Merging of geochemical datasets from neighbouring regions, compiled during differently administered programs, in order to create seamless geochemical maps is complicated due to factors such as differences in sampling methodologies and analytical protocols, and sample densities. In this study, a suite of 5,510 lake-sediment samples from western and northern Labrador has been re-analyzed by ICP-MS after aqua-regia digestion, in order to merge the results with a suite of 26,727 lake-sediment samples collected in an adjacent area of the province of Quebec, analyzed by the same method. This merging of datasets has enabled the creation of regional geochemical maps of a contiguous area in northeastern Canada of almost 300,000 km². This activity is one of several surficial geochemistry and mapping activities in northern Quebec and Labrador that form part of the Geological Survey of Canada’s Geo-mapping for Energy and Minerals (GEM-2) Program (2013-2020) (McClenaghan et al. 2016). The purpose of this article is to report on the old and new lake-sediment datasets and about the ongoing production of new lake-sediment geochemical maps for the Quebec-Labrador region that will be published in the first half of 2017.

Samples

The Quebec lake-sediment samples were collected during six separate campaigns and have also been analyzed by various methods (Beaumier 1982; 1983; 1984a,b; 1985; 1986a-c; 1987a,b). Of those samples, however, it is only the 24,261 samples analyzed by ICP-MS after Aqua-Regia digestion by Acme Analytical Laboratories in Vancouver that were used for the data amalgamation (Maurice & Labbé, 2009). The Labrador samples were re-analyzed in 2015 by Bureau Veritas Mineral Laboratories (the successor company to Acme) and reported by McCurdy (2016) and McCurdy et al. (2016). These new data are for a subset of samples that are part of a total of 19,433 samples, which were collected over most of the territory as part of the National Geochemical Reconnaissance (NGR) program of the Geological Survey of Canada (Boyle et al. 1981; Hornbrook et al. 1983; Friske and Hornbrook 1991; Friske et al. 1993a-d, 1994). These lake-sediment samples were previously analyzed for a variety of elements by various methods and after various digestion methods, as well as by INAA (Table 1 - See page 5). Only the recent re-analyses by Aqua Regia/ICP-MS are considered here. There is general correspondence, between the Quebec and Labrador programs, in the analyzed elements and their lower detection limits (Table 2 - See page 5), although the detection limits for Au and Pt in the Quebec dataset are both 1 ppb, compared to 0.2 ppb and 2 ppb in the new Labrador dataset. Also, the Labrador samples were analyzed additionally for Dy, Er, Eu, Gd, Ho, Lu, Nd, Pr, Sm, Tb, Tm and Yb which are omitted from this study since there are no corresponding data for the Quebec samples.

While the sample coverage over Labrador and most of Quebec was fairly even at 6 to 8 samples/100 km², coverage over the southern part of the Labrador Trough (Fig. 1 - See page 6) in Quebec was at least four times as dense (Amor 2015). In order to provide even coverage over the study area, a random sub-selection of 25% of the samples was taken from the total collected in this higher-density area. Sub-selection was done independently within each NTS 1:50,000 map sheet, to avoid regions of over- or under-selection, or ‘clumping’, but the resulting coverage is still somewhat uneven compared to the remainder of the study area.

Geology

The area covered by the lake-sediment sampling is entirely underlain by Precambrian rocks of the Canadian Shield (Hoffman 1990; Wardle & Van Kranendonk 1996). It consists of a major zone of diachronous accretion and collision between three Archean-age crustal blocks: i) the Superior Craton (Archean), ii) the Core Zone (mostly Archean with earliest-Paleoproterozoic crust) and iii) the North Atlantic Craton (Archean), and intervening Paleoproterozoic-age supracrustal sequences and magmatic arcs (Fig. 1). The boundary between the Core Zone and North Atlantic Craton is the Torngat Orogen, a zone of high metamorphic grade and ductile, mostly dextral transcurrent shear formed at ca. 1.87-1.84 Ga (Wardle et al. 2002). The Torngat Orogen preserves an accretionary prism dominated by metapelites (Tasiuyak Gneiss) and the tectonically exhumed deep root of a ca. 1.87-1.86 Ga magmatic arc (Lac Lomier Complex). The Burwell Domain, exposed on the northern tip of Labrador, consists of ca. 1.89 Ga tonalites and orthogneisses emplaced in Archean-age crust (Scott & Machado 1995). On its western side, the Core Zone is
Providing unrivalled confidence in your assay data

We have the largest dedicated mining CRM production facility in the world, supplying over 1200 customers in 105 countries. OREAS gold CRMs are the most homogeneous available, giving you peace of mind that comes with negligible sampling error. Our new line of SuperCRMs™ feature method specific certification of full ICP-OES and MS suites. Find out how OREAS can add value and certainty to your operations by contacting info@ore.com.au now.

AUSTRALIA
ORE Research & Exploration Pty Ltd
www.oreas.com

NORTH AMERICA
Analytical Solutions Ltd
www.explorationgeochem.com
Amalgamated lake-sediment data from Quebec and Labrador, Canada

Notes from the Editor

EXPLORE issue 173 includes one technical article that describes a new series of lake sediments geochemistry maps for eastern Canada, written by Steve Amor, Martin McCurdy, Bob Garrett, David Corrigan, and Fabien Solgadi.

EXPLORE thanks all those who contributed to the writing and/or editing of this issue: Steve Amor, Dennis Arne, Al Arseneault, Nigel Brand, Ben Cooke, David Corrigan, Bob Garrett, David Leng, Ray Lett, Matt Leybourne, Martin McCurdy, Paul Morris, Ryan Noble, Roger Paulen, and Fabien Solgadi. In this last issue of 2016, EXPLORE gratefully acknowledges our three corporate sponsors for the year, ALS Minerals, SciAps, and Olympus, as well as our advertisers, for their continuing financial support.

Below is the team that has provided readers with 4 excellent issues this year. Our team wishes all AAG members and other readers of EXPLORE a successful 2017.

Beth McClenaghan, Editor
Pim van Geffen, Business Manager
Steve Amor, Calendar of Events
Al Arseneault, New Members list/AAG business office news
Ryan Noble, President’s Letter
Dennis Arne, Elements content
Dave Smith, AGM Minutes, Council Elections, and AAG business
David Leng, editing assistance
Dennis Arne, Ray Lett, Geochemical Nuggets
Vivian Heggie, Page layout and mailing

Beth McClenaghan
Editor
President’s Message

It has been a solid year for the AAG, our membership and finances remain stable, our journal (GEEA) impact factor has improved at a better rate than our competitors and we are well underway with the organisation of the next IAGS in Vancouver, Canada in 2018.

Again, like previous years, we’ve had a great series of articles published in EXPLORE in 2016 and I want to encourage our members to consider publishing an article in EXPLORE. Some of our readers are concerned about the impact of their research, and in most cases this relates to impact factors for journals. Impact factors may be important, but it is not the only measure of impact. While EXPLORE does not have an impact factor, the actual impact of what is published here may far outweigh that numerical value. A lot of the EXPLORE readers are linked to industry or active in applying research. In essence, if it is seen in EXPLORE it has a chance to be acted upon and creating real impact. I have not overheard an explorationist or someone working in environmental remediation state “I read this paper in Nature and I think we should try it here.” I can, however, attest to people doing this with respect to EXPLORE articles. One of my own publications on groundwater sampling and analysis was regularly handed out to local project geologists to try to obtain some regional groundwater samples for exploration. Some of this groundwater sampling lead to further exploration and generation of targets, some results actually identified a future economic ore body (although it wasn’t drilled for a few years until coincident EM and structure matched up). As applied geochemists, this is what we are aiming for, so please consider publishing synopsis of your applied research here.

Also, my personal opinion is that more people read the EXPLORE articles more fully than even GEEA articles, and certainly a lot more AAG members read both GEEA and EXPLORE than the latest articles in our competitor journals. A case in point was the recent EXPLORE article by Leybourne et al. on mercury (July 2016, Issue No. 171). Just this week I was discussing this article in the hallway with another geochemist. The topic is not something either of us were actively working on, and hence we both would not have read about it had it be published in another journal. The accessibility of the article in EXPLORE meant that we had both at least taken some time to relate to this work.

Finally, another big benefit of publishing in EXPLORE is that the format, colour printing and a lot of little nit-picking annoyances that are associated with journals are not a problem. The articles are reviewed, but the turnaround is pretty quick and Beth McClenaghan (Editor) and her team certainly have a fast and efficient publication timeline if the science and the presentation are of good quality.

As always at this time of year many of us are getting ready for a break from work. I thank you all for your support of the AAG through 2016 and trust you will continue to renew your membership for 2017 and beyond. I hope you get a good break and switch off from your geochemistry day jobs. I wish you a safe and relaxing start to 2017.

Warm regards,

Ryan Noble
AAG President
ryan.noble@csiro.au
Amalgamated lake-sediment data... continued from page 1

Table 1: Summary of lake-sediment analyses for samples collected in Quebec and Labrador databases that were reported prior to current study.

