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Determination of Gold in Soils and Sediments by Fire Assay or Aqua Regia Digestion: Choosing the Optimal Method

INTRODUCTION

Although there are a number of analytical techniques that are used to measure the content of Au in soils, sediments and rocks, it is not always obvious to the exploration geochemist which is the optimal method to use. Some methods are designed to extract all of the Au present within the sample, whereas other methods only provide, at best, 'near-total' abundance, and some methods are specifically designed to extract only Au associated with specific mineral phases. Advances in analytical techniques, instrumental sensitivities and demands of the exploration and industrial processing industries have meant that Au detection limits are continuously being lowered (e.g., Mladenova *et al.* 2012). Low detection limits are particularly important for geochemical exploration in deeply covered terrain, where Au contents of soils, till, and sediments may be governed by poorly understood transport mechanisms, with consequent uncertainties in where Au is sequestered (Cameron *et al.* 2004).

There are a variety of methods that are used in analysis for Au, including inductively coupled plasma emission spectroscopy (ICP-ES), ICP mass spectrometry (ICP-MS), atomic absorption spectroscopy (AAS), graphite furnace AAS, and neutron activation analysis (NAA). There is also an increase in the use of hyphenated techniques, in particular laser ablation ICP-MS, e.g., femtosecond laser ablation analysis for Au in fire assay buttons (Vanhaecke *et al.* 2010). Several methods for extracting Au from geological matrices in addition to fire assay and aqua regia also exist, including more traditional techniques such as cyanide leach (Leduc & Itard 2003), and newer methods such as activated carbon microextraction (Hassan *et al.* 2011) and cloud point extraction (Tong *et al.* 2011; Hartmann & Schuster 2012). For a recent review see Mladenova *et al.* (2012). Many of the newer techniques are capable of reaching Au detection limits at the low ppt level,

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President's Message

The new Association website has now been up and running for a few months. Webmaster Gemma Bonham-Carter indicates that it is running smoothly, after a few expected start-up hiccups, mostly involving logging in to the Members page. The website includes a banner of five photographs across the top of the page that show geochemical work in action. Ideally, this group of photos will be replaced periodically, perhaps once a year or so. But for this to happen, we need contributions from AAG members. Please consider sending landscape-format photographs on this broad topic with brief captions to Gemma. The captions should include location, date, topic, and photographer. As photograph banners are replaced, we plan to archive the older photographs with their captions on a future webpage. Also remember that we are always looking for new content for the *Latest News* and *What's New* webpages. Few contributions have been received in the last several months. Any irregularities found in the new website should be brought to Gemma's attention for remedy (webmaster@appliedgeochemists.org). On a related topic, Ryan Noble is exploring the possibility of establishing a YouTube channel for AAG. For this to happen, he (Ryan.Noble@csiro.au) will need ideas and video content from you, the AAG membership. This avenue is being explored to appeal to younger web-savvy geochemists, plus those of us older geochemists who strive to stay abreast of ever-evolving media trends.

The initiative to document the history of AEG/AAG is moving forward under the leadership of Beth McClenaghan. Using documents forwarded by Beth and Bob Garrett as a start, John Hansuld and Eion Cameron are capturing the earliest years of the Association. For long-time members, if you have anecdotal stories or photographs of those early years, please pass them on to Beth (Beth.McClenaghan@nrcan-rncan.gc.ca) and she will forward them to John and Eion. It is important that we capture a record of the Association's early years now, as many of the

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but these require time-consuming and complicated extraction and pre-concentration steps not suited to a production laboratory, and so will not be discussed further.

In this paper we discuss the benefits and limitations of two of the major Au analytical methodologies (fire assay and aqua regia digestion) used on soils, till and surficial media and provide insights into how to determine the optimal method to use based on the type of exploration or analytical program. To illustrate the utility of both methods, we also present a case study where we have analyzed more than 2000 soil samples by both fire assay and aqua regia digestion.

GOLD BY FIRE ASSAY

Fire assay (FA) is a fusion technique that results in full sample decomposition, followed by a separation step to preconcentrate the Au contained within the sample. There are two major sub-types of fire assay: Pb and NiS. The NiS-FA method is particularly useful where all of the platinum group metals (PGM) are required in addition to Au (Hall & Oates 2003; Savard *et al*. 2010; LeFort *et al.* 2011). However, where Au is the primary metal of interest, the NiS-FA technique is less widely used, owing to the increased complexity of the method, and because some studies have shown that the method has lower Au recoveries compared to the Pb-FA method (e.g., Juvonen *et al.* 2004). Thus,

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founding Members have passed away. The document about the early-years should serve as a guide for subsequent AAG volunteers in capturing the middle and most recent decades of the Association with words and photographs. We hope that the final product will be rich in content (text, photographs, figures, tables, etc.) and we plan to have it available from the AAG website for inspection and download. Thank you in advance to all who are working on this important endeavor.

A new AAG fee structure was approved at the November 2012 Council meeting. Full membership remains unchanged at $100 USD, but we now have options and price variations for receiving *GEEA* either as digital only or print copies, and for receiving *Elements* or not. Details on the new fee structure were covered in my annual dues letter sent to all members and are available on AAG's website under the Membership tab.

The 26th International Applied Geochemistry Symposium to be held in November 2013 in in Rotorua, New Zealand is fast approaching. Planning details are being finalized under Tony Christie's stellar leadership. This will be a must-attend meeting, with an excellent technical program, a variety of workshops, and some amazing fieldtrip opportunities. AAG Members, their spouses, and other geoscience colleagues are encouraged to reserve dates for attending this meeting. Current information for the symposium is at http://www.gns.cri.nz/iags/ (or Google "26th IAGS").

I ask you to continue your involvement with AAG by renewing your membership as soon as possible, encouraging non-member colleagues to join AAG, applying for Fellowship status (criteria on the AAG website), and becoming more active in AAG by serving on Council or on a committee. Your active participation in AAG ensures its future success.

Bob Eppinger
President

Notes from the Editor

The March 2013 issue of **EXPLORE** features one technical article by Matt Leybourne and Sarah Rice of ALS Geochemistry that reviews the optimal methods for determining gold contents in soils and sediments.

EXPLORE thanks all contributors and reviewers for this first issue of 2013: Steve Amor, Graeme Bonham-Carter, Benedetto De Vivo, Bob Eppinger, Gwendy Hall, Rémy Poulin, Dave Smith, Emilie Ruffiange, Pertti Sarala, Erick Wieland, and Wang Xueqiu.

Beth McClenaghan
Editor

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the NiS-FA will not be discussed further.

The Pb-FA technique involves mixing of a sample with a flux, which includes PbO, Na_2CO_3, $Na_2B_4O_7 \bullet 10H_2O$, silica and flour. The precise amounts of these ingredients commonly need to be adjusted depending on the sample matrix, in particular the sulfide content. A small amount of Au-free Ag is added and the sample mixture is then fused under reducing conditions at high temperature (~1000 °C); the Au, Ag and precious metals form a dense button with the Pb. The Pb button is recovered and fused again under oxidizing conditions to separate the Pb from the Au (see for example, Hall & Oates 2003).

Advantages of the Pb-FA method are that it is a: 1) complete digestion of the sample, so that Au encapsulated within resistive minerals is measured; 2) process that results in a preconcentrated sample that is relatively free of the sample and fusion matrix, so that minimal sample dilution or matrix-associated interferences are encountered during analysis; and 3) historically standardized method generally performed in the same manner by different laboratories such that data from different sources are reliably comparable.

By contrast, the limitations of the method include: 1) the detection limit for Au by Pb-FA is controlled mainly by the impurities in the flux, rather than instrumentation; 2) flux ingredients commonly need to be modified depending on the nature of the sample (e.g., high sulfide), requiring more highly skilled laboratory technicians than is the case for aqua regia digestion; 3) the total dissociation of Au-bearing minerals negates information on how much Au is available in native form or in sulfide phases versus encapsulated phases; and 4) large sample aliquot required (15 or 30 g), although this can also be an advantage as it reduces the nugget effect.

GOLD BY AQUA REGIA DIGESTION

In aqua regia digestion, the sample is subjected to attack by a mixture of concentrated HCl and HNO_3 acids. Aqua regia is a widely used in soil, sediment and rock analysis as a partial digestion. Aqua regia is the term used to typically describe a 1:3 mixture of concentrated nitric (HNO_3) and hydrochloric (HCl) acids. Note, however, that this usage is not consistent, with ratios between the two acids being variable between different laboratories and research groups. Because aqua regia is not a total digestion technique, other factors in addition to the nitric/hydrochloric acid concentrations and ratio influence metal recoveries. One of the most critical factors is temperature; higher temperatures generally result in higher metal recoveries, and more consistent results in the experience of ALS Geochemistry.

Aqua regia is particularly useful for Au dissolution; neither nitric acid nor hydrochloric acid alone will keep Au in solution. The two acids, combined, perform the required steps to dissolve Au and keep it in solution. Nitric acid and reaction products in combination with HCl (e.g., nitrosyl chloride, NOCl) are strong oxidizers, forming gold ions (Au^{3+}) in solution following dissolution of Au-bearing minerals. The hydrochloric acid provides the source of Cl- ions, which form strong aqueous chloroaurate ($AuCl_4-$) complexes, removing Au from solution and allowing Au dissolution and oxidation reactions to progress i.e., (Renner *et al.* 2000):

$$Au(s) + 3\,NO_3^-(aq) + 6\,H^+(aq) \rightarrow Au^{3+}(aq) + 3\,NO_2(g) + 3\,H_2O(l)$$

$$Au^{3+}(aq) + 4\,Cl^-(aq) \rightarrow AuCl_4^-(aq)$$

The advantages of the aqua regia Au method compared to Pb-FA include the following: 1) lower detection limits compared to Pb-FA are achieved in many laboratories, owing to the ready production of ultraclean HCl and HNO_3 via distillation and the advances made in ICP-MS instrumentation in recent years; 2) this relatively simple digestion method means that less technical training and experience for laboratory personnel is required than is the case for Pb-FA; and 3) small sample sizes (< 1 g) can be analyzed for Au when analyzing the clay size (< 2 μ) fraction.

