC will play a major role in collecting new data.

The development of ICP-MS techniques has had a far-reaching effect on all areas of geochemistry, including exploration geochemistry. Analytical data for dozens of elements in sediments and waters not previously available continue to provide research opportunities for geochemists. Modern micro-analytical techniques such as high-resolution ion microprobe and laser ablation ICP-MS available at the GSC provide rapid analysis of isotopic distributions within individual grains of ore minerals, and the subsequent development of databases can be used to identify individual deposits. Piercey (2010) noted that techniques such as laser ablation ICP-MS and laser

ablation multi-collector ICP-MS are providing geochemical and isotopic signatures of resistate minerals in rocks that could in the future be applied to exploration. An obvious application of these new technologies would be to examine indicator minerals collected from stream sediments.

Resource assessments will continue to be a major focus for the GSC and the systematic collection and analysis of lake and stream sediments and waters remain one of the best methods for quickly providing data for large areas at reasonable cost. Predictive geochemical mapping will become an increasingly important means of identifying rock types in unexplored regions. Finally, geochemical databases developed at the GSC for public use will continue to grow and evolve as new information is added and new applications are developed for these data.

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Survey count 188

Province All

Organisation All

Survey Type All

Year = All

Title NGR

Abstract

Location

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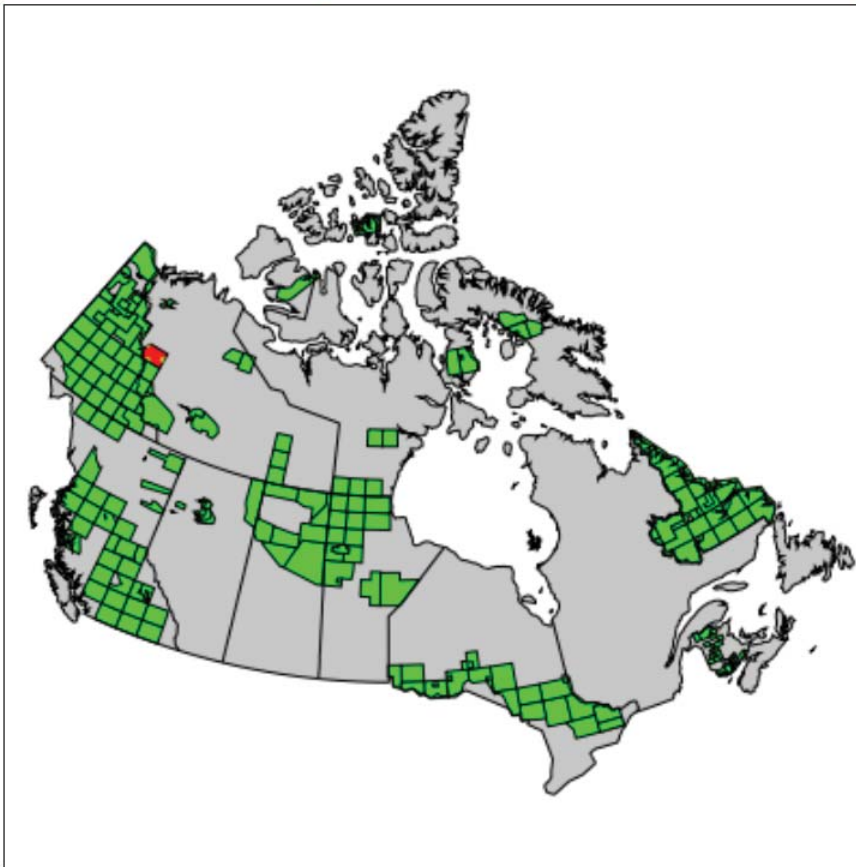
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NTS

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Figure 4. Index map query interface from the CDoGS website.

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historical information. We thank Beth McClenaghan for many valuable suggestions offered during a preliminary review of this article.

* Author's Note: Co-author Bill Coker passed away in January, 2014. He was an important contributor to the GSC's National Geochemical Reconnaissance program and this article. Those interested, may read Bill's obituary in **EXPLORE** 162.