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Digestion</th>
<th>Finish/Method</th>
<th>Number of Samples</th>
<th>Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quebec</td>
<td>Aqua regia</td>
<td>ICP-ES</td>
<td>26497</td>
<td>Ag, Al, As, B, Ba, Be, Bi, Ca, Cd, Ce, Co, Cr, Cu, Eu, Fe, Ga, Ge, In, K, La, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Sc, Sm, Sr, Th, Ti, V, Y, Zn, Zr</td>
</tr>
<tr>
<td></td>
<td>Aqua regia</td>
<td>ICP-MS</td>
<td>24261</td>
<td>Ag, Al, As, Au, B, Ba, Be, Bi, Ca, Cd, Ce, Co, Cr, Cs, Cu, Fe, Ga, Ge, Hf, Hg, In, K, La, Li, Mg, Mn, Mo, Na, Nb, Ni, P, Pb, Pt, Pb, Re, Sc, Sb, Sc, Se, Sn, Sr, Te, Th, Ti, Ti, U, V, W, Y, Zn, Zr</td>
</tr>
<tr>
<td></td>
<td>Multiacid (HNO$_3$-HCl-HF-HClO$_4$)</td>
<td>ICP-MS</td>
<td>1869</td>
<td>Ag, Al, As, Au, Ba, Be, Bi, Ca, Cd, Ce, Co, Cr, Cs, Cu, Dy, Er, Eu, Fe, Ga, Gd, Hf, Ho, K, La, Li, Lu, Mg, Mn, Mo, Na, Nb, Ni, P, Pb, Pt, Pt, Pb, Re, Sc, Sb, Sc, Se, Sn, Sr, Ta, Te, Th, Ti, Ti, U, V, W, Y, Zn, Zr</td>
</tr>
<tr>
<td></td>
<td>Aqua regia</td>
<td>AAS</td>
<td>17169, 268, 18116, 12132</td>
<td>As, Cr, Hg, Sn</td>
</tr>
<tr>
<td></td>
<td>INAA</td>
<td>15393 - 15881</td>
<td>As, Au, Br, Cs, Sb, Se, Tm, U, W</td>
<td></td>
</tr>
<tr>
<td>Labrador</td>
<td>Multiacid (HNO$_3$-HCl-HF-HClO$_4$)</td>
<td>ICP-ES</td>
<td>18357</td>
<td>Ag, Al, Be, Ca, Ce, Co, Cr, Cu, Dy, Fe, Ga, K, La, Li, Mg, Mn, Mo, Na, Nb, Ni, P, Pb, Sc, Sr, Th, Ti, V, Y, Zn, Zr</td>
</tr>
<tr>
<td></td>
<td>Aqua regia</td>
<td>AAS</td>
<td>19419, 10364, 19419, 10364</td>
<td>Co, Cu, Fe, Mn, Ni, Pb, Zn</td>
</tr>
<tr>
<td></td>
<td>Aqua regia</td>
<td>Hydride AAS</td>
<td>18946, 2449</td>
<td>As, Sb</td>
</tr>
<tr>
<td></td>
<td>Aqua regia</td>
<td>Colorimetry</td>
<td>4636</td>
<td>As</td>
</tr>
<tr>
<td></td>
<td>INAA</td>
<td>19196</td>
<td>As, Au, Ba, Br, Ce, Co, Cr, Cs, Eu, Fe, Hf, La, Lu, Mo, Na, Ni, Rb, Sb, Sc, Sm, Ta, Tb, Th, U, W, Yb</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Delayed neutron counting (DNC)</td>
<td>18763</td>
<td>U</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gravimetry</td>
<td>26489</td>
<td>Loss on Ignition (L.O.I.)</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Lower Detection Limits (LDL) for aqua regia/ICP-MS determinations in this study. Analyses of Labrador samples also included Dy, Er, Eu, Gd, Ho, Lu, Nd, Pr, Sm, Tb, Tm and Yb. Detection limits for the Quebec and Labrador samples were 1 and 0.2 ppb respectively for Au, and 1 and 2 ppb for Pt.

<table>
<thead>
<tr>
<th>Element</th>
<th>Units</th>
<th>LDL Quebec</th>
<th>LDL Labrador</th>
<th>LDL Quebec</th>
<th>LDL Labrador</th>
<th>LDL Quebec</th>
<th>LDL Labrador</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ag</td>
<td>ppm</td>
<td>0.002</td>
<td>0.002</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Al</td>
<td>ppm</td>
<td>100</td>
<td>100</td>
<td>5</td>
<td>5</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>As</td>
<td>ppm</td>
<td>0.1</td>
<td>0.1</td>
<td>0.02</td>
<td>0.02</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Au</td>
<td>ppb</td>
<td>1</td>
<td>0.2</td>
<td>100</td>
<td>100</td>
<td>0.1</td>
<td>0.5</td>
</tr>
<tr>
<td>B</td>
<td>ppm</td>
<td>20</td>
<td>20</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Ba</td>
<td>ppm</td>
<td>0.5</td>
<td>0.5</td>
<td>1</td>
<td>1</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Be</td>
<td>ppm</td>
<td>0.1</td>
<td>0.1</td>
<td>100</td>
<td>100</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Bi</td>
<td>ppm</td>
<td>0.02</td>
<td>0.02</td>
<td>1</td>
<td>1</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Ca</td>
<td>ppm</td>
<td>100</td>
<td>100</td>
<td>0.01</td>
<td>0.01</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Cd</td>
<td>ppm</td>
<td>0.01</td>
<td>0.01</td>
<td>10</td>
<td>10</td>
<td>0.01</td>
<td>0.1</td>
</tr>
<tr>
<td>Ce</td>
<td>ppm</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Co</td>
<td>ppm</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Cr</td>
<td>ppm</td>
<td>0.5</td>
<td>0.5</td>
<td>10</td>
<td>10</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Cs</td>
<td>ppm</td>
<td>0.02</td>
<td>0.02</td>
<td>0.01</td>
<td>0.01</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Cu</td>
<td>ppm</td>
<td>0.01</td>
<td>0.01</td>
<td>10</td>
<td>10</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Fe</td>
<td>ppm</td>
<td>100</td>
<td>100</td>
<td>1</td>
<td>2</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Ga</td>
<td>ppm</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Ge</td>
<td>ppm</td>
<td>0.1</td>
<td>0.1</td>
<td>1</td>
<td>1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
</tbody>
</table>

continued on page 6
Amalgamated lake-sediment data... continued from page 5

separated from the Superior Craton by the ca. 1.83-1.79 Ga New Quebec Orogen (Clark & Wares 2005). This predominantly tranpressional orogen consists of greenschist- to lower-amphibolite facies clastic and chemical sedimentary rocks representing i) autochthonous rift-to-drift sequences, as well tectonically overlying flysch, banded iron-formation and molasse sediments interlayered with minor volcanic rocks (Kaniapiscau Supergroup), ii) belts composed predominantly of mafic volcanic rocks and sills interlayered with sediments comprised mostly of meta-sillstone and black shales (Baby-Howse and Doublet domains) with the Doublet interpreted as remnant of a back-arc basin (Rochon et al. 1993), and iii) Mid- to upper-amphibolite facies, Paleoproterozoic-age clastic metasedimentary and minor mafic metavolcanic rocks that are in thrust contact with the Baby-Howse and Doublet zones in basement-involved thick-skinned tectonics (Rachel-Laporte zone). Rocks of the Baby-Howse and Doublet zones are intruded by voluminous, ca. 1.88 Ga metagabbro sills of the Montagnais suite. Based on continuity of regional aeromagnetic patterns, Archean crust occurring in basement windows and east of the Labrador Trough is interpreted to have Superior Craton affinity; that hypothesis, however, remains to be tested. The Core Zone is also host to a ca. 1.84-1.81 Ga continental magmatic arc, the De Pas Batholith (Dunphy & Skulski 1996).

The southeastern portion of the map presented in Figure 1 is intruded by voluminous Mesoproterozoic-age plutons, including the Nain Plutonic Suite, emplaced between ca. 1.46 and 1.29 Ga (Emslie & Stirling 1993; Amelin et al. 1999). The latter are economically important, being host to the Voisey’s Bay magmatic Ni-Cu deposit as well as the Strange Lake REE deposit. The southernmost extent of the lake sediment survey, east of the Smallwood Reservoir, covers the Seal Lake Group, a set of ca. 1.25 Ga volcano-sedimentary sequences with low-grade metamorphic overprint that contains numerous copper occurrences (van Nostrand & Corcoran 2013). The study area is bounded to the south by the Grenville Orogen.