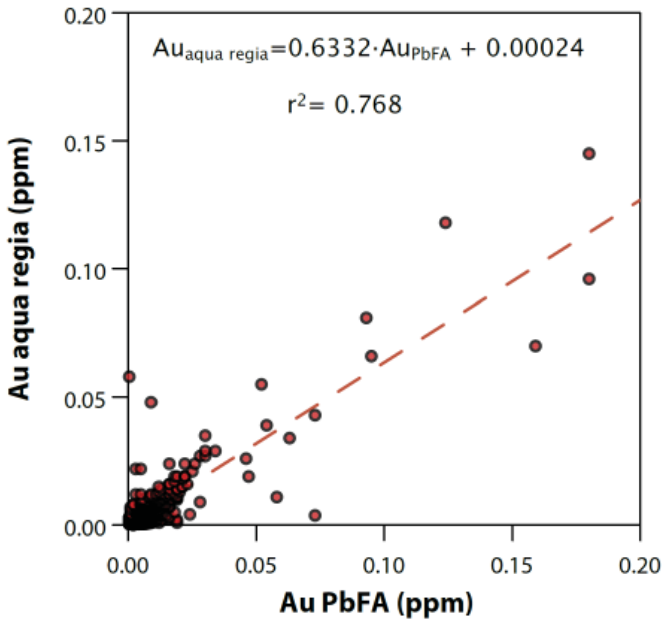

***Figure 1**. Plot of Au content determined by Pb-FA versus Au by aqua regia.*

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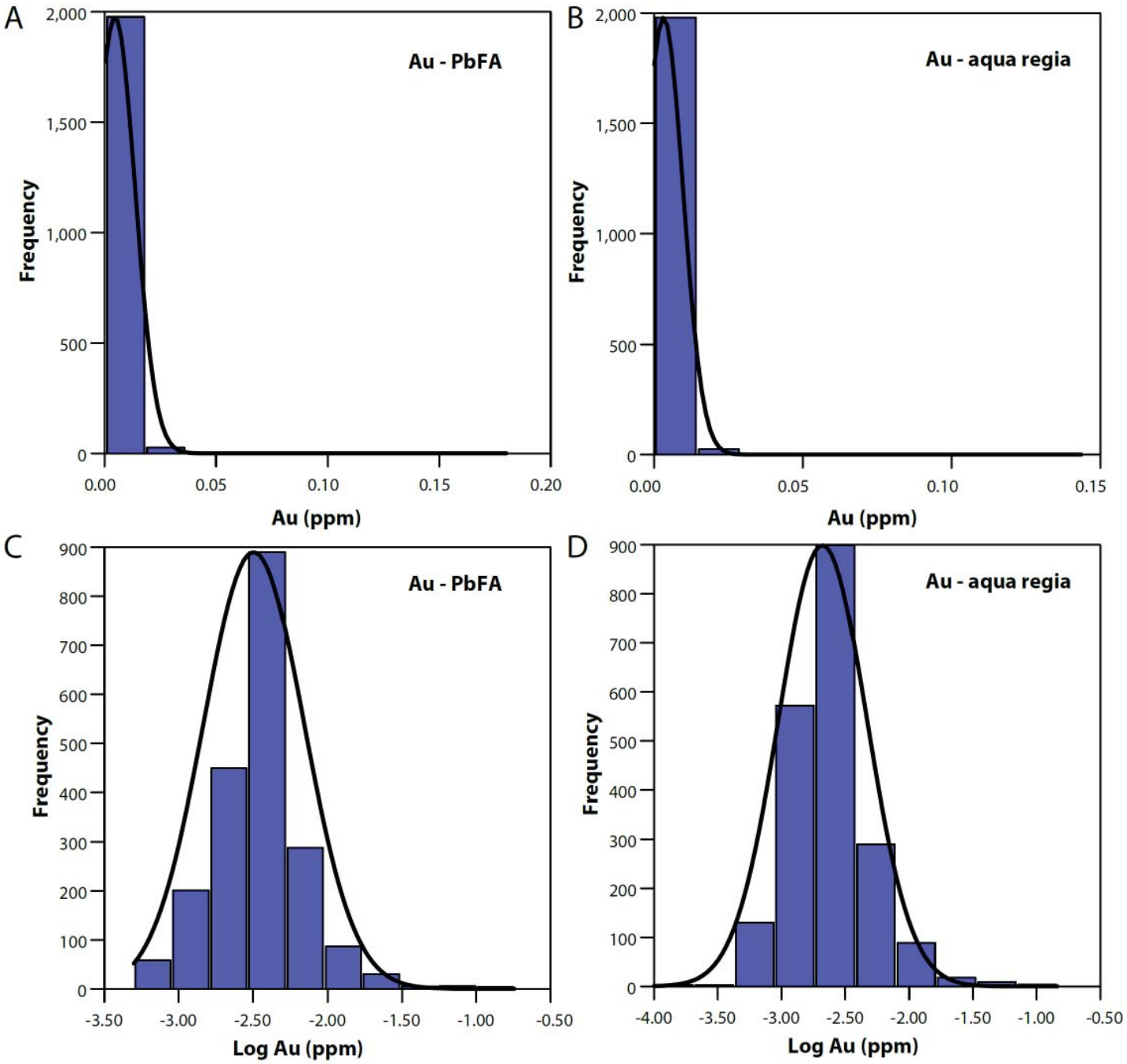

Figure 2. *Frequency distribution plots for Au content determined by Pb-FA and aqua regia. The Au data are in ppm and show the highly skewed (i.e., non-normal) nature of Au in geological materials. However, the data for both methods are approximately log normal (C and D).*

By contrast, the limitations of the method include: 1) for most samples, an aqua regia digest will not recover 100% of the Au, in particular, Au occluded within most (alumino) silicate minerals; 2) large sample sizes (25-50 g) for representative analysis for Au require special laboratory setup to maintain consistent heating and mixing across the digestion solution; 3) depending on the mineralogy of the sample, the total dissolved solids content can be high, as this method does not involve preconcentration and separation in the same way as the Pb-FA method.

CASE STUDY

In order to evaluate the differences between Pb-FA and aqua regia analyses of soil, till and sediment

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for Au, we analyzed 2016 samples of soils from northwestern Canada, using both methods, with a nominal weight of 25 g for aqua regia and 30 g for Pb-FA in most cases (except where sample volumes were too low, in which case the nominal weights were around 15 g, and 10 g in rare cases). Soil samples were dry screened to -80 mesh (< 0.177 mm) prior to analysis. For this dataset, 123 samples were determined to contain less than detection amounts of Au for one of the two methods (Pb-FA detection limit = 0.001 ppm; aqua regia detection limit = 0.0001 ppm for most samples, 0.001 ppm for a small subset). Because the number of samples reported as below detection was small relative to the total number of samples, in the figures and for the statistics presented below, we have reassigned the below detection samples Au values to half the respective method detection limit.

For the 2016 samples, Au values by Pb-FA ranged from the detection limit of 0.0005 ppm to 0.18 ppm (mean = 0.0047 ppm, median = 0.0030 ppm, standard deviation = 0.0090 ppm, skewness = 12.8), whereas aqua regia Au values ranged from 0.0001 to

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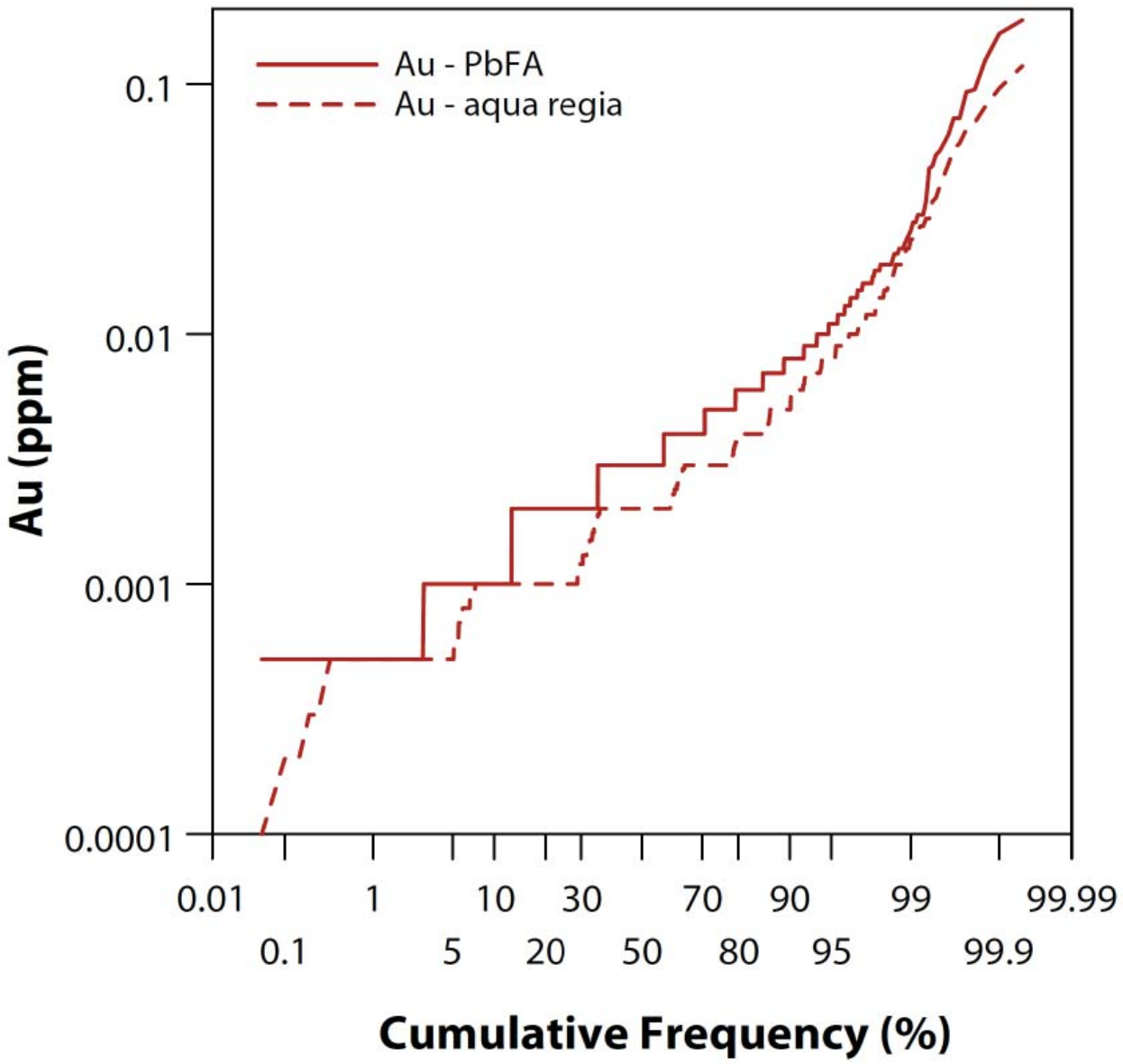

***Figure 3**. Cumulative frequency plot for Au by Pb-FA and aqua regia. Both datasets show similar distribution patterns, with a shift to lower abundance overall for the aqua regia Au.*