References

- ADCOCK, S.W., SPIRITO, W.A. & GARRETT, R.G. 2013. Geochemical data management: issues and solutions. *Geochemistry: Exploration, Environment, Analysis*, **13**, 337-348.
- ANGLIN, C.D. & HARRISON, J.C. 1999. Introduction to the mineral and energy resource assessment of Bathurst Island area, Nunavut (MERA 1). In: ANGLIN, C.D. & HARRISON, J.C. (eds) *Mineral and Energy Resource Assessment of Bathurst Island Area, Nunavut, Parts of NTS 68G, 68H, 69A, 69B and 79A*. Geological Survey of Canada, Open File **3714**, I-XI.
- ALLAN, R.J. 1971. Lake sediment: a medium for exploration of the Canadian Shield. *Canadian Institute of Mining and Metallurgy Bulletin*, **64**, 43-59.
- BOSTOCK, H.S. 1967. Physiographic regions of Canada. Geological Survey of Canada, Map **1254A**.
- BRUMMER, J., GLEESON, C.F. & HANSULD, J. 1987. A historical perspective of exploration geochemistry in Canada. *Journal of Geochemical Exploration*, **28**, 1-39.
- CAMERON, E.M. 1976. Geochemical reconnaissance for uranium in Canada: notes on methodology and interpretation of data. In: *Report of Activities Part C*. Geological Survey of Canada, Paper **76-1C**, 229-236.
- COKER, W.B. 1974. *Lake sediment geochemistry in the Superior province of the Canadian Shield*. PhD thesis, Queen's University, Kingston, Ontario.
- COKER, W.B., HORNBROOK, E.H.W. & CAMERON, E.M. 1979. Lake sediment geochemistry applied to mineral exploration. In: HOOD, P.J. (ed.) *Geophysics and Geochemistry in the Search for Metallic Ores*. Geological Survey of Canada, Economic Geology Report **31**, 435-478.
- COKER, W.B. & NICHOL, I. 1975. The relation of lake sediment geochemistry to mineralization in the northwest Ontario region of the Canadian Shield. *Economic Geology*, **70**, 201-218.
- DARNLEY, A.G., CAMERON, E.M. & RICHARDSON, K.A. 1975. The federal-provincial uranium reconnaissance program. In: *Uranium Exploration '75*. Geological Survey of Canada, Paper **75-26**, 49-68.
- FALCK, H., LEMKOW, D., WRIGHT, D.F. & HARRIS, J.R. 2007. Introduction to the Nahanni Mineral and Energy Resource Assessment (MERA 2). In: WRIGHT, D.F., LEMKOW, D. & HARRIS, J.R. (eds) *Mineral and Energy Resource Assessment of the Greater Nahanni Ecosystem Under Consideration for the Expansion of the Nahanni National Park Reserve, Northwest Territories*. Geological Survey of Canada, Open File **5344**, 7-29.
- GRUNSKY, E.C., MCCURDY, M.W., PERHSSON, S.J., PETERSON, T.D. & BONHAM-CARTER, G.F. 2012. Predictive geologic mapping and assessing the mineral potential in NTS 65/A/B/C, Nunavut, with new regional lake sediment geochemical data. *Geological Survey of Canada*, Open File **7175**, 1 sheet.
- HANSULD, J.A. 1971. Geochemical exploration in the Canadian Shield – state of the art, introductory and historical remarks. *Canadian Mining and Metallurgical Bulletin*, **64**, 27.
- HICKEN, A.K., MCCLENAGHAN, M.B., PAULEN, R.C. & LAYTON-MATTHEWS, D., AVERILL, S.A. & CRABTREE, D. 2013. Indicator mineral signatures of the Izok Lake Zn-Cu-Pb-Ag volcanogenic massive sulphide deposit, Nunavut: part 2 till. Geological Survey of Canada, Open File **7343**.
- HORNBROOK, E.H.W. 1972. Winter works lake bottom sediment sampling program for the Timmins – Val d'Or region. In: *Report of Activities Part A*. Geological Survey of Canada, Paper **1972-1A**, 126-127.
- HORNBROOK, E.H.W., DAVENPORT, P.H. & GRANT, D.R. 1975. Regional and detailed geochemical exploration studies in glaciated terrain in Newfoundland. *Newfoundland Department of Mines and Energy, Mineral Development Division*, Report **75-2**, 130 p.
- HORNBROOK, E.H.W. & GARRETT, R.G. 1976. Regional geochemical lake sediment survey, east-central Saskatchewan. *Geological Survey of Canada*, Paper **75-41**, 20 p.
- MCCLENAGHAN, M.B. & KJARSGAARD, B.A. 2007. Indicator mineral and surficial geochemical exploration methods for kimberlite in glaciated terrain, examples from Canada. In: GOODFELLOW, W.D. (ed.) *Mineral Deposits of Canada: A Synthesis of Major Deposit Types, District Metallogeny, the Evolution of Geological Provinces and Exploration Methods*. Geological Association of Canada, Special Publication No. **5**, 983-1006.