Comparison of Quebec and Labrador Analyses

The application of the same methods of digestion and analysis to both suites of samples greatly facilitates the merging of data from the two jurisdictions, despite their having been collected and analyzed at different times, and as part of two separately administered programs. There are no paired analyses (from the Quebec and Labrador programs) of the same samples, with which to establish rigorously the relationship between the two programs. Instead, to verify the closeness of the correspondence, analyses of samples from the Quebec dataset, collected close to the border between the two jurisdictions, have been paired with their ‘nearest neighbours’ on the Labrador side. In all cases, the paired samples were separated by a distance of 2 km or less; they have been separated into high-loss on ignition (LOI) and low-LOI datasets, using a threshold of 18.4%. This threshold was arrived at by examining the behaviour...
With Z you can determine a variety of critical geochemical elements in the field, for even the lightest of elements: Low atomic number elements/major elements: H, Li, Be, B, C, N, O, Na, Mg, Al, Si, P, K, Ca, Halogens: F, Br, Plus Transition and Heavy Metals, REE and Precious Metals.

By using the LIBZ rastering specific parts of sample can be precisely targeted for analysis yielding valuable information about mineral chemistry, zonation and alteration at a micro scale. Generate elemental “heat maps” in the field in real time.

SciAps, Inc.
2 Constitution Way
Woburn, MA 01801

+1 339 927 9455
www.sciaps.com
sales@sciaps.com
Amalgamated lake-sediment data... continued from page 6

Figure 1: Simplified geological map of the Precambrian Shield in Quebec and Labrador. Modified after James et al. (2003). Study area outlined by red box.

Actlabs adds value to your projects:

- Precise and Accurate Results
- Fast Turnaround
- Responsive and Knowledgeable Customer Service

A global company with a local full laboratory presence.

CustomerService@actlabs.com
www.actlabs.com
Introducing the **VANTA™** Handheld XRF Analyzer

**Rugged**
- Drop tested to military standards for maximum uptime
- IP65 rated* for protection against water and dust

**Revolutionary**
- Accurate, repeatable results in seconds for instant geochemistry and mineralogy
- Axon™ technology for higher count rates per second and excellent limits of detection (LODs)

**Productive**
- Intuitive software features designed to maximize user throughput
- Data are easily exported via Wi-Fi, Bluetooth®, or USB for streamlined data delivery and archiving

Contact your local Olympus sales representative or visit:

*V series analyzers are IP 64 rated

Vanta and Axon are trademarks of Olympus Corporation. The Bluetooth® word mark and logos are registered trademarks owned by Bluetooth SIG, Inc. and any use of such marks by Olympus Corporation is under license.
ROCKLABS is a global innovator in sample preparation equipment. Our New Zealand ingenuity combined with technical excellence positions us at the forefront internationally. We design and manufacture systems, equipment and certified reference materials which transform the processes of metals and minerals research, mining and exploration organisations around the world.

- On-site service and assistance along with spare parts and after-market support in most countries.
- Extensive range from bench top ring mills and sample dividers through to large combination crushers, pulverisers and fully automated systems.
- Reference Materials division is the world-leading producer of high-quality, globally certified laboratory standards for the Gold, Silver, Platinum, and Palladium industries, which provides vital quality assurance and quality control management.
- We have a team of chemists and a statistician to advise and assist in the use of reference materials and analysis of results.

www.rocklabs.com
of a variety of elements with increasing LOI content in the Quebec and Labrador samples (Fig. 2), and corresponds closely to a cutoff arrived at similarly by Trépanier (2007).

Application of paired t-tests (R-Project, 2016), following log_{10} transformations, to these high and low-LOI subsets, and both subsets combined, led to the conclusion that if attention was restricted to sample pairs separated by distances of 2 km or less, there was no significant difference (indicating a 'background shift') between analyses of Al, Ba, Cd, Co, Cr, Cu, Fe, Hg, K, La, Li, Mg, Mo, Ni, Pb, Rh, S, Sr, Th, Ti, U or V in the Labrador and Quebec datasets at the 95% confidence level. In the case of Be, Ca, Ce, Cs, Ga, Mn, Nb, P, Sc, Se, Sn, Ti, V, Zn and Zr, at least one (but not all three) of the paired t-tests showed no significant differences. Only Ag showed significant differences in all three tests. More than 10% of the analyses of As, Au, Ge, Hf, In, Re, Sb, Te and W were less than the lower detection limit in all six datasets and are not amenable to statistical calculations of this kind; nevertheless, map plots of some of these elements are instructive.

An alternate procedure used the average difference between the pairs in log_{10} units; this was then anti-logged and the difference from unity (equivalent to zero difference between the logarithms) was expressed as a percentage. Where the difference was ≤10%, the element was deemed acceptable for mapping, and where >10% and ≤15% the element was deemed acceptable with caveats. Based on the ≤10% criterion the following elements would be 'mappable': Al, Ba, Be, Cd, Cu, Hg, Mg, Ni, Pb, S, Sr, Th, Ti, and U. Relaxing the criterion to ≤15% allowed for these additional elements to be mappable: Ca, Cr, Fe, Ga, Hf, K, La, Li and, Y.

**Geochemical Plots**

Figures 3 to 7 show the aerial distribution of values of K, U, Pb, S and Cu in the combined datasets. These elements were chosen because they are each loaded significantly in different principal components extracted from each of the four datasets (Quebec / Labrador / high LOI / low LOI) and are therefore probably representative of the dominant processes affecting the distribution of the elements over the
Amalgamated lake-sediment data... continued from page 11

**Figure 3:** Distribution of K (unweighted moving medians) in Labrador and NE Quebec lake sediments.

**Figure 4:** Distribution of U (unweighted moving medians) in Labrador and NE Quebec lake sediments.

**Figure 5:** Distribution of Pb (unweighted moving medians) in Labrador and NE Quebec lake sediments.

**Figure 6:** Distribution of S (unweighted moving medians) in Labrador and NE Quebec lake sediments.

The plotted value assigned to each sample is a moving unweighted median (Gustavsson et al. 2001) of all values of samples falling within a 10-km radius; this has the effect of smoothing the data while preserving the sample locations. In all cases the data are divided into five quintile class intervals; that is to say, the samples assigned to each colour make up 20% of the entire region.
Amalgamated lake-sediment data... continued from page 12

Figure 7: Distribution of Cu (unweighted moving medians) in Labrador and NE Quebec lake sediments.

Figure 8: Distribution of Sb (unweighted moving medians) in Labrador and NE Quebec lake sediments.

Figure 9: Distribution of Sn (unweighted moving medians) in Labrador and NE Quebec lake sediments.

The total. Figures 8 and 9 show the distribution of Sb and Sn, whose areal distributions display a number of interesting features.

Levelling between Quebec and Labrador datasets

Results of the paired t-tests described above suggest that there is very little need for levelling of the two datasets. Therefore, the datasets can be combined without a serious discontinuity appearing at the provincial border (e.g., Amor 2015). One exception to this generalization is Ag; therefore the data from Labrador for this element have been levelled using regression equations derived for nearest-neighbour pairs, separated into high-LOI (>18.4%) and low-LOI groups. Results are shown in Figures 10a and 10b.

In the dataset from Quebec, an internal levelling issue is apparent for Cd and Hg, with samples from project 1997520 showing significantly higher values of the first element, and lower values of the second, than in samples from projects 1983050, 1983055 and 1984059. This results in a linear discontinuity along the east-west boundary of project 1997520’s area of coverage (Figs. 11a, b). A nearest-neighbour regression exercise was carried out on these data and the results are shown in Figures 12a and 12b.

Conclusion

Multi-element (ICP-MS) analyses of lake sediments from adjacent parts of northeastern Quebec and Labrador, that were collected over an area of approximately 300,000 km², were merged to create geochemical maps of this large area. Though the analyses were carried out under different programs at different times, there were no levelling issues between the two datasets for most elements, although levelling was necessary for Cd and Hg within the Quebec
Figure 10a: Distribution of unadjusted Ag (unweighted moving medians) in Labrador and NE Quebec lake sediments.

Figure 10b: Distribution of levelled Ag (unweighted moving medians) in Labrador and NE Quebec lake sediments.

Figure 11a: Distribution of unadjusted Cd (unweighted moving medians) in Labrador and NE Quebec lake sediments.

Figure 11b: Distribution of levelled Cd (unweighted moving medians) in Labrador and NE Quebec lake sediments.
dataset. Application of unweighted moving medians, and 5-colour quintile class intervals, has resulted in maps clearly showing a variety of broad geochemical features.

The most distinctive geochemical feature is related to the 1,100 km long, iron-ore bearing Labrador Trough of the New Quebec Orogen, which has elevated values of Cu, and other elements including Sb and As, over about half of its strike length, starting at the Smallwood Reservoir in the south and extending to Ungava Bay in the north. Other known geological features with a distinct signature in the composition of the lake sediments include the rocks of the Seal Lake Group in the southeastern corner of the study area; this area hosts host Cu mineralization and lake sediments display elevated values of U, Sb, Ag and Cd, amongst other elements.

In conclusion, the merging of the two datasets has been achieved with very few difficulties and it is hoped that the merged data will create an added stimulus to mineral exploration in both Quebec and Labrador.