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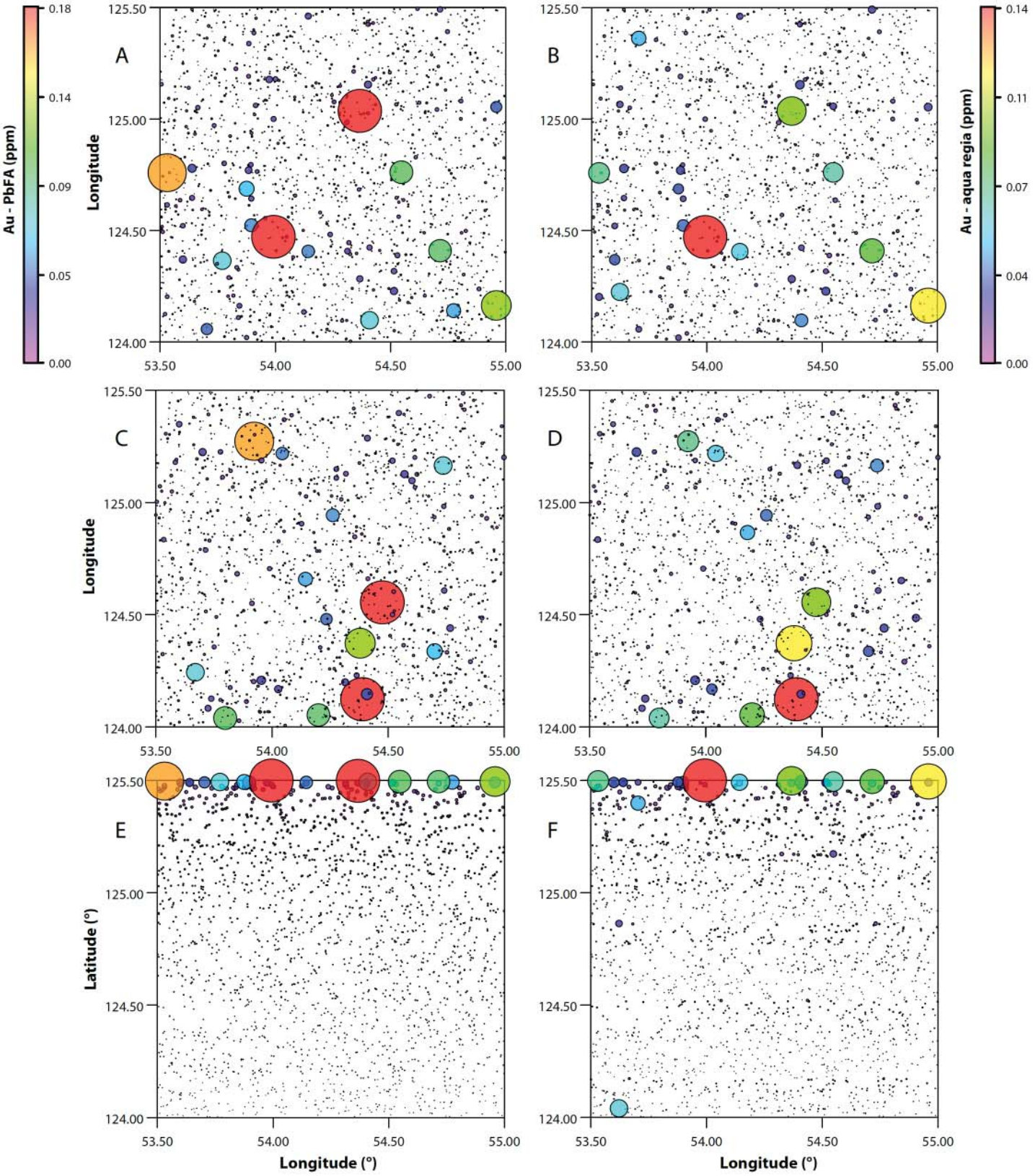

Figure 4. *Proportional dot plots of Au by Pb-FA (A, C, E) and aqua regia (B, D, F). The locations were generated randomly within a randomly selected region of space measuring 1.5° by 1.5° in latitude and longitude, to mimic a typical regional geochemical survey.*

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0.145 ppm (mean = 0.0032 ppm, median = 0.0020 ppm, standard deviation = 0.0065 ppm, skewness = 12.3) (Fig. 1A). The means and medians of the two datasets are statistically significantly different at the 99% confidence interval (Students T-test; $p < 0.001$). However, for the log-normalized data, although also statistically significantly different in terms of mean and median, both datasets are approximately log-normally distributed and have similar log-probability distributions (Figs. 2, 3). Overall, the two datasets show a statistically significant correlation at the 99% confidence interval (Fig. 1A; $r^2 = 0.768$). The strong correlation indicates that despite some scatter in the data, both datasets would show similar geochemical anomalies. The parallel shapes but shift to lower Au contents in the aqua regia log-probability distribution compared to the Pb-FA distribution indicates that, on average, about 80% of the Au is recovered by aqua regia digestion.

The difference in Au recovery between the two methods is interpreted to reflect the inability of an aqua regia digestion to extract Au that is occluded in resistant minerals. Aqua regia will digest all native Au, carbonate, sulfide and Fe, Mn oxide minerals, suggesting that the most likely location of the occluded Au is in quartz and/or silicate minerals (Church et al. 1987). The extent to which an aqua regia digestion will extract Au is therefore dependent primarily on sample type (both in terms of medium sampled and deposit type being targeted) and nature of Au sequestration and the grain size of the material being analyzed; a finer sieve fraction or grind (<0.063 mm vs <0.177 mm) exposes more surface area for an aqua regia leach. The much stronger correlation between the two methods for the ranked data versus the paired data (i.e., Fig. 1B versus 1A) may in part be due to analytical uncertainties, but is probably dominantly a function of the nugget effect for Au, even for sample sizes as large as the 25-30 g nominal weights dominantly used in this study.

To test the robustness of both methods for mineral exploration, we generated a random set of locations within a fictional study area and produced

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proportional dot maps for both Au techniques (Fig. 4). In Figure 4 there are three scenarios plotted. Figures 4A (Pb-FA) and 4B (aqua regia) show the results where the individual samples are assigned random locations (although the same location for both methods). The anomalies produced are therefore randomly distributed, yet both methods show similar the anomaly patterns, although with slight differences in relative intensity (Figs. 4A, 4B). Figures 4C and 4D show the same data, but in this case, the Au data were ranked prior to assigning the random locations. Again, both analytical methods produce essentially identical anomaly patterns. Finally, the data were ranked and the latitude data were ranked (longitude remained randomized; Figs. 4E, 4F). Because of this latitude ranking, all of the Au Pb-FA anomalies lie along the upper limits of the 'study area'. The Au aqua regia anomalies are essentially identical, although the mismatches are more evident where plotted this way, e.g., there is an anomaly in the SW corner of the map area (Fig. 4F). For geochemical exploration in glaciated terrain, previous studies have shown that most of the native Au in till is < 0.177 mm in size (e.g., McClenaghan 2001), indicating that the aqua regia digestion method would be a suitable alternative to Pb-FA, with the advantage of lower detection limits (i.e., 0.0001 with a 25 g aliquot, 0.0002 with a 0.5 g aliquot). Indeed, a recent study by Ward *et al.* (2013 in press) has shown that analysis of the clay sized fraction (<0.002 mm) of till by aqua regia digestion reduces the nugget effect for Au and enhances anomaly to background signals for fine-grained Au. Note that the clay fraction Au would best be analyzed in conjunction with a larger size fraction to account for nugget Au; McClenaghan (2001) noted that the greatest abundance of Au in till was in the 0.01 to 0.05 mm fraction.

SUMMARY

Both the Pb-FA and aqua regia digestion methods are excellent choices for routine geochemical exploration soil surveys. The decision as to which method to choose will rest primarily on the nature of the sample medium and requirements of the exploration program, such as detection limits and sizes of sample available. The costs and analytical turnaround for Ob-FA and aqua regia Au are typically comparable. For soil, till and stream sediment geochemical surveys, aqua regia is an excellent method of choice, owing to relative ease of analysis and ability to achieve low detection limits; the low detection limits offset the fact that typically < 100% of the Au is recovered. Furthermore, the conditions of the aqua regia digestion can be adjusted (i.e., acid strength, HNO_3/HCl value, temperature) depending on the strength of leach desired. As shown by our case study, it is important to recognize that for many deposit types (and depending on Au transport mechanism), the aqua regia digest will not be total for Au. This is not always critical, as in many soil and till surveys we are interested in the more labile Au in any case (Cameron *et al.* 2004). By contrast, for drill core and rock samples, fire assay is the method of choice because of its ability to liberate essentially all the Au contained within the sample. However, as we have shown here, Au anomalies for the case study are essentially identical, albeit with subtle differences in anomaly strength, as determined by Pb-FA and aqua regia results.

Acknowledgments

We thank the editor of **EXPLORE**, Beth McClenaghan, and reviewers Gwendy Hall and Graeme Bonham-Carter for insightful comments that improved the manuscript.

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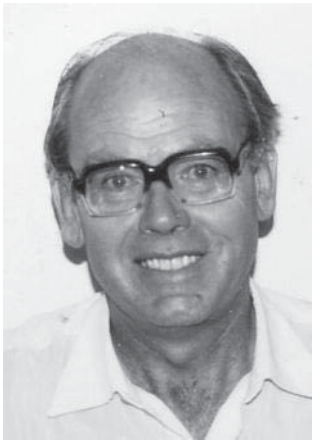
2013-2014 Regional Councillors

Patrice de Caritat

Patrice obtained his university degrees in geology from Belgium (Hons) and Australia (PhD). He first took up a brief industry supported Post-Doctoral Fellowship at the Australian National University, working on the geodynamic evolution of eastern Australian basins, then a 3-year Post-Doc at the University of Calgary, Canada, where he studied water-rock interaction in the Western Canada Sedimentary Basin. Subsequently, Patrice took up a Senior Research Scientist position at the Geological Survey of Norway, working mostly on the Kola Ecogeochemistry project (www.ngu.no/kola), which mapped the geochemical distribution of 60+ elements in snow/rain, stream/lake and ground water, moss, lichen, humus, O, B and C soil horizons, overbank sediments, till and bedrock, in the Barents region of northern Norway-Finland-Russia. After this, he returned to Australia to take up a Program Leader position in the Cooperative Research Centre for Landscape Evolution and Mineral Exploration (CRC LEME), where he was particularly involved in developing geochemical and isotopic indicators to improve the usefulness of groundwater as a sampling medium for mineral exploration in regolith-dominated terrains. He currently is Principal Research Scientist at Geoscience Australia, where he lead the recently completed National Geochemical Survey of Australia project (www.ga.gov.au/ngsa). Patrice's main research interests are regolith and groundwater geochemistry, particularly water-rock interaction, isotope geochemistry and continental-scale geochemical mapping. Patrice is a Fellow of the Association of Applied Geochemists (AAG), AAG Councillor (2011-12), member of the Editorial Board of *Geochemistry: Exploration, Environment, Analysis*, and Society News Editor for *ELEMENTS*.

Romy Matthies

Romy is a biogeochemist with eight years of experience in the mining industry and research. She obtained her Ph.D. from Newcastle University, UK, and is now working as a Marie Curie Postdoctoral Fellow at Waterloo University, Canada. Her areas of expertise encompass mine drainage prediction and passive remediation. As part of her postdoctoral research she investigates stable metal isotopes and their fractionation processes. Romy is looking forward to serve for a second term as an AAG councillor.