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MCCLLENAGHAN, M.B. & CABRI, L.J. 2011. Gold and platinum group element indicator minerals in surficial sediments. *Geochemistry: Exploration, Environment, Analysis*, **11**, 251-263.

MCCLLENAGHAN, M.B., HICKEN, A.K., AVERILL, S.A., PAULEN, R.C. & LAYTON-MATTHEWS, D. 2012a. Indicator mineral abundance data for bedrock and till samples from the Izok Lake Zn-Cu-Pb-Ag volcanogenic massive sulphide deposit, Nunavut. Geological Survey of Canada, Open File **7075**.

MCCLLENAGHAN, M.B., BUDULAN, G., AVERILL, S.A., LAYTON-MATTHEWS, D. & PARKHILL, M.A. 2012b. Indicator mineral abundance data for bedrock and till samples from the Halfmile Lake Zn-Pb-Cu volcanogenic massive sulphide deposit, Bathurst Mining Camp, New Brunswick; Geological Survey of Canada, Open File **7076**.

MCCLLENAGHAN, M.B., OVIATT, N.M., AVERILL, S.A., PAULEN, R.C., GLEESON, S.A., MCNEIL, R.J., MCCURDY, M.W., PARADIS, S. & RICE, J.M. 2012c. Indicator mineral abundance data for bedrock, till and stream sediment samples from the Pine Point Mississippi Valley-Type Zn-Pb deposits, Northwest Territories. *Geological Survey of Canada*, Open File **7267**.

MCCLLENAGHAN, M.B., KJARSGAARD, I.M., AVERILL, S.A., LAYTON-MATTHEWS, D., CRABTREE, D., MATILE, G., MCMARTIN, I., & PYNE, M. 2013a. Indicator mineral signatures of magmatic Ni-Cu deposits, Thompson Nickel Belt, Manitoba: Part 2 – till data. Geological Survey of Canada, Open File **7200**.

MCCLLENAGHAN, M.B., PARKHILL, M.A., AVERILL, S.A., PRONK, A.G., SEAMAN, A.A., BOLDON, R., MCCURDY, M.W. & RICE, J.M. 2013b. Indicator mineral abundance data for bedrock, till, and stream sediment samples from the Sisson W-Mo deposit, New Brunswick. Geological Survey of Canada, Open File **7387**.

MCCURDY, M.W., MCNEIL, R.J. & DAY, S.J.A. 2012. Geochemical, mineralogical and kimberlite indicator mineral data for silts, heavy mineral concentrates and waters from two geochemical surveys (2010 and 2011) on Victoria Island, Northwest Territories (nts87g, 87h, 88a and 88b). *Geological Survey of Canada*, Open File **7198**.

MCMARTIN, I., CORRIVEAU, L. & BEAUDOIN, G. 2011. An orientation study of the heavy mineral signature of the NICO Co-Au-Bi deposit, Great Bear magmatic zone, NW Territories, Canada. *Geochemistry: Exploration, Environment, Analysis*, **11**, 293-207.

OVIATT, N.M., MCCLLENAGHAN, M.B., PAULEN, R.C., GLEESON, S.A., AVERILL, S.A. & PARADIS, S. 2013. Indicator minerals in till and bedrock samples from the Pine Point Mississippi Valley-type district, Northwest Territories. *Geological Survey of Canada*, Open File **7423**.

PIERCEY, S.J. 2010. An overview of petrochemistry in the regional exploration for volcanogenic massive sulphide (VMS) deposits. *Geochemistry: Exploration, Environment, Analysis*, **10**, 119-136.

SPIRITO, W.A. & ADCOCK, S.W. 2010. Canadian geochemical data on the web. *EXPLORE* **149**, 2-8.

UTTING, D.J., LITTLE, E.C., YOUNG, M.D., MCCURDY, M.W., DYKE, A.S. & GIRARD, I. 2008. Till, stream sediment and bedrock analyses, North Baffin Island, Nunavut (NTS 37E, F, G, H and 47E). *Geological Survey of Canada*, Open File **5742**.

WRIGHT, D.F., LEMKOW, D. & HARRIS, J.R. 2007. Mineral and energy resource assessment of the greater Nahanni ecosystem under consideration for the expansion of the Nahanni National Park Reserve, Northwest Territories. *Geological Survey of Canada*, Open File **5344**.

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