Acknowledgements

This research was funded by the Geological Survey of Canada’s Geo-mapping for Energy and Minerals (GEM-2) program. It was carried out in collaboration with the Ministère de l’Énergie et des Ressources naturelles du Québec (MERNQ) and the Geological Survey of Newfoundland and Labrador (GSNL). Heather Campbell, Beth McClanaghan, and Roger Paulen are thanked for reviewing earlier drafts of the manuscript.

References

AMELIN, Y., LI, C. & NALDRETT, A.J. 1999. Geo-
chronology of the Voisey’s Bay intrusion, Labrador, Canada, by precise U-Pb dating of co-existing bad-
deleyite, zircon and apatite. Lithos, 47, 33-51.


BEAUMIER, M. 1982. Lake-sediment geochemistry in the George River region, Nouveau-Quebec. Ministry of Energy and Natural Resources, Quebec (in French); Open File Quebec 82-16.

BEAUMIER, M. 1983. Additional data for the lake-
sediment survey in the George River region, Nouveau-
Quebec. Ministry of Energy and Natural Resources, Quebec (in French); Open File Quebec 83-18.

BEAUMIER, M. 1984a. Lake-sediment geochemistry in the Rivière à la Balcine region, Nouveau-Quebec. Ministry of Energy and Natural Resources, Quebec (in French); Open File Quebec 84-43.

BEAUMIER, M. 1984b. Gold in lake sediments, Scheffer-
ville region. Ministry of Energy and Natural Resour-
ces, Quebec (in French); Preliminary Report 84-07.
Amalgamated lake-sediment data... continued from page 15


BEAUMIER, M. 1986a. Lake-sediment geochemistry in the Caniapiscau region. Ministry of Energy and Natural Resources, Quebec (in French); Open File 86-23.


BEAUMIER, M. 1987a. Lake-sediment geochemistry in the Rivièr à la Baleine region; additional data. Ministry of Energy and Natural Resources, Quebec (in French); Open File 86-22.

BEAUMIER, M. 1987b. Lake-sediment geochemistry in the Lac Otelnuk region. Ministry of Energy and Natural Resources, Quebec (in French); Open File 87-14.


CLARK, T., & WARES, R., 2005. Lithotectonic and metallogenic synthesis of the New Quebec Orogen (Labrador Trough), Ministère des Ressources naturelles, de la Faune et des Parcs, Québec; MM 2005-01.


Amalgamated lake-sediment data... continued from page 16


VAN NOSTRAND, T., & CORCORAN, C. 2013. Geology of the western Mesoproterozoic Seal Lake Group, central Labrador (including all of NTS map areas 13L/2 and 7 and parts of 13L/1, 3, 6, 8, 9, 10, 11, 14, 15 and 16 and 13E/14 and 15). In Current research, Compiled and Edited by C. P. G. Pereira and D. G. Walsh, Government of Newfoundland and Labrador, Department of Natural Resources, Geological Survey, Report 13-1.


ALS Laboratories method codes covering the period 1983 through 2015

A table listing ALS methods codes through time is available on the AAG website for download as part of the EXPLORE 173 issue (Appendix attachment). This table is intended as a guide only for EXPLORE readers. Any specific information relating to any issued laboratory certificates should be confirmed with your ALS representative before being relied upon.

Ben Cooke
ALS Client Services Manager, Geochemistry Western Region, Australia
The Association of Applied Geochemists (AAG) is the only professional association dedicated to the science of applied geochemistry and the future of the AAG is in large part in the hands of the next generation of applied geochemists. Recognising this, the AAG offers a variety of incentives for applied geochemistry students to be a part of the Association, including subsidies for membership and attendance at the AAG’s biennial symposium, prizes and awards for talks and posters presented at symposia, and for student-authored papers that are published in AAG’s journal Geochemistry: Exploration, Environment, Analysis (GEEA).

AAG is not alone in recognising the importance of applied geochemistry students and the thesis work they undertake. Analytical laboratories are aware of the important focus that AAG puts on applied geochemistry, and that in several years applied geochemistry students will be the laboratories’ customers. The majority of theses undertaken by applied geochemistry students involve analytical work, the cost of which can be onerous, especially with increasing difficulty in securing funding to support students.

Considering both the AAG and analytical laboratories have an interest in students of applied geochemistry, AAG initiated a collaboration with laboratories in 2011 to broker in-kind analytical support for applied geochemistry students. The program attracted sufficient support from laboratories to run effectively until 2013, when a downturn in the exploration industry forced laboratories to reconsider their involvement, despite their endorsement of the value of the initiative.

The program recommenced in 2015, with sponsorship from Actlabs, ALS, Bureau Veritas Minerals, and Intertek-Genalysis. These laboratories offer a wide range of analytical services for research in applied geochemistry spanning the environmental as well as mineral exploration fields, from BSc through to PhD students. The application process for in-kind analytical support is simple (see Student page on the AAG website), https://www.appliedgeochemists.org/index.php/students/2-uncategorised/15-in-kind-analytical-research-funding-for-students.

If you are interested in this program, download an application form, fill it in, and submit it to: education@appliedgeochemists.org.

One condition of accepting the in-kind support is that students must report on their results either in GEEA or EXPLORE, the AAG’s newsletter. To date, six applied geochemistry students have received support, covering a wide range of topics (see next column).

Paul Morris
AAG Education Committee

Applicant: Mathew Bodnar
Year: 2016
Institution: University of British Columbia (Canada)
Degree: MSc
Thesis Title: *Mapping chemical dispersion above a buried VMS in a till covered terrain, Lara VMS deposit, Vancouver Island, Canada.*
Sponsoring Laboratory: ALS

Applicant: Victor Vincent
Year: 2016
Institution: Modibbo Adama University of Technology (Nigeria)
Degree: BSc
Thesis Title: *Geological investigation of sediment hosted sulphide deposits of Azara-Akiri-Wuse Area, Northcentral Nigeria*
Sponsoring Laboratory: ALS

Applicant: Enerst Tata
Year: 2014
Institution: University of Buea (Cameroon)
Degree: PhD
Thesis Title: *Felsic plutonism, hydrothermal alteration and granite-related gold mineralization, Batouri gold district, SE Cameroon: geochronology and geochemical constraints*
Sponsoring Laboratory: Intertek-Genalysis

Applicant: Marcus Phua
Year: 2014
Institution: University of Melbourne (Australia)
Degree: MSc
Thesis Title: *Petrogenesis of the gabbroic intrusions hosting magmatic Ni-Cu-PGE sulphides at Melba Flats, Western Tasmania*
Sponsoring Laboratory: Bureau Veritas - Minerals
Publication: SEG conference paper abstract, 2015

Applicant: Andrew Lucas
Year: 2011
Institution: University of Western Australia (Australia)
Degree: PhD
Thesis Title: *Evaluating the diffusive gradients in thin films technique for the detection of multi-element anomalies in soils*
Sponsoring Laboratory: Intertek-Genalysis
Publication: EXPLORE v161

Applicant: Xin Du
Year: 2011
Institution: University of Western Australia (Australia)
Degree: PhD
Thesis Title: *Particle size fractionation and chemical speciation of REE in a lateritic weathering profile in Western Australia*
Sponsoring Laboratory: Intertek-Genalysis
Publication: EXPLORE v157
Introduction

Stream sediment geochemical surveys are a robust, economical exploration method for discovering new mineral deposits (Fletcher 1997). In British Columbia, Canada, most government and private sector-managed regional geochemical surveys use samples collected from active first and second order streams followed by analysis of the <0.177 mm fraction of the sample for a wide range of elements by techniques such as an Aqua Regia (AR) digestion combined with inductively coupled plasma mass spectroscopy (ICP-MS) (Jackaman & Lett 2013; Rukholv & Nasiri 2015). For most geochemical pathfinder elements (e.g. As, Cu, Pb, Mo, Zn), the average variability in element concentrations in a typical 0.5 kg stream sediment sample is reproducible within one standard deviation so that anomalous geochemical signals reflect mineralization within the stream catchment basin rather than the variation from sampling bias. However, the variability of heavy mineral grains with a high proportion of elements such as Au, W, Sn, and Pt can be large because they are erratically distributed through the sediment. This variability is due to hydraulic sorting of mineral grains (Rittenhouse & Thorp 1943) and the so called ‘nugget effect’ where a larger, single grain can bias the analytical result (Day & Fletcher 1989).

Modelling mineral grain dispersion in streams can, to some degree, predict the optimum sediment sample and grain size for reducing the high sampling variability in different fluvial energy environments (Day & Fletcher 1991). Sand sized and finer sediment may be scoured from fast flowing streams typical of mountainous, high rainfall regions in western British Columbia, but gold grains are likely to be concentrated in turbulent reaches of a stream when the water flows rapidly over a rough stream bed. Larger gold particles can be expected to accumulate because turbulence often reflects stream bed smoothness and ultimately bedload transport capacity. Smaller gold grains may also become suspended in the turbulent water despite the their high density.