Tom Molyneux

1958 Obtained BSc Honours Degree in Geology at Trinity College Dublin
1964 Obtained MSc in Geology at Univ. Pretoria, South Africa
1971 Obtained PhD in Geology at Univ. Pretoria, South Africa
1959-1961 Exploration for De Beers Corp. in Tanzania
1961-1991 Geological exploration for Anglo American Corp .
1976 Joined Association of Exploration Geochemists
1991-1993 worked for the South African Council for Geoscience (Geol. Survey) compiling mineral reserves, etc.
1994-present Geological and geochemical consultant based near Dublin, Ireland
2004-2007 From a base at The Univ. Pretoria he compiled the surface geology of the Eastern Bushveld Complex on 1:50 000 scale with an accompanying booklet (ISBN 978-1-86854-092-3).
2008 Elected Fellow of Geological Society of South Africa

Peter Rogers

Peter has 40 years+ worldwide experience in economic geology, mineral exploration and environmental geochemistry.
AAG Experience: 2 Council terms New Membership Committee; Chair of 2001 IGES in Santiago de Chile; AAG Bibliographic Committee
AAG vision to widen appeal in Colombia and S. America with strengthened industry participation and financing.

- 1970 B.Sc. University College London + 1974 Ph.D. University of Leicester fluid inclusions Pennine Orefields.
- 1970 diamond exploration in South Africa and Botswana
- 1974 British Geological Survey (BGS) aggregates + Geochemist in Peru, Costa Rica, Economic Geologist to the British Antarctic Survey
- 1982 Nova Scotia Department of Natural Resources, Geochemist
- 1995 founder of Chavin Consulting Limited, with specializations in blind prospecting deep prospecting

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methods in covered areas including deserts, volcanics and laterites; vegetation and heavy mineral methods. Completed exploration projects in the many different terrains of the Americas including the Boreal glaciated forests of Canada to the Atacama high altitude desert, the high Andes to the Amazon jungles. Recently completed projects in North and South America for Au, VMS, tailings remediation using non-toxic recovery methods and dimension stone.

- Early 2011 Vice President Exploration Colombia for Cordillera Gold Limited.

Cliff Stanley

Cliff obtained his bachelors degree in Earth Science from Dartmouth College, and his MSc (applied geochemistry, economic geology) and PhD (mathematical geology) from the University of British Columbia. Dr. Stanley has been a professor in the Department of Earth & Environmental Science at Acadia University, Wolfville, Nova Scotia since 1998, and beforehand served seven years as Adjunct Professor with the Mineral Deposit Research Unit at UBC.

Dr. Stanley is author of over 50 papers in Economic Geology, Geochemistry, and Mathematical Geology, has supervised numerous bachelors, masters, and doctoral students and post-doctoral fellows. His present research interests are in the field of lithogeochemistry, hydrothermal alteration, sampling, geochemical quality control, mathematical applications in geochemistry, and partial digestion geochemistry. Dr. Stanley has served five terms on the AAG Council (2000-2004, 2005-2009, and 2010-2012), was the AAG distinguished lecturer (2003-2004). He is happy to continue his commitment to the Association by serving on council once again.

Dr. Stanley's recent administrative experience includes service as Acting Chair of the Department (1.5 years), vice-chair of the admissions committee for the Association of Professional Geoscientists of Nova Scotia (12 years), and the provincial representative from that association on the Canadian Geoscience Standards Board (12 years).

Peter Winterburn

Peter was born in the UK in 1962. He completed a Geological Sciences B.Sc. (Hons) at the Univ. Aston, Birmingham, followed by a Ph.D. at Univ. Edinburgh in 1988 on Geochemistry of Ultramafic Xenolihs in Kimberlites. Thereafter he relocated to South Africa to take up the position of Isotope Geochemist with the

CSIR in Pretoria. He joined Anglo American in 1990 as Geochemical Database Manager, followed by Geochemical Laboratory Manager at the Anglo Research Facilities and finally as Manager of the Geochemistry Department in Exploration. Following the consolidation of Anglo American and Minorco in 1999, he became the Regional Geochemist for Africa, and subsequently the Regional Geochemist for South American in 2002 based out of Santiago, Chile. In 2007 he returned to South Africa as the Chief Chemist managing metal accounting and metallurgical plant auditing. Peter joined Vale (then CVRD) in 2008, as the Chief Geochemist (Exploration) initially based in South Africa and since 2009 has been based out of Toronto with a role of enhancing and developing best practise geochemistry in exploration, operations and research and development on a Global Basis. He is a Fellow of the AAG.

AAG Regional Councillor Report For China

APPLIED GEOCHEMISTRY RESEARCH PROJECTS IN CHINA

Introduction

In China, applied geochemistry research is focusing on geochemical exploration, regional geochemical mapping, global geochemical baselines, and environmental geochemical survey. Geochemical exploration continues to be the strongest in the field of applied geochemistry in China. Most of funds for applied geochemistry research from the government and companies are allocated to regional- and local-scale geochemical surveys/exploration for mineral resources. A small amount of funds is allocated to global-scale geochemistry and environmental geochemistry projects. Some large or nation-wide applied geochemistry research projects in China are introduced as follows.

China Geochemical Baselines Project

The China Geochemical Baselines Project (CGB), as a part of Global Geochemical Baselines (Darnley et al., 1995), was initiated in 2008 and was planned to be completed in 2013 (Wang Xueqiu, 2012). The purpose is to document the abundance and spatial distribution of chemical elements across the whole China. The database and accompanying element distribution maps represent a present geochemical baseline against which can be quantified future chemical changes and past chemical evolutions. Approx. 1500 grids of

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China Geochemical Baselines Networks were designed to cover the whole China's land (9.6 million km2). Each grid is 1°(lng.) x 40′(lat.) (approx. 80kmx80km) (Fig. 1). Soil (overbank/floodplain/catchment sediments) samples and rock samples were collected. At each soil sampling site, two samples are taken from surface horizon (0-25 cm) and deep horizon (>100 cm or C horizon). Typical rock samples, representing different geological times, are simultaneously collected in order to interpret the geogenic sources of soil geochemical patterns and to understand the chemical evolution during the past geological time from Archaeozoic to Quaternary. Approximately 18 000 rock samples and 6 000 soil samples have been collected until 2012. 81 geochemical parameters including 78 chemical elements are determined by ICP-MS/AES following 4-acid digestion and XRF following fusion as backbone methods combined with other 10 methods. Analytical quality is under strict control by using standard reference samples to obtain harmonious high-quality data. A Internet-based software named *Digital Chemical Earth* was developed for managing the database and maps, and allow people to access vast amounts of geochemical data and maps through the Internet.

The data show greatly intersting results for understanding the past geological events dispalyed by rock samples and for quantifing the chemical changes displayed by soil samples. For example, iridium anomalies were discovered in the Cretaceous and Tertiary (K-T) boundary in Yunnan, southwestern China, where the Lufengosaurus fossils were located. The concentrations of Ir range from 0.2-0.8 ppb, average value is 0.41 ppb in the boundary tufaceous limestone and tufaceous claystone, whereas Ir concentrations in Cretaceous sandstone and Tertiary mudstone are less than 0.02 ppb (Wang, 2012). It may imply that Iridium in the boundary is extraterrestrial origin, providing us with understanding dinosaurs extinctions due to the impact of an earth-crossing asteroid (Alvarez et al.1980). Soil geochemical baselines can be quantified the chemical changes. For example, dramatic changes of CaO concentrations and distribution deminsion were quantified in the past 15 years by comparing sampling in 1994 and 2009 in southern China. Floodplain sediments or catchment overbank sediments have been collected by the Environmental Geochemical Monitoring Network Projec (EGMON) in 1994 (Xie and Cheng 2001) and by the China Geochemnical Baselines in 1999 (Wang, 2012). The average concentration decreases from 0.53% to 0.41%, distribition area of concentrations

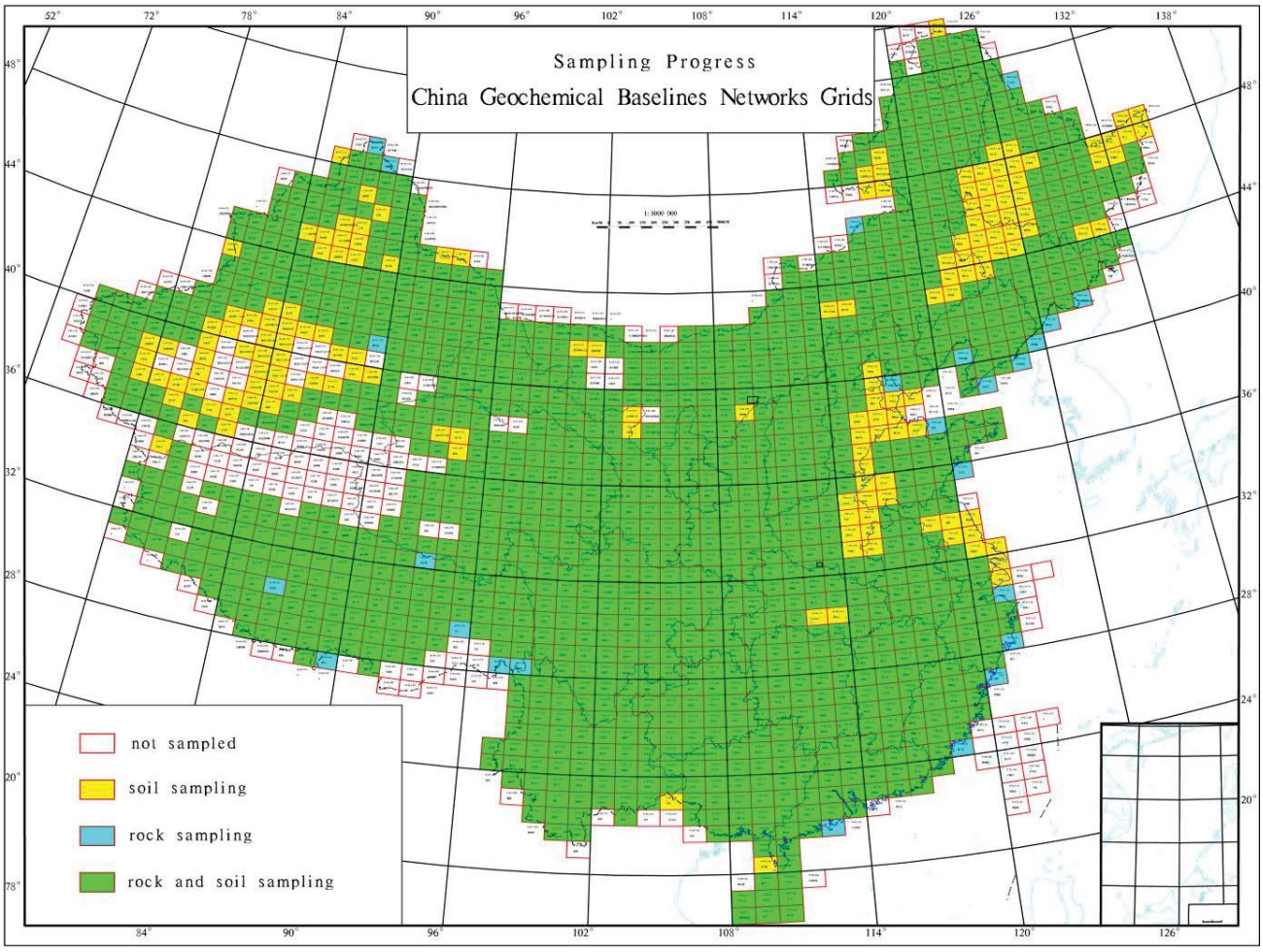

***Figure 1**. Sampling progress of China Geochemical Baselines (colour areas finished).*

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<1% CaO extends from 872 000km² to 1073 000km², increasing 23% compared to that in 1994, due to leaching of CaCO3 by acid rains influenced by human activities in southern China (Wang 2012). Increase of acid rain precipitatio are mainly due to coal, oil and gas burning, because the duration of the past 15 years is the fastest increase phase of industralization and urbanization in the history. We could predict or quantify future changes by using the present geochemical baselines.

Regional Geochemical Survey/Mapping Projects

The Regional Geochemistry- National Reconnaissance Project (RGNR) mainly using stream sediment sampling has covered all the hilly and mountainous regions in China approx. 6 million km², where the stream sediment samples are available since 1978 (Xie 1997). The project has made great contributions to mineral discoveries in China. However, the sampling methods continue to be refined for the remaining regions including basins, desert, elion and grassland terrains, where stream sediments are not available. Recently, the good research progress is that development of effective sampling methods for the north and northwestern China Gobi desert, desert basins, and semi-desert grassland landscapes. Sampling of catchment basin sediments in semi-desert terrains and fine fraction of regolith samples (-120 mesh) from the weakly cemented clay-rich horizon at a depth of 10-40cm in desert terrains are effective for delineation of regional targets. Geochemical survey at a density of one sample per 100 km² in an area of approximately 150 000 km2 in southern Xinjiang desert has delineated regional targets of Au, Cu, Pb, Zn and U from 1999-2002 (Wang *et al.* 2007). Some large ore deposits have been discovered by follow-up exploration at the targets.

The developed sampling method is being applied in China-Mongolia Boundary Geochemical Mapping Project at a scale of 1:1,000,000 since 2006. 10532 samples have been collected across the boundary area of approximately 1 million km² at a sample density of 1 per 100 km². Geochemical Atlas of 69 elements were produced and provided to Mongolia (Fig. 2). The results shows that (i) regional geochemical patterns were firstly identified at the world's largest REE ore deposit in China; (ii) regional patterns of Cu-Au-Mo have a good correlation with the porphyry metallogenic province in Mongolia. (iii) regional patterns of Ag-Pb-Zn have a good correlation with the polymetallic province. Four China scientists were awarded for the Mongolian Medal of Honour, which is the highest-ranking honour for geologists who have made a great contribution to Mongolian Geology and Mineral Resources.

Environmental Geochemical Survey Projects

Regional Multi-purpose Geochemical Survey Project

The China eastern agriculturally and industrially developed regions located in Quaternary plains were not mapped by the RGNR project. The China Geological Survey and provincial governments have jointly implemented multi-purpose geochemical survey projects since 2002 (Xie et al. 2008). The projects will provide geochemical data for environmental assessment, land use planning, agricultural production increase.

Soils are taken as the general sampling media. Other media such as lake sediments, sea sediments, water and vegetables (crops) are collected in some regions for some

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***Figure 2**. China geochemists presenting the Geochemical Atlas to Mongolia.*

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specific purposes. Soil samples were collected from two layers: surface (0-20cm) and deep (150-200cm) horizon. The surface samples indicate anthropogenic influence and the deep samples indicate natural environments. The sampling density for the surface sample is 1sample/ km^2 and for the deep sample is 1 sample/4km^2. Four samples are composed into one analytical sample, i.e. one analytical top soil sample per 4km^2 and one deep soil sample per 16km^2. Samples were ground to -200 mesh for analysis.

Fifty two parameters (Ag, Al, As, Au, B, Ba, Be, Bi, Br, C, Ca, Cd, Ce, Cl, Co, Cr, Cu, F, Fe, Ga, Ge, Hg, I, K, La, Li, Mg, Mn, Mo, N, Na, Nb, Ni, P, Pb, Rb, S, Sb, Sc, Se, Si, Sn, Sr, Th, Ti, Tl, U, V, W, Y, Zn, Zr), organic carbon(Org.C) and pH were determined. Approx. 1 million km2 has been covered up to 2011. A series of geochemical atlas have been published (China Geological Survey 2010; 2011a; 2011b).

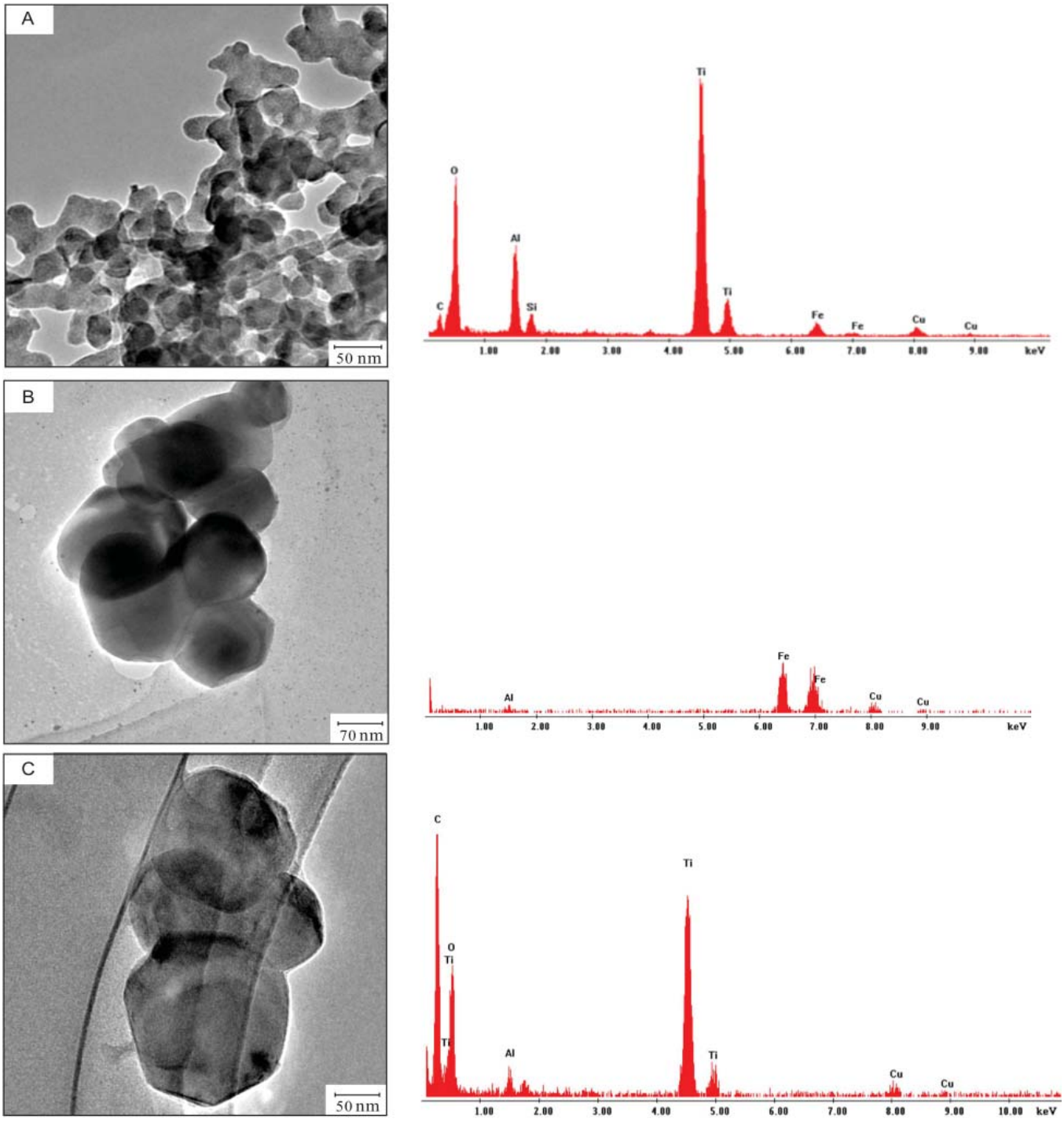

Figure 3. *Nanoparticles of crystal crystal structure Cu-Ti metals in gases, soils and ores at Zhouan Cu-Ni deposit, Nanyang, Henan, China: A) nanoparticles of Cu-Ti in soil gases; B) nanoparticles of Cu-Ti in soils; C) nanoparticles of Cu-Ti in ore rocks.*

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Mining Contamination Geochemical Survey Project

The project is designed to carry out orientation geochemical survey at selected 10 large mines in China. Samples of tailings, stream sediments, soils, river water, underground water, and cones at each mining area are collected. The project began in 2011 and the results have not published.

Deep-penetrating geochemistry

Exploration geochemistry research activities have centered on transport mechanism and development of methods for concealed deposits in covered terrains. Deep-penetrating geochemical methods such as selective leaching, geogas, electrical extraction have revealed that anomalies do exist at surface overlying mineral deposits covered by transported overburden. We do not yet fully understand the dispersion processes though many researchers recently have given different migration models. Recent years, a great progress on deep-penetrating geochemistry has been made in findings of evidences of nano-particles of metals over the covered ore deposits.

Nanoparticles of metals were observed in gases, soils and ore rocks at the copper-nickle, gold, copper-gold-silver deposits using a transmission electron microscope (TEM) equipped with an energy dispersive spectroscope (Wang & Ye 2011; Wang et al. 2012, Ye et al. 2012). Particle diameters range from 10 to 200 nm. Most of them are generally tens of nanometers in diameter with ordered crystal structure observed by the TEM. The particles tend to assemblage shaped like a grape cluster. The particles are composed of native copper, compound metals of Cu-Fe, Cu-Fe-Mn, Cu-Ag Cu-Cr, Cu-Ni, and compound metals with Si, Al, Ca, O, P from the copper-nickel deposit and Au, Cu-Au, Cu-Fe, Cu-Ti from the gold deposit. The facts of nanoscale particles with crystal structure (Fig. 3) show that nanoscale particles both in gases and soils originate from the ore deposit. The findings of nanoscale particles of mineralization metals provide direct observation evidence that the nano-particles of metals could penetrate through sedimentary, metamorphic and soil covers to the surface. A new method for separation of nanoscale particles from soils was developed to search for concealed deposits.

SYMPOSIUM, WORKSHOPS AND TRAINING COURSES

The 4th Natinal Applied Geochemistry Symposium

The 4th China National Applied Geochemistry Symposium took place in Chengdu, China, November 26-28, 2012. The symposium was sponsored by the China Association of Applied Geochemistry and hosted by the Chendu University of Science and Technology. Approximately 350 participants attended the sympsium. Student paper prize was awarded for 10 students selected from 100 student participants in the symposium.