Under these conditions moss mats, attached to boulders and logs adjacent to the stream channel can capture suspended sediment, including the smaller gold grains, from the stream water and in the process greatly improve gold anomaly contrast (Matysek et al. 1988). Comparing element distribution in the material (e.g., bar sediment, moss mat sediment) typically sampled during regional surveys can help understand the geochemical behaviour of elements in different stream environments and suggest the best sampling strategy. This article describes the distribution of Au and other elements in stream and moss mat sediment and in heavy mineral concentrates along a poorly developed mid-channel bar in a branch of the Sombrio River on Southern Vancouver Island (Fig. 1).
An example of gold variation... continued from page 19

boulder-gravel bar in the Sombrio River upstream from the Highway 14 bridge (Fig. 2). This bar was selected because it is a previously reported stream sediment sample location from a typical regional geochemical sampling (RGS) survey (Matysék et al. 1990) and is used here to demonstrate how specific site selection can potentially influence results. The Sombrio River has a shoot and pool profile and drains a catchment area of an estimated 12 km². There is a 2 m high rock ledge across the channel 30 m upstream from the bar head and this outcrop may be the source of the larger boulders scattered along the surface of the bar (Fig. 2). There is no recorded Sombrio River water discharge, but an Environment Canada (2016) gauge installed on Garbage Creek, located 15 km northeast of the Sombrio River, has historical discharge data that may be typical of the area. Garbage Creek drains a 2.9 km² catchment area and flows North into the San Juan River. In March 2007, the gauge recorded an annual maximum daily discharge of 7.06 m³ sec⁻¹ and in September annual minimum daily discharge of 0.011 m³ sec⁻¹. The average width of the Sombrio River at the midpoint of the bar is 7 m; the bar is roughly 40 m from head (upstream) to tail (downstream) and the deposit consists of poorly sorted boulder to sand sized sediment.

At each of the three sites, 0.5 - 0.7 kg of sand to silt sized sediment was collected from the surface of the bar and transferred to a Hubco™ sample bag. Gravel to sand sized sediment was excavated from a shallow pit at each sample point, sieved on site to recover 10-12 kg of <2 mm sized sediment and stored in a 6 mm PVC bag. Moss mats were collected from boulders along the east bank of the river at locations that correspond to the longitudinal bar sample points. At one of the moss mat sites, a duplicate sample was taken. Stream sediment and moss mat samples were dried at 40°C, disaggregated and sieved to <0.177 mm (~80 mesh). The samples were submitted to Acme Analytical Laboratories Ltd. (now Bureau Veritas Minerals), Vancouver where 15 g of the <0.177 mm size fraction was leached with 90 ml HNO₃-HCl-H₂O (1:1:1 v/v) for 1 hour, diluted to 300 ml and the solution analysed for 37 elements including Au by inductively coupled plasma–mass spectrometry (AR-ICPMS). The <0.177 mm fraction of the 1990 regional geochemical survey stream sediments samples were initially analysed by an Aqua Regia digestion followed by atomic absorption spectrometry (AAS) for trace elements and for Au by lead collection fire assay-AAS finish at Barringer Magenta Ltd., Calgary, Alberta. In 2010, the archived <0.177 mm samples were re-analysed by Acme Analytical Laboratories Ltd. for 57 elements by AR-ICPMS. Each <2 mm bulk sample was processed through a Morfee spiral concentrator to recover gold and other higher density grains. The gold grains were counted and the mineral concentrate photographed.

Results

Gold grain counts in the mineral concentrate and element concentrations in the stream and moss-mat sediment vary from the head of the bar to its tail (Table 1). However,

<table>
<thead>
<tr>
<th>Sample</th>
<th>92C071023</th>
<th>92C071024</th>
<th>92C071025</th>
<th>92C071025*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location UTM E</td>
<td>404913</td>
<td>404910</td>
<td>404907</td>
<td>404911</td>
</tr>
<tr>
<td>Location UTM N</td>
<td>5374204</td>
<td>5374200</td>
<td>5374197</td>
<td>5374197</td>
</tr>
<tr>
<td>Site type</td>
<td>Head Bar</td>
<td>Mid Bar</td>
<td>Tail Bar</td>
<td>RGS Site</td>
</tr>
<tr>
<td>Au ppb (river bar sediment)</td>
<td>454.4</td>
<td>8.6</td>
<td>1.9</td>
<td></td>
</tr>
<tr>
<td>Au ppb (moss mat sediment)</td>
<td>2.7</td>
<td>7.1</td>
<td>1.3</td>
<td>58</td>
</tr>
<tr>
<td>Au grains in concentrate</td>
<td>6</td>
<td>8</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>kg of &lt;1.7 mm sediment sample</td>
<td>6.5</td>
<td>6</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Au grains normalized to 10 kg</td>
<td>4</td>
<td>5</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Gold concentrations in the <0.177 mm fraction of stream sediments and moss mat sediments analysed by AR-ICPMS and gold grain count in heavy mineral concentrates in samples from the Sombrio River Bar. Sample 92C071025* is a field duplicate. Normalized gold grain counts are calculated from the ratio of the <2 mm sieved sediment sample weight to a 10 kg mass.

concentrations of mineralization pathfinder element in the stream sediment and moss mat sediment at the three site along the bar are very similar and are below the 95th percentile geochemical threshold values established from

continued on page 21
An example of gold variation... continued from page 20

the NTS 092C RGS data reported by Jackaman (2011). Only As in RGS sample 092C891284 just exceeds the 95th percentile geochemical threshold (Table 2). The highest Au value (454 ppb) detected is in the stream sediment from the surface at the head of the bar, whereas sediment Au values from the middle and tail sites along the bar are <10 ppb. Moss mat sediment Au values increase from <10 ppb at locations by the head and middle bar sites, but increase to 58 ppb Au by the tail of the bar. The percent mean difference \[\left\{\frac{(X_1 - X_2)}{(X_1 + X_2)/2}\right\} \times 100\] between the duplicate moss mat sediment sample values is more than 25 percent for Au, Ag and Pb, but much smaller than 25 percent for the other elements. The visible number of gold grains in the mineral concentrates increases from 6 in the bar head sample to 13 in the tail sample. Normalized gold grain counts calculated from the ratio of the <2 mm sieved sediment sample weight to a 10 kg weight are 4 grains in the bar head sample, 4 grains in the mid bar sample, and 7 grains in the bar tail sample. The mineral concentrate from sample 92C071025 contains gold grains that are generally reshaped and range in size up to 1 mm (Fig. 3). Other minerals tentatively identified in the mineral concentrate are magnetite and garnet. The 1990 RGS detected 89 ppb Au in stream sediment taken from the Sombrio River near the gravel-boulder bar and 800 ppb in a stream sediment sample from second branch of the Sombrio River (Fig. 2).