CCOP-CGS-IUGS Seminar on Geochemical Mapping

A seminar on geochemical mapping was held in Nanjing, China, on 28-29 March, 2012. The seminar was sponsored by the China Geological Survey and hosted by the Institute of Geophysical and Geochemical Explora-

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Figure 4. *Group photograph of CCOP Geochemical Mapping Seminar in Nanjing, China.*

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tion and the the Coordinating Committee for Geoscience Programmes in East and Southeast Asia (CCOP) and 55 participants from 14 CCOP countries attended the seminar (Fig. 4). Dr. Wang Xueqiu and Dr. David Smith, co-leaders for IUGS/IAGC Global Geochemical Baselines, Dr. Alecos Demetriades, treasurer for the IUGS/IAGC Global Geochemical Baselines gave presentations on the following topics:

- History and Accomplishments of the IUGS/IAGC Task Group on Global Geochemical Baselines
- Global-scale Geochemical Baselines Mapping
- Regional-/National-scale Geochemical Mapping in China
- Geochemical Atlas of Europe: Techniques and Management
- European Ground Water Geochemistry Atlas Using Bottled Water as a Sampling Medium,
- European Geochemical Atlas of Agricultural and Grazing Land Soil
- Continental-scale Soil Geochemical Survey in North America.

Training Course on Geochemical Mapping and Environmental Geochemical Survey for African Countries

A training course on Geochemical Mapping and Environmental Geochemical Survey for African Countries took place in Beijing, August 13 to September 12, 2012. This is the 3rd training course on geochemical mapping for Africa given by China, after the first course in 2004 and 2011. The training course was sponsored by the Ministry of Commerce of the People's Republic of China and organised by the Academy for International Business Officials (AIBO) of the Ministry of Commerce and the China Geological Survey (CGS). Twenty three geoscientists from 12 African countries (Eritrea, Ethiopia, Guinea, Liberia, Malawi, Nigeria, Sierra Leone, South Sudanese, Sudan, Tanzania, Uganda and Zimbabwe) participated in the course. The training course comprised 2-week lectures, 1-week field sampling training (Fig. 5) and 1-week excursion. Lectures covered the following topics:

- Basic principles related to geochemical mapping
- Geochemical mapping procedures - design and planning, field sampling, chemical analysis, data processing and map generation
- Global-scale geochemical baselines
- Regional/national-scale geochemical mapping
- Application of geochemical mapping data for mineral resources
- Environmental geochemical survey and its applications
- Laboratory analysis for 76 elements used in geochemical mapping
- Geochemical data management and map generation.

Implementation proposals for global-scale, national/regional-scale geochemical mapping in African countries were discussed in the training course. Professor Wang Xueqiu, Dr. Zhou Guohua and Mr. Zhang Qin from the Institute of Geophysical and Geochemical Exploration (IGGE), Dr. Liu Dawen and Dr. Xiang Yunchuan from the Develpment and Resaecrh center of the China Geological Survey gave the above-mentioned lectures.

The field sampling trip to Beijing suburb focused on stream sediments and overbank sediments sampling in mountainous terrains, and soil sampling in plain terrains. Field sampling trip to inner Mongolia focused on grassland sampling.

Figure 5. *Photo showing overbank sediment sampling training for geochemists from African countries.*

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Training Course on Geochemical Mapping for Asian Countries

A training course on Geochemical Mapping for Asian Countries are taking place in Beijing from October 22 to November 20, 2012. A total of 46 participants from 12 countries (Armenia, Cambodia, East Timor, Kazakhstan, Kyrgystan, Malasia, Mongolia, Pakistan, Tajikistan, Thailand, Vietnam) participated in the course. The lecture topics are the same as those of the Training Course on Geochemical Mapping and Environmental Geochemical Survey for African Countries.

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AAG Regional Councillor Report for Southern Europe

The EuroGeoSurveys Geochemistry Expert Group (which has succeeded the FOREGS Geochemistry Working Group) is very active in continental-scale applied geochemical projects. Since, the publication of the FOREGS Geochemical Atlas of Europe (http://weppi.gtk.fi/publ/foregsatlas/) the group has completed two projects concerned with (a) European ground water geochemistry using bottled mineral water as the sampling medium, and (b) the publication of a book on urban geochemistry. This work can be found in the following publications:

1) Reimann, C. and Birke M., Eds + 79 others, 2010. Geochemistry of European Bottled Water. Borntraeger Science Publishers, Stuttgart. 268 pp. URL: http://www.schweizerbart.de/publications/detail/isbn/9783443010676/Geochemistry-of-European-Bottled-Water;

2) Birke, M., Demetriades, A. & De Vivo, B. (Guest Editors), 2010. Mineral Waters of Europe. Special Issue, *Journal of Geochemical Exploration*, 107(3), 217-422. This volume includes 15 contributions from national teams of Croatia, Serbia, Slovenia (2), Hellas (2), Slovakia, Hungary, Italy (2), Fennoscandia, Germany (2), Portugal and Estonia;

3) Johnson, C.C., Demetriades, A., Locutura, J. & Ottesen, R.T. (Editors), 2011. Mapping the Chemical Environment of Urban Areas. Wiley-Blackwell, Oxford, UK, 616 pp. Avalaible online at: http://eu.wiley.com/WileyCDA/WileyTitle/productCd-0470747242,descCd-description.html),

In Europe, two large projects are presently being carried out

(1) the Geochemistry of European Agricultural and Grazing Land Soil (GEMAS – URL: http://gemas.geolba.ac.at/) and

(2) Urban Geochemistry (URGE). The first will be completed in 2013, and the second in 2014.

Activities of the GEMAS and URGE Project Teams for 2013-14 include publication of (1) a European Atlas on the geochemistry of agricultural and grazing land soil, reporting data elaboration and geochemical maps for 68 determinands, covering almost the entire European territory until the Urals, and (2) case studies on urban geochemical mapping projects carried out in 10-12 European cities using a common sampling, sample preparation and analytical protocols.

Results of both GEMAS and URGE projects will be presented in a Session organised at the Goldschmidt Conference in 2013 in Florence. A selection of papers presented in this Session will be published in a Special Issue of the Journal of Geochemical Exploration.

A significant contribution to European regional geochemistry in 2012 is the publication of the regional soil geochemical atlas of Spain (URL: http://www.igme.es/INTERNET/actividadesIGME/lineas/CartoGeo/geoquimica/geoquimicaIng.htm). About 40,000 soil samples were collected and analysed for 63 elements.

Another significant contribution to European urban geochemistry in 2012 is the completion of the surface soil geochemical project in Dublin in Ireland (URL: http://www.gsi.ie/surge).

Publications by EuroGeoSurveys Geochemistry Expert Group members on different aspects of European ground water geochemistry, and the GEMAS project:

Birke, M., Reimann, C., Rauch, U., Demetriades, A., De Vivo, B., Klos, V., Gosar, M., Ladenberger, A. & GEMAS Project team. Cadmium distribution in cropland and pasture soils of Europe. GEMAS Volume (in press).

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AAG Regional Councillor Report for Northern Europe

The mineral exploration and mining boom continues to be strong in Fennoscandia. Numerous companies (both foreign and local) are working in the region looking for not only gold, PGE and base metal deposits that used to be the main targets, but also for so-called high technology elements such as In, Li, the REE, Sc and Y. A primary reason for the broader focus on a wider range of elements and metals is the mineral strategy of the European Union that emphasizes increased European self-sufficiency and import independence of strategic metals.

One of the key characteristics of current mineral exploration in Fennoscandia is the application of applied geochemistry. Much of the exploration is in glaciated terrains and till geochemistry is still considered the most beneficial tool for tracing potential source rocks for target metals and minerals. Regional and target-scale till geochemical data are the basic datasets for exploration, and new sampling projects are on-going for mapping new areas or condensing older datasets. For example, in Sweden the SGU has launched a new regional till geochemical mapping project focusing on the northern part of the country.

Recently, the use of portable XRF analyzers has increased significantly in mineral exploration. The primary uses of pXRF analyzers are in bedrock mapping and boulder prospecting. GTK has also done testing for the use of pXRF on till and pre-glacial weathered bedrock samples in exploration, and the results seem to be promising.

Tekes – the Finnish Funding Agency for Technology and Innovation - launched a year ago a new five year program called Green Mining (2011-2016; http://www.tekes.fi/programmes/GreenMining) .The programme creates new business that requires new, specialised expertise alongside the growing field of traditional mining. The central content of the programme consists of two thematic areas: 1) Intelligent and minimum-impact mines, and 2) new mineral resources. The programme offers funding for projects within the topic of the programme, networking events and service expertise processes as well as the promotion of international cooperation. Advances are also being looked for in applied geochemical and indicator mineral analysis and sampling methods in glaciated terrains.

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Sampling a fumerol; White Island, New Zealand
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THE ASSOCIATION OF APPLIED GEOCHEMISTS
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Minutes of the 2012 Annual General Meeting of the Association of Applied Geochemists

Held at the 34th International Geological Congress (IGC), Brisbane, Australia, 8 August 2012

I. Call to Order – Establishment of Quorum

AAG Secretary D. Smith, in the absence of President Eppinger, called the Annual General Meeting (AGM) to order at 7:00 PM local time and determined that more than the necessary 15 AAG Fellows required for a quorum were present. Sixteen AAG Fellows attended.

II. President's report (D. Smith for B. Eppinger)

D. Smith presented the following report from President Eppinger:

AAG Membership,

Please accept my apologies for not attending AAG's Annual General Meeting at the 34th International Geological Congress. A family emergency—my Mother's last days—has precluded my IGC attendance. Dave Smith has graciously offered to present this short summary of AAG activities for the first 7 months of 2012. Thank you, Dave.

First, I want to thank the AAG Executive, Matt Leybourne, Gwendy Hall, and Dave Smith, and our Past President, Paul Morris, for easing my transition in the Presidency, and for their sage advice. Also, thank you to all AAG Regular and Regional Council Members for participating in the running of our society. Thanks to Gwendy and to Beth McClenaghan for their editorship responsibilities for GEEA and EXPLORE, respectively, and to Sarah Lincoln as EXPLORE's Business Manager. Thanks also go to Jamil Sader as AAG's Website Coordinator and to Gemma Bonham-Carter for administering the website. Finally, Betty Arseneault deserves a huge thank you for her day-to-day running of AAG as our Business Manager. Without Betty, I fear that all would fall apart!

The 26th International Applied Geochemistry Symposium will be held on 18-21 November, 2013 in Rotorua, New Zealand. Planning, under the stellar leadership of Local Organizing Committee Chairman Tony Christie, is well underway. This is promising to be a must-attend meeting, with an excellent technical program, a variety of workshops, and some amazing fieldtrip opportunities. I encourage all AAG Members to attend, and encourage your geoscience colleagues to attend as well! You can get to the symposium website by Googling "26th IAGS".

When I began my term as President, a major concern was in securing proposals for the 27th IAGS in 2015. At the Rovaniemi, Finland meeting, there was some discussion about having this meeting return to the USA. AAG Councillor Erick Weiland is leading the charge in developing a strong proposal for having the meeting in Tucson, Arizona. Stay tuned as this develops further. I can't leave the IAGS discussion without sincerely thanking Pertti Sarala for leading a remarkable 25th IAGS in Rovaniemi, Finland. Simply outstanding! Finally, David Cohen has revised and updated the AAG Code of Practice for Symposia and an associated Guidelines document that were approved this Spring by Council for future AAG symposia.

As Chairman of the Awards and Medals Committee, Paul Morris, with the help of fellow committee members, revised the guidelines for nominating, approving, and presenting Gold and Silver Medals to deserving geoscientists. The revised guidelines were approved by Council this Spring and forwarded to Jamil for posting on AAG's website.

Speaking of the website, we are close to finalizing the new AAG website. Most of the content had been transferred by Gemma in 2011, but we were stymied in moving forward by the need for specialized programming for the Members Area part of the website. Gemma and Jamil sought help from a website development service and Council approved the expenditure for this work in June. We should have a new website up and running by this Fall. Andrew Ransom, our former Webmaster, has moved on from this volunteer position. Thank you, Andrew, for many years of service to AAG.

In June, Ravi Anaand was unanimously approved by Council as AAG's Distinguished Lecturer for 2013-2014. Ravi is an excellent choice, having a broad background in applied geochemistry and in being a dynamic speaker. Ravi has a varied list of titles on which he will be speaking. He is also embarking in 2013 on a CSIRO-funded world tour, which will facilitate his giving presentations to AAG Membership and other geoscientists. Please contact Ravi (ravi.anand@csiro.au) to help facilitate his presentations in your part of the world. Both Rob Bowell and Scott Long are thanked for jointly serving as AAG Distinguished Lecturers in 2011-2012.

With Erick Weiland leading the charge, AAG now has a new student funding opportunity—the In-Kind Student Support Initiative, approved by Council this last Spring. With this program, AAG serves as a broker in linking students to various analytical laboratories (currently ALS, Becquerel, Genalaysis, and Ultratrace) who work directly with the students in providing analytical support. Erick is actively seeking students, so spread the word! Another on-going student funding program, the ioStipend (ioGlobal and AcmeLabs) provides in-kind analytical research funds for BSc, MSc, and PhD students. Finally, the Distinguished Applied Geochemists fund provides travel money for students to attend AAG-sponsored symposia. Criteria for all three programs are found on AAG's website. Students are required to present at the meetings and to write articles in either GEEA or **EXPLORE**. Please, let students know of these funding opportunities—they are the future of our organization.

We presently are discussing a restructure of AAG membership fees. Currently, we charge $100 US, but our cost for GEEA, Elements, and office expenses totals $115 per member, assuming 520 full-paying memberships. However, we essentially give away student memberships at $10 each, which results in an even larger spread. When we absorbed the cost of Elements a few years ago we said that we would revisit the economics of that decision and now is that time. Your input on this is needed, as we will be making a decision in September for the fee structure for 2013 and beyond.

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AAG Annual Meeting Minutes...

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Finally, I want to encourage AAG Members and Fellows to become more involved in running our organization. Without everyone's volunteer efforts, the various activities of AAG would not move forward. If you have not been active, it is your time to step forward. Members should consider upgrading their membership to Fellow. And Fellows should consider becoming more involved in Council and in serving on committees. We need your help and we need new blood to keep our association vital and relevant. Also, write up your research and submit it to our journal GEEA—we need more content to fill issues for 2013.

Membership Statistics from June Council Meeting
- 516 paid members for 2012
- 15 new student
- 26 new regular
- 1 new Fellow

Financial Statistics from February Council Meeting
- Developing Countries Membership Fund, $15,725.00 US
- Distinguished Applied Geochemists fund, $19,863.00 US
- CIBC US $82,784.90
- CIBC CAN $7,510.23
- TD Investment Account, $586,400.55

III. Other business

No other business matters were brought forward at the AGM.

IV. Adjournment

After a short discussion among AGM participants on the current status and future of the Association, D. Smith declared the 2012 Annual General Meeting adjourned at 7:30 PM local

New Association Dues Options in 2013

The Association annual dues provide membership to the longest-serving association focussing on the application of exploration and environmental geochemistry (42 years and counting!), as well as options for receiving the Association's quarterly journal *Geochemistry: Exploration, Environment, Analysis* (GEEA), its **EXPLORE** newsletter, and the thematic magazine *Elements.* GEEA continues to grow in terms of its circulation and measurable scientific impact, whereas **EXPLORE** is a forum for circulation of new ideas and discussion. We now have options for receiving GEEA either as digital only or print copies, and receiving *Elements* or not. The various tiered options for Association annual dues are:

Membership Type	Options				
	EXPLORE	GEEA print	GEEA digital	Elements	Cost (USD)
Regular or Fellow	yes	yes	yes	yes	$100
Regular or Fellow	yes	yes	yes	--	$85
Regular or Fellow	yes	--	yes	yes	$85
Regular or Fellow	yes	--	yes	--	$70
Senior Member or Fellow	yes	--	--	yes	$40
Senior Member or Fellow	yes	--	--	--	$20
Student	yes	--	yes	yes	$10
Subsidized Developing Country Member	yes	yes	yes	yes	$10

Dues can be paid on AAG's *new and improved* website (www.appliedgeochemists.org). This website is easier to navigate, has increased functionality, better security measures, and highlights the work of the AAG and its members. For Members Area access, all AAG members must log in to the new AAG website and establish a new password as follows:
- Go to www.appliedgeochemists.org
- On the left hand side of the page under 'Member Login', click "forgot password" The next screen should ask for an email address. Enter the email address that is associated with your AAG membership.
- Go to your email inbox and you will receive an email with verification code to choose a new password. Please follow the instructions in this email. Usernames will be the first letter of your first name and last name, all one word and lowercase, as in: "barseneault". If this username does not work, click on "forgot username" to have it sent to you.
- IMPORTANT: When renewing your membership, please be sure to tick 'YES' on the boxes at the bottom of the form to ensure that your name is put on the AAG mailing list and to show up in member's searches. Your contact information will not be distributed outside of the AAG and will only be visible to AAG members.

Please submit all questions about on line dues payment to our Webmaster, Gemma Bonham-Carter at: webmaster@appliedgeochemists.org)

Career Opportunity in
Mineral Exploration Geochemistry
UBC-Industry Exploration Geochemistry Initiative

The Mineral Deposit Research Unit (MDRU) in the Department of Earth, Ocean and Atmospheric Science (EOAS) at The University of British Columbia (UBC), Vancouver, Canada has launched a new industry-sponsored research and training venture in Exploration Geochemistry. We are seeking a candidate to take the position of Research Chair to lead this unique, exciting, and well-funded Exploration Geochemistry Initiative. The successful candidate will have the opportunity to provide leadership and innovation to develop a robust research program building new foundations in the field of Exploration Geochemistry.

In this position, the Chair will launch a major research initiative to advance collaborative, industrially-relevant research. To achieve this goal, the successful candidate will bring an innovative perspective to the field of geochemistry, as well as experience in conducting and managing applied research projects. The Chair will also play a lead role in providing an enthusiastic environment to train young researchers to contribute to the production of the next generation of exploration geochemists.

Key research objectives will include contributing to the understanding of processes of element transport in the surficial environment, and advancing the development of new mineral exploration techniques. These objectives will be accomplished with a fully-funded research team to be established by the successful candidate, which will consist of Post-Doctoral Fellows, PhD and MSc level graduate students, and industry support and collaboration.

The Exploration Geochemistry Initiative will operate in the supportive MDRU research environment and will also benefit from the support of various industry partners and the large exploration geochemical community in Vancouver. In addition, the initiative will benefit from interactions with other UBC geochemical expertise and infrastructure such as the Pacific Centre for Isotopic and Geochemical Research, the Multidisciplinary Applied Geochemistry Network (MAGNET) which is a new NSERC–Collaborative Research and Training Experience Program that supports training in applied geochemistry, and the newly created Canada Research Chair in Applied Geochemistry.

Core funding for the Exploration Geochemistry Initiative has been provided by generous industry grants from Acme Analytical Laboratories Ltd with the potential for additional support from the National Science and Engineering Research Council (NSERC) to establish an Industrial Research Chair. This Chair is designed to attract the best candidate who demonstrates collaborative research strengths and has the ability to collaborate across discipline boundaries. The position is a five-year term with opportunities for extension. The position may carry an academic appointment within UBC. Preference will be given to candidates with industry experience. A PhD, teaching experience, and publication record are preferable but not required. Salary and benefits will be competitive with industry.

For further information on the MDRU Exploration Geochemistry Initiative, contact Dr. Craig Hart, MDRU Director, at chart@eos.ubc.ca or Dr. Peter Bradshaw, Chairman of the Search Committee, at pbradshaw@firstpointminerals.com. Additional background information is available on the MDRU website at http://www.mdru.ubc.ca. Expressions of interest consisting of a CV and a one-page cover letter should be sent by email, from which a shortlist of suitable candidates will be identified.

UBC hires on the basis of merit and is committed to employment equity. UBC is strongly committed to diversity within its community and especially welcomes expressions of interest from visible minority group members, women, Aboriginal persons, persons with disabilities, persons of any sexual orientation or gender identity, and others who may contribute to the further diversification of ideas. However, Canadians and Permanent Residents of Canada will be given priority.

30Jan2013

MDRU-Mineral Deposit Research Unit
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The Association of Applied Geochemists

announces the

2012 AAG Student Paper Competition

The AAG announces the 9th biennial Student Paper Competition. The paper must address an aspect of exploration geochemistry or environmental geochemistry related to mineral exploration and be based on research performed as a student.
The student must be the principal author and the paper must have been published in Geochemistry: Exploration, Envirnoment, Analysis no more than three years after completion of the degree. All eligible papers in 2011 and 2012 volumes of GEEA will be reviewed by the selection panel.

The winner will receive:

- A cash prize of $1000CAD generously donated by SGS Minerals Services;
- A 2-year membership of AAG, including the society's journal (GEEA); EXPLORE newsletter, publication of an abstract and CV of the winner;
- a certificate of recognition; and
- $500US towards expenses to attend an AAG-sponsored meeting, courtesy of AAG.

The results of the 2012 competition will be announced at the 26th IAGS in Rotorua, New Zealand. Details are available from the Chair of the committee or the AAG Students' page (http://www.appliedgeochemists.org/).