Within the Sombrio River drainage basin there is at

<table>
<thead>
<tr>
<th>Sample</th>
<th>1023SS</th>
<th>1023MM</th>
<th>1024SS</th>
<th>1024MM</th>
<th>1025SS</th>
<th>1025MM</th>
<th>1025MM (dup)</th>
<th>92C891238</th>
<th>92C891284</th>
<th>92C891247</th>
<th>92C891248</th>
</tr>
</thead>
<tbody>
<tr>
<td>UTM E</td>
<td>404913</td>
<td>404916</td>
<td>404910</td>
<td>404913</td>
<td>404907</td>
<td>404910</td>
<td>404911</td>
<td>404372</td>
<td>404905</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UTM N</td>
<td>5374204</td>
<td>5374204</td>
<td>5374204</td>
<td>5374197</td>
<td>5374197</td>
<td>5374197</td>
<td>5374478</td>
<td>5374174</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site type</td>
<td>Head bar</td>
<td>Head bar</td>
<td>Mid bar</td>
<td>Mid bar</td>
<td>Mid bar</td>
<td>Mid bar</td>
<td>Tail bar</td>
<td>Tail bar</td>
<td>Tail bar</td>
<td>Tail bar</td>
<td>Tail bar</td>
</tr>
<tr>
<td>Ag ppb</td>
<td>82</td>
<td>30</td>
<td>43</td>
<td>35</td>
<td>52</td>
<td>31</td>
<td>48</td>
<td>30</td>
<td>33</td>
<td>148</td>
<td></td>
</tr>
<tr>
<td>As ppm</td>
<td>21.3</td>
<td>16.6</td>
<td>14.2</td>
<td>14.1</td>
<td>14.9</td>
<td>17.3</td>
<td>9.3</td>
<td>23.5</td>
<td>23.2</td>
<td></td>
<td>23.2</td>
</tr>
<tr>
<td>Au ppb</td>
<td>454.4</td>
<td>2.7</td>
<td>8.6</td>
<td>7.1</td>
<td>1.9</td>
<td>1.3</td>
<td>58</td>
<td>800</td>
<td>89</td>
<td>16.6</td>
<td></td>
</tr>
<tr>
<td>Ba ppm</td>
<td>190.7</td>
<td>157</td>
<td>191.8</td>
<td>146</td>
<td>205.1</td>
<td>151.4</td>
<td>149.3</td>
<td>113</td>
<td>142.5</td>
<td>152</td>
<td>78.9</td>
</tr>
<tr>
<td>Bi ppm</td>
<td>0.13</td>
<td>0.11</td>
<td>0.12</td>
<td>0.12</td>
<td>0.12</td>
<td>0.11</td>
<td>0.11</td>
<td>0.09</td>
<td>0.08</td>
<td>0.27</td>
<td></td>
</tr>
<tr>
<td>Cd ppm</td>
<td>0.04</td>
<td>0.03</td>
<td>0.04</td>
<td>0.03</td>
<td>0.05</td>
<td>0.03</td>
<td>0.03</td>
<td>0.1</td>
<td>0.04</td>
<td>0.59</td>
<td></td>
</tr>
<tr>
<td>Co ppm</td>
<td>11.1</td>
<td>8.6</td>
<td>11.9</td>
<td>8.9</td>
<td>11.3</td>
<td>9.2</td>
<td>9</td>
<td>7</td>
<td>7</td>
<td>28.2</td>
<td>111.8</td>
</tr>
<tr>
<td>Cr ppm</td>
<td>48</td>
<td>37.3</td>
<td>51.8</td>
<td>39</td>
<td>52.2</td>
<td>39.5</td>
<td>38.1</td>
<td>69</td>
<td>33.8</td>
<td>78.9</td>
<td>362.8</td>
</tr>
<tr>
<td>Cu ppm</td>
<td>24.17</td>
<td>21.81</td>
<td>23.64</td>
<td>21.04</td>
<td>21.94</td>
<td>22.14</td>
<td>21.96</td>
<td>19</td>
<td>16</td>
<td>11.9</td>
<td>111.8</td>
</tr>
<tr>
<td>Fe pct</td>
<td>2.96</td>
<td>2.32</td>
<td>3.02</td>
<td>2.42</td>
<td>3.04</td>
<td>2.43</td>
<td>2.43</td>
<td>2.17</td>
<td>2.29</td>
<td>7.38</td>
<td>1554.3</td>
</tr>
<tr>
<td>Hg ppb</td>
<td>10</td>
<td>7</td>
<td>11</td>
<td>13</td>
<td>-5</td>
<td>7</td>
<td>7</td>
<td>21</td>
<td>25</td>
<td>357</td>
<td>1324.5</td>
</tr>
<tr>
<td>Mn ppm</td>
<td>347</td>
<td>260</td>
<td>395</td>
<td>294</td>
<td>373</td>
<td>278</td>
<td>284</td>
<td>253</td>
<td>268</td>
<td>1324.5</td>
<td></td>
</tr>
<tr>
<td>Mo ppm</td>
<td>0.36</td>
<td>0.32</td>
<td>0.35</td>
<td>0.32</td>
<td>0.35</td>
<td>0.29</td>
<td>0.3</td>
<td>0.33</td>
<td>0.36</td>
<td>2.39</td>
<td></td>
</tr>
<tr>
<td>Al pct</td>
<td>1.88</td>
<td>1.53</td>
<td>2.11</td>
<td>1.57</td>
<td>2.07</td>
<td>1.57</td>
<td>1.58</td>
<td>1.47</td>
<td>1.48</td>
<td>3.4</td>
<td></td>
</tr>
<tr>
<td>Ni ppm</td>
<td>22.3</td>
<td>18.3</td>
<td>21.9</td>
<td>18.1</td>
<td>23.2</td>
<td>19</td>
<td>19.2</td>
<td>17</td>
<td>18.3</td>
<td>52.6</td>
<td></td>
</tr>
<tr>
<td>Pb ppm</td>
<td>2.95</td>
<td>2.37</td>
<td>3.33</td>
<td>2.69</td>
<td>2.92</td>
<td>2.61</td>
<td>3.36</td>
<td>2</td>
<td>3.05</td>
<td>11.45</td>
<td></td>
</tr>
<tr>
<td>Sb ppm</td>
<td>0.21</td>
<td>0.12</td>
<td>0.16</td>
<td>0.17</td>
<td>0.22</td>
<td>0.14</td>
<td>0.15</td>
<td>0.16</td>
<td>0.13</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>V ppm</td>
<td>79</td>
<td>64</td>
<td>83</td>
<td>66</td>
<td>84</td>
<td>67</td>
<td>65</td>
<td>63</td>
<td>64</td>
<td>256</td>
<td></td>
</tr>
<tr>
<td>Ti pct</td>
<td>0.16</td>
<td>0.133</td>
<td>0.168</td>
<td>0.133</td>
<td>0.178</td>
<td>0.135</td>
<td>0.133</td>
<td>0.127</td>
<td>0.135</td>
<td>0.318</td>
<td></td>
</tr>
<tr>
<td>Zn ppm</td>
<td>50.9</td>
<td>41.3</td>
<td>53.9</td>
<td>40.3</td>
<td>55.4</td>
<td>41.2</td>
<td>41.8</td>
<td>41.5</td>
<td>42.2</td>
<td>125</td>
<td></td>
</tr>
<tr>
<td>Sample Wt g</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>0.5</td>
<td>7.5</td>
<td>7.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td></td>
</tr>
</tbody>
</table>

**Table 2.** Element concentrations in the <0.177 mm fraction of stream sediments (SS) and moss sediments (MM) analysed by AR-ICPMS. Samples collected in 2007 are prefixed by 92C07 and two regional geochemical survey moss mat sediments samples collected in 1989 are identified as 92C891238 and 92C891284. The < 0.177 mm fraction of these two samples was analysed by AR-ICPMS by Jackaman (2011). Element concentrations at the 95 percentile calculated from the regional survey data reported by Jackaman (2011) are shown for comparison to the stream sediment and moss mat sediment values. Gold values in italics (e.g., 800 ) were determined by a lead fire assay - AAS finish.

![Figure 3. Photograph of heavy mineral concentrate from bulk sample 92C071025 showing gold grains and other minerals. Scale bar - 1 mm.](image)
least one Au-Cu-As mineral occurrence (Sombrio 2 - MIN-
FILE 092C 214), but the background element concentra-
tions found in sediment from the river bar likely reflect
downstream bed load dilution of any mineralized sediment
transported and deposited during high rainfall events. Gold
appears concentrated in the surface sediment at the bar
head whereas in the moss mat sediment the gold is higher
towards the tail of the bar, although there is a large differ-
ence between moss mat sediment duplicate sample values.
The difference between Au values in the stream and moss
mat sediment is likely due to the sorting of the grains by size
and density as the water flow varies over the bar. There may
also be variable immersion of the moss in the river water
during periods of high flow changing the amount of sus-
pended gold captured from the water. This emphasises the
need for care in sampling moss below the high water level.
While sediment Au content decreases downstream from the
bar head the number of gold grains increases towards the
bar tail. Intuitively, the higher water turbulence near the bar
head should concentrate higher density and coarser/larger
minerals and, thus, increase the number of gold grains.
One reason for the difference between the predicted and
actual distribution of the gold grains and the Au content of
sediment is that a large pool below the rock ledge upstream
from the bar may dissipate energy during periods of turbu-
ient flow and reduce sediment sorting along the bar. The
concentration of trace elements typically associated with
sediment mineral chemistry (e.g. Fe, Ti, Al) is higher in the
bar surface sediment than in the moss mat sediment and the
values in the surface sediment only vary slightly from bar
head to bar tail (Table 2). This suggests that there has been
limited winnowing of sediment from the bar during high wa-
ter flow and that the bar is a relatively stable fluvial deposit.
The distribution of the Au in the stream and moss mat sedi-
ment is ambiguous and is difficult to explain because of the
small number of samples analysed. However, gold grains
found in all the bar sediments and the Au content of moss
mat sediment suggest bulk sediment sampling from stream
bars and preparation of mineral concentrates complimented
by moss mat sampling may be a viable strategy for detecting
Au in high energy streams.

Conclusions
Sampling stream and moss-mat sediment from this river
bar in a catchment basin draining a gold mineralized area
demonstrates that:
• Sediment from the bar surface and moss-mats from the
stream bank adjacent to the bar have variable Au con-
tents.
• Gold concentrations in the sand-size fraction decreases
downstream from the head of the bar towards the tail,
however, the inverse is true for gold grain counts that
increase slightly from the head of the bar towards the
tail. The moss mat Au signature in the Sombrio River
is ambiguous, but sampling moss mats has been proven
effective for improving Au anomaly contrast in fast flow-
ing mountain streams.

• Screened and concentrating bulk sediment samples by
panning on site would be another (although slower)
method for detecting the gold in stream bars.

Acknowledgments
Ms. Z. Sandwith is especially thanked for helping with
sampling in the Sombrio River and for carrying several
heavy bulk sediment samples from the river up a steep bank
to Highway 14. The British Columbia Ministry of Energy
and Mines, Geological Survey generously provided funds
for the sampling and sample analysis as part of a student
training exercise in geochemical sampling methods. Critical
reviews by W. Jackaman, Noble Exploration Services and A.
Hickin, British Columbia Geological Survey are very much
appreciated and greatly improved the early drafts.

References
British Columbia Ministry of Energy and Mines, 2016. MIN-
.aspx?minfilno=092C%20%202014
British Columbia Ministry of Energy and Mines, 2016. MIN-
FILE 092C 044 http://minfile.gov.bc.ca/Summary.
.aspx?minfilno=092C%20%20044
netite at reach and bar scales in a gravel-bed stream, British
morphology on the distribution of gold in stream sediments
from Harris Creek, British Columbia, Canada. Journal of Geo-
chemical Exploration, 32, 1-16.
Fletcher, W.K. 1997. Stream sediment geochemistry in today's
exploration world; In Gubins, A.A. (ed) Proceedings of Ex-
ploration 97: Fourth Decennial International Conference of
Mineral Exploration, 249-260.
Holland, S.S. 1976, Landforms of British Columbia. British Co-
Regional Geochemical Survey database with new field survey
and sample reanalysis data to support mineral exploration
(NTS 082F, K, 092L, L, 093J, 102I); In Geoscience BC Sum-
Jackaman, W. 2011. Regional Stream Sediment and Water Geo-
chemical Data, Vancouver Island, British Columbia (parts of
NTS 92B, 92C, 92E, 92F, 92G, 92K, 92L, 102I), Geoscience
Matysek, P.F., Jackaman, W., Gravel, J.L. & Feulgen, S. 1990. Brit-
ish Columbia Regional Geochemical Survey - Victoria/Cape
Flattery (NTS 92B/C), British Columbia Ministry of Energy,
Mines and Petroleum Resources, BCRGS 24/Geological
Survey of Canada Open File 2182.
stream sediments; EXPLORE, 62,1-4.
Rittenhouse, R. & Thorp, E.M. 1943. Heavy minerals in sediment-
transportation studies; EOS, American Geophysical Union
Transactions, 24, October/November 1943, 524–530.
geochemical survey database. British Columbia Ministry
of Energy and Mines, British Columbia Geological Survey
Geofile 2015-3.
New AAG Members

Fellow (Voting Member)

Renguang Zuo
China University of Geosciences
State Lab. of Geological Processes and Mineral Resources
No. 388, Lumo Road, Hongshan District
Wuhan, Hubei
CHINA 430074
Membership # 4336

Member

Ryan Bennett
Senior Partner
RCF Management LLC
4936 South Fillmore Court
Cherry Hills Village, CO
UNITED STATES 80113
Membership # 4337

David M. Leng, P.Geol.
President and CEO RGCI
20 Palmerston Avenue
Brantford, ON
CANADA
Membership # 4339

Student Member

Craig Richardson
PhD Student
University of British Columbia
4183 West 16th Avenue
Vancouver, British Columbia
CANADA V6R 3E4
Membership # 4332

Victor Chavez
PhD Student
Universidad Catolica Del Norte
Urb.Tahuaycani G-11
Aracuipa, ARE
PERU AREQ-01
Membership # 4338

Recently Published in Elements

Volume 12, no. 5, Studying the Earth with LA-ICP-MS

The October edition of Elements focuses on the contribution made to the Earth Sciences by advances in laser ablation inductively coupled mass spectrometry. Sylvester and Jackson give a brief history of the development of the technique, followed by a description of the state of the art of major and trace analysis by Jenner and Arevalo. Woodhead, Horstwood and Cottle discuss recent advances in isotopic analyses by LA-ICP-MS, while Wagner, Fusswinkel, Walle and Heinrich examine analysis of hydrothermal fluid inclusions using the technique. Muller and Fietzke describe the role of LA-ICP-MS in palaeoclimate research and Almirall and Trejos do the same for forensic science. Finally, Degryse and Vanhaecke look at the use of LA-ICP-MS in archeological non-destructive analyses. LA-ICP-MS is a method that has now moved out of research laboratories and into some commercial laboratories, so this issue of Elements is great way to catch up with the science.

Dennis Arne

Geochemistry: Exploration, Environment, Analysis

Preservation of co-occurring As, Sb and Se species in water samples with EDTA and acidification

Debo Wu and Thomas Pichler 117

Geochemical assessment of mine waste cover performance post reclamation at Parc mine, North Wales

A. A. Davies, W.F. Perkins & R.J. Bowell 127

Assessment of water quality for drinking/irrigation purpose from Mangla dam, Pakistan

M. Saleem, J. Iqbal & M.H. Shah 137

Portable X-ray fluorescence measurements on exploration drill-cores: comparing performance on unprepared cores and powders for ‘whole-rock’ analysis

A. Bourke & P.S. Ross

147 Natural and anthropogenic sources of atmospheric dust at a remote forest area in Guizhou karst region, southwest China

Y. Tang, G. Han, F. Li & Q. Wu 159

Geochemistry of a large impoundment – Part II: Fe and Mn cycling and metal transport

L. Sun, M.I. Leybourne, C.F.W. Rissmann & T. Brikowski 165
Exploration ‘17
October 21 to 25, 2017, Toronto, Canada

Exploration ‘17 is the sixth of the very successful series of DMEC decennial mining exploration conferences, which have been held in the seventh year of every decade starting in 1967. The theme of the Exploration ‘17 conference is “Integrating the Geosciences: The Challenge of Discovery,” featuring a multi-national, multi-disciplinary technical programme, exhibition, workshops and field schools.

www.exploration17.com/About.aspx

Posters

Program Schedule
Oral presentations are by invitation only
http://www.exploration17.com/Program-Schedule.aspx

Workshops
Workshop 1 - Uncertainty in 3D modelling and Inversion
Workshop 2 - Integrated Spectral Geology
Workshop 3 - Advanced Concepts in Evaluating & Interpreting Geochemical Data
Workshop 4 - Integrated Interpretation - Modelling of Geological & Geophysical Data for Mineral Exploration
Workshop 5 - Application of Indicator Mineral Methods to Bedrock & Sediments
Workshop 6 - Advances in Geophysical Technology
Workshop 7 - Seismic Methods & Exploration
Workshop 8 - Improving Exploration with Petrophysics: The Application of Magnetic Remanence & Other Rock Physical Properties to Geophysical Targeting
Workshop 9 - Status & New Developments in Field Portable Geochemical Techniques and Site Technologies for Mineral Exploration
Workshop 10 - Future of Mineral Exploration Drilling & Sampling
Workshop 11 - Assay Quality Control: The Master Class
Workshop 12 - SEG DISC 2017, EM Fundamentals and Applications
Workshop 13 - Data Integration for the Next Generation of Mineral Exploration Models
Workshop 14 - Making Your Case: Clear, Memorable & Compelling
Workshop 5: **Application of Indicator Mineral Methods to Bedrock and Sediments,**  
**Sunday October 22, 2017**

This one-day short course will review principles, methods, and developments the application of indicator mineral methods to mineral exploration around the world by providing presentations by some of the most experienced practitioners in the field. Indicator mineral methods applied to exploration for a broad range of deposit will be reviewed, including gold, diamonds, VMS, porphyry copper-gold, rare metals, and tungsten. Topics will also in include heavy mineral sample processing methods and microanalytical techniques.

**Speakers**

**Jamie Wilkinson,** Natural History Museum and Imperial College London and **David Cooke,** ARC Centre of Excellence in Ore Deposits (CODES)  
Porphyry indicator minerals (PIMS) and porphyry vectoring and fertility tools (PVFTS)

**Michael Seller,** De Beers  
Lithosphere thickness determinations and kimberlite diamond potential

**Rob Chapman,** The University of Leeds  
Detrital gold as a pathfinder for hypogene mineralization

**Paul Spry,** Iowa State University  
Trace element chemistry of silicates and oxides as indicators to metamorphosed base metal sulfide deposits in the Cambrian Kanmantoo Group, South Australia

**Andy McDonald,** Laurentian University  
Overview of tourmaline as an indicator mineral in exploration

**Sarah Dare,** University of Ottawa  
Overview of magnetite as an indicator mineral

**Dan Kontak,** Laurentian University  
A review of scheelite chemistry and its use an a discriminator in ore-deposit settings, use as an indicator mineral and monitor of ore-forming processes

**Stu Averill,** Overburden Drilling Management Ltd.  
Instructive oddities from 40 years of indicator mineral exploration

**Beth McClenaughan,** Geological Survey of Canada  
Indicator mineral signature of the Strange Lake REE deposit, Labrador

Introduction to indicator mineral methods, sample processing & quality control

**Dan Layton-Matthews,** Queen's University  
Microanalytical analysis of indicator minerals applied to mineral exploration
Laurentian University is one of the recognized world leaders in mineral exploration research and is the top Canadian university in research funding for Economic Geology and in Applied Geophysics from the Natural Sciences and Engineering Research Council (NSERC). Laurentian University, located in Sudbury, Ontario, is the only university in Canada where geology and mineral exploration are integral components of the University's strategic plan.

With CAD $104 million in funding provided by the Canada First Research Excellence Fund (CFREF) and partners, Laurentian University, through strategic partnerships with five Canadian universities, six government geological surveys and three international research centres, will conduct Metal Earth - the largest ever mineral exploration research project undertaken in Canada. Metal Earth seeks to identify and understand the processes responsible for Earth’s differential metal endowment during the Precambrian. This research initiative aims to transform our understanding of Earth’s early evolution and how we explore for metals.

Metal Earth will be led by the Mineral Exploration Research Centre (MERC), the mineral deposit research arm of the Harquail School of Earth Sciences (HES), which is housed in the Willet Green Miller Centre in Sudbury.

Laurentian University is seeking individuals with demonstrated excellence in research and teaching. Successful candidates are expected to actively participate in Metal Earth’s research in addition to developing their independent vigorous and externally-funded research programs. They will teach at the undergraduate and graduate levels in the HES as well as professional courses through the Goodman School of Mines and other units.

Laurentian University is inviting applications for the following four faculty positions in its award-winning Harquail School of Earth Sciences:

- Research Chair in Exploration Targeting (tenured position) – beginning July 1, 2017
  Applicants for this Research Chair will have achieved international prominence in mineral exploration or ore systems research, will have demonstrated leadership in managing large, multidisciplinary, collaborative geoscience projects, and will have a strong understanding of the system and mechanics of publicly funded research both within and outside Canada. He/she will provide leadership for national and international research programs that target ore systems through the integration of multi-scale geoscience (tectonic-structural-geophysical-geochemical-mineralogical-isotopic-surficial) data. This is a tenured position at the Associate or Full Professor level.

- Professor of Exploration Geophysics (tenure track) – beginning July 1, 2017
  This Professor will conduct research and teach on seismology as applied to exploration and Precambrian crustal evolution. This is a tenure-track position at the Assistant or Associate Professor level.

- Professor of Precambrian Geology (tenure track) – beginning January 1, 2018
  This Professor will conduct research and teach on Precambrian Geology and Precambrian Tectonics as they relate to Earth’s evolution and metallogeny. Extensive experience in conducting field-based research and geological mapping is essential. This is a tenure-track position at the Assistant or Associate Professor level.

- Professor of Earth Systems Modelling (tenure track) – beginning January 1, 2018
  This Professor will conduct research and teach on Earth Systems, their application to ore systems, and the interrogation and integration of large multi-parameter geoscience datasets to develop new mineral exploration models. Professional experience in mineral exploration and data analytics is desired. This is a tenure-track position at the Assistant or Associate Professor level.

For additional information regarding Laurentian University, MERC, and Metal Earth please visit their website at www.laurentian.ca, http://merc.laurentian.ca, http://merc.laurentian.ca/metalearth and http://hes.laurentian.ca. To apply, please forward your resume and cover letter to laurentian@boyden.com. Applications will be reviewed beginning in January 2017 but will be accepted until the positions are filled.

Laurentian University is an equal opportunity employer and is strongly committed to employment equity and diversity within its community. Laurentian University especially welcomes and encourages applications from members of visible minorities, women, Aboriginal persons, members of sexual minorities and persons with disabilities. Applicants may self-identify as a member of an employment equity group. All qualified candidates are encouraged to apply. However, Canadians and permanent residents will be considered first for these positions. The University has a policy of passive bilingualism (English/French) as a condition of tenure. Information can be found at www.laurentian.ca. LU faculty members are part of the Laurentian University Faculty Association (LUFA). Candidates are advised to read the Collective Agreement at www.lufapul.ca.
CALENDAR OF EVENTS

International, national, and regional meetings of interest to colleagues working in exploration, environmental and other areas of applied geochemistry. These events also appear on the AAG web page at: www.appliedgeochemists.org.

Please let us know of your events by sending details to:
Steve Amor
Geological Survey of Newfoundland and Labrador
P.O. Box 8700, St. John's, NL, Canada, A1B 4J6
Email: StephenAmor@gov.nl.ca Tel: +1-709-729-1161

2016

5-9 DECEMBER American Exploration and Mining Association Annual Meeting. Sparks NV USA. Website: www.miningamerica.org

12-16 DECEMBER AGU Fall Meeting. San Francisco CA USA. Website: fallmeeting.agu.org/2016/

2017


5-8 MARCH Prospectors and Developers Association of Canada Annual Convention. Toronto ON Canada. Website: www.pdac.ca/convention

20-26 MARCH 48th Lunar and Planetary Science Conference. Woodlands TX USA. Website: www.hou.usra.edu/meetings/lpsc2017

11-14 APRIL 25th International Mining Congress and Exhibition of Turkey. Antalya Turkey. Website: imect.org.tr/defaulten.asp

23-28 APRIL European Geosciences Union General Assembly 2017. Vienna Austria. Website: tinyurl.com/j3ff8wn


6-11 MAY European Workshop on Modern Developments and Applications in Microbeam Analysis. Konstanz Germany. Website: www.microbeamanalysis.eu

9-11 MAY 8th World Conference on Sampling and Blending (WCSB). Perth WA Australia. Website: www.wcsb8.com


15-17 MAY XVIIth International Conference: Geo-informatics, Theoretical and Applied Aspects. Kyiv Ukraine. Website: tinyurl.com/j54kayw

4-7 JUNE 14th International Estuarine Biogeochemistry Symposium. Rimouski QC Canada. Website: www.iebs2017.com

4-7 JUNE FUTORES II — Future understanding of tectonics, ores, resources, environment and sustainability. Townsville Qld Australia. Website: www.jcu.edu.au/futorex

5-9 JUNE 13th International Congress of Applied Mineralogy Taranto Italy. Website: www.sciyeventevents.com/amam-icam2017

5-9 JUNE 7th International Workshop on Compositional Data Analysis. Siena Italy. Website: www.compositionaldata.com/codawork2017

11-16 JUNE 11th International Symposium on Geochemistry of the Earth’s Surface. Guiyang China. Website: www.datas-online.net/ges2017/

12-14 JUNE 14th Australasian Environmental Isotope Conference. Wellington New Zealand. Website: tinyurl.com/juqtdy

13-15 JUNE PEG2017 – 8th International Symposium on Granitic Pegmatites. Kristiansand Norway. Website: tinyurl.com/h8hw9g

25-30 JUNE Catchment Science: Interactions of Hydrology, Biology & Geochemistry. Lewiston ME USA. Website: tinyurl.com/zst629v

26-30 JUNE 14th International Conference on Sustainable Use and Management of Soil, Sediment and Water Resources – AquaConSoil 2017. Lyon France. Website: www.aquaconsoil.org

4-8 JULY 32nd International conference of Society for Environmental Geochemistry and Health. Brussels Belgium. Website: segh-brussels.sciencesconf.org

16-20 JULY International Conference on the Biogeochemistry of Trace Elements. Zurich Switzerland. Website: icobte2017.ch/

16-21 JULY 13th International Conference on Mercury as a Global Pollutant Providence RI USA. Website: mercury2017.org/initial/index.php

4-9 AUGUST Magmatism of the Earth and related strategic metal deposits. Miasl Russia. Website (Facebook): tinyurl.com/zxsjpy6. Email: va_zaitsev@inbox.ru

12-17 AUGUST 21st World Congress of Soil Science. Rio de Janeiro Brazil. Website: 21wcss.org/


20-23 AUGUST 14th Biennial SGA Meeting. Quebec City QC Canada. Website: sga2017.ca/
20-29 AUGUST  12th International Eclogite Conference. Åre Sweden. Website: www.geology.lu.se/IEC12
2-9 SEPTEMBER  18th Annual Conference of International Association for Mathematical Geosciences. Fremantle WA Australia. Website: http://iamg2017.com
11-14 SEPTEMBER  SIAM Conference Mathematical and Computational Issues in the Geosciences. Erlangen Germany. Website: www.siam.org/meetings/gs17
17-22 SEPTEMBER  28th International Meeting on Organic Geochemistry. Florence Italy. Website: www.houseofgeochemistry.org/imog/

21-25 OCTOBER  Exploration ‘17. Toronto ON Canada. Website: www.exploration17.com
22-25 OCTOBER  GSA Annual Meeting. Seattle WA USA. Website: www.geosociety.org/meetings/2017/
31 OCTOBER-  10th Fennoscandian Exploration and Mining. Levi Finland. Website: fem.lappi.fi/en
7-8 DECEMBER  19th International Conference on Nuclear and Environmental Radiochemical Analysis. Sydney NSW Australia. Website: tinyurl.com/js9gsu

2018
16-21 JUNE  28th International Applied Geochemistry Symposium. Vancouver BC Canada. Website: rfg2018.org
8-13 JULY  Geoanalysis 2018. Sydney NSW Australia. Website: 2018.geoanalysis.info