David Cohen
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AAG Student Support Initiative
Analytical Support for BSc (Hons), MSc and PhD Students in Applied Geochemistry

In 2011, AAG implemented a coordinated program with analytical laboratories to provide In-Kind Student Support for applied geochemical research projects. We are off to an exciting start with several students currently being assisted, multiple laboratories participating, and the first student paper published in EXPLORE #157: "Particle size fractionation and chemical speciation of REE in a lateritic weathering profile in Western Australia". Ms. Xin Du is from University of Western Australia with Genalysis Laboratory Services (Intertek) sponsoring the analyses. The latest Student/Laboratory match-up is Markham Phillips from the University of Otago in New Zealand who is being supported by ALS Geochemistry in Vancouver, Canada on his research into *"Granite host and it's alteration suites as well as geochronology of gold bearing sulphide minerals"* in New Zealand.

Investment in Applied Geochemistry

The AAG Council believes that securing both the future of the Association and that of applied geochemistry requires attracting more students to the science. As an investment in the future, the AAG wishes to encourage and support students whose area of study is Applied Geochemistry. For students of applied geochemistry, a major cost component in any research is the geochemical analyses. AAG believes that by identifying appropriate students, using a set of simple criteria, and coordinating with analytical laboratories that are willing to offer support in terms of geochemical analyses, high quality research and training in fundamental geochemical principles can result. The research is then published through the AAG journal (***Geochemistry: Exploration, Environment, Analysis***) or the ***EXPLORE*** newsletter.

Laboratories Participating in the In-Kind Student Support Initiative

Four laboratories generously signed on to provide the analytical support to students during 2012; committing over $35,000 in terms of analytical support:

- Becquerel Laboratories Inc., Mississauga, Ontario, Canada
- ALS Geochemistry, North Vancouver, BC, Canada
- Genalysis / Intertek, Gosnells, Western Australia
- Ultratrace / Bureau Veritas, Canning Vale, Western Australia

If your laboratory or student is interested in being a part of this program, please contact the chair of AAG's Education Committee, Erick Weiland (education@appliedgeochemists.org), who can provide you with details of this program. Student applications and instructions may also be found on the AAG web site: http://www.appliedgeochemists.org/ student's page under the Student Support link.

Education Committee
Eric Grunsky, Ray Lett, Ryan Noble, Nigel Radford, Erick Weiland (Chair)

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

2013

7-12 April 2013. European Geosciences Union General Assembly. Vienna, Austria. Website: www.egu2013.eu

23-25 April 2013. 7th International Conference on the Impact of Environmental Factors on Health. Budapest, Hungary. Website: http://tinyurl.com/cf2yp73

24-28 April 2013. Basalt 2013 - Cenozoic Magmatism in Central Europe. Goerlitz, Germany. Website: http://tinyurl.com/cybv74v

5-8 May 2013. Canadian Institute of Mining, Metallurgy, and Petroleum 2013 Conference and Exhibition. Toronto ON, Canada. Website: http://web.cim.org/toronto2013beta

12-16 May 2013. 13th European Workshop on Modern Developments & Applications in Microbeam Analysis. Porto, Portugal. Website: http://tinyurl.com/8jp48zr

19-22 May 2013. AAPG 2013 Annual Convention & Exhibition. Pittsburgh PA, USA. Website: www.aapg.org/pittsburgh2013

22-24 May 2013. Geological Association of Canada/Mineralogical Association of Canada Annual Meeting. Winnipeg MB Canada. Website: http://gacmacwinnipeg2013.ca

26 May – 2 June 2013. PEG 2013: Sixth International Symposium on Granitic Pegmatite. Bartlett NH USA. Website: http://tinyurl.com/8b5fhnu

9-14 June 2013. Water-Rock Interaction XIV Symposium. Avignon, France. Website: www.wri14-2013.fr

15-16 Jun 2013. 5th European Gemmological Symposium. Leiden, The Netherlands. Website: http://tinyurl.com/b5c97q5

16-20 June 2013. 12th International Conference on the Biogeochemistry of Trace Elements. Athens GA USA. Website: http://tinyurl.com/ca39d7g

16- 21 June 2013. Catchment Science: Interactions of Hydrology, Biology & Geochemistry. Andover NH USA. Website: http://tinyurl.com/ah27v26

17-19 June 2013. Mineralogical Society Annual Meeting: Minerals for Life. Edinburgh UK. Website: www.minersoc.org/minerals-for-life.html

17-20 June 2013. Conference on Mathematical and Computational Issues in the Geosciences. Padova, Italy. Website: www.siam.org/meetings/gs13

30 June – 4 July 2013. 12th International Estuarine Biogeochemistry Symposium. Plymouth, UK. Website: www.iebs2013.org

3-5 July 2013. 8th International Conference on the Environmental Effects of Nanoparticles and Nanomaterials. Aix-en-Provence France. Website: www.nano-environment2013.org

5-13 July 2013. 11th ICAM International Congress for Applied Mineralogy. Mianyang China. Website: www.icam2013.org

8-12 July 2013. 29th European Conference of the Society for Environmental Geochemistry and Health. Toulouse, France. http://segh2013.sciencesconf.org/

20-24 July 2013. American Crystallographic Association (ACA) Annual Meeting. Honolulu HI USA. Website: http://tinyurl.com/aruja56

28 July-2 August 2013. 11th International Conference on Mercury as a Global Pollutant Edinburgh UK. Website: www.mercury2013.com

28 July – 2 August 2013. Gordon Research Conference: Atmospheric Chemistry. West Dover VT USA. Website: http://tinyurl.com/8ashaoc

4-8 August 2013. Microscopy & Microanalysis 2013. Indianapolis IN USA. Website: www.microprobe.org/events

12-15 August 2013. 12th SGA Biennial Meeting. Uppsala, Sweden. Website: www.conference.slu.se/sga2013

18- 23 August 2013. EnvironMetal Isotopes EMI 2013. Ascona Switzerland. Website: www.ibp.ethz.ch/events/conference

25-30 August 2013. Goldschmidt 2013. Florence, Italy. Website: www.goldschmidt.info/2013

25-29 August 2013. ECM 28 - XXVIII European Crystallographic Meeting. Warwick UK. Website: http://ecm28.org

1-7 September 2013. International Conference on Gas Geochemistry 2013. Patras Greece. Website: http://conf12.ic-gg.org

2-10 September 2013. 10th International Eclogite Conference. Courmayeur, Italy. Website: www.iec2013.unito.it

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CALENDAR OF EVENTS

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2-6 September 2013. 15th Conference of the International Association for Mathematical Geosciences. Madrid Spain. Website: http://tinyurl.com/9wo8kmo

22-27 September 2013. 10th Applied Isotope Geochemistry Conference. Budapest Hungary. Website: www.aig10.com

24-27 September 2013. SEG Conference: Geoscience for Discovery. Whistler BC, Canada. Website: www.seg2013.org

13-18 October 2013. International Symposium on Environmental Biogeochemistry. Wuhan China. Website: www.isebiogeochemistry.com

27-30 October 2013. GSA 2013 Annual Meeting. Denver CO USA. Website: www.geosociety.org/meetings/2013

29-31 October 2013. 9th Fennoscandian Exploration and Mining Meeting. Levi, Finland. Website: http://fem.lappi.fi/en

18-21 November 2013. 26th International Applied Geochemistry Symposium, Rotorua, New Zealand. Website: www.gns.cri.nz/iags

2014

1-5 September 2014. 21st General Meeting of the International Mineralogical Association. Johannesburg South Africa. Website: www.ima2014.co.za

Please let us know of your events by sending details to:

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Review of Exploration Geochemistry Modular Course (GEOL5806)

Laurentian University, Sudbury, Ontario, Canada

From December 6 to 16, 2012, I had the opportunity to participate in the biennial Exploration Geochemistry Modular Course (GEOL5806) offered by the Department of Earth Sciences at Laurentian University (LU) in Sudbury, Ontario, Canada as part of their Applied M.Sc. in Mineral Exploration program (http://earthsciences.laurentian.ca). This course was organized by Dr. Michael Lesher (DES/MERC) and consisted of 11 days of lectures and laboratory exercises given by speakers from academia and government.

The first five days was an intensive review on geochemical theory and background, including analytical methods, lithogeochemistry, alteration indices, mass balance, and radiogenic and stable isotopes. The following four days focused on lithogeochemistry and exploration techniques implemented for a variety of mineralization styles. Some of the topics covered included hydrothermal sediments and applications, exploration geochemistry of SEDEX deposits, VMS systems, Au-deposits, and U-deposits. The final two days of the course we covered soil geochemistry, regional surficial geochemical exploration techniques in Ontario, till sampling methods in glaciated terrain and ice flow indicators and glacial dispersal trains.

A total of 45 people attended the course this year, including graduate students from: LU, Lakehead University, University of Western, University of Ottawa, Carleton University, and University of Waterloo. Attendees also included industry geoscientists from Hudbay Minerals, Goldcorp, HTX, Stillwater, Caracle Creek and government professionals (Ontario Geological Survey). Despite the diverse backgrounds and specialties amongst the attendees, everyone managed to keep up with the fast pace lectures and assignments.

Participants benefitted from a number of guest lecturers with various backgrounds; professors Michael Lesher, Daniel Kontak, Harold Gibson (LU/MERC) and Kurt Kyser (Queen's University), Geological Survey of Canada geoscientists Jan Peter, Eric Grunsky, Wayne Goodfellow and Beth McClenaghan, and Ontario Geological Survey geoscientists Marcus Burnham, Jennifer Hargreaves, Stew Hamilton, Richard Dyer and Dave Crabtree.

Overall the course was very intensive and covered a wide range of geochemical theory and application. Laboratory exercises provided a practical application for our newly gained geochemistry knowledge.

Rémy S. Poulin
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ioStipend

In-kind Analytical Research Fund for BSc(Hons), MSc and PhD students

Much has been said and written about the broadening gulf between the demand for qualified explorationists and the supply coming out of our colleges, technical institutes and universities. One merely has to attend any geo-conference and gaze out over the sea of grey to fully grasp the situation our industry faces. This is all the more evident in the field of exploration geochemistry whose members have always been in short supply.

As consultants and service industries, we owe our livelihood to mining and exploration and thus have a vested interest in its development. We believe that any aid to promote fresh faces into our sector is helping to secure our future.

Acme Analytical Laboratories Ltd. and **ioGlobal** are taking the bold initiative of directly aiding students in the geosciences via the **ioStipend**. The **ioStipend** is a grant available to students conducting exploration-related geochemical studies at a recognized educational institution. The grant is in the form of analytical services using any package provided by Acme Analytical Laboratories Ltd. Students and/or their teachers/advisors can apply for the grant by submitting the application to ioGlobal who will vet the proposals.

The grant is intended to promote the collection of high quality, base-line data for comparison with more "esoteric data" (eg, isotopic data, partial digests, non-standard sample media) generated during the course of research, and to promote broad training in fundamental geochemical principals across the geosciences.

The **ioStipend** allows for amounts of approximately $5,000 (AUD, CAD or equivalent) for in-kind analytical work. Successful applicants will also be provided with 3 academic licences of **ioGAS**, the new exploratory data analysis software package available from ioGlobal.

The application form is available at www.ioglobal.net.

It is envisaged that three or four of these awards will be made each year.

Applications are reviewed by an expert group of ioGlobal's geochemists

Eligibility Criteria

Preference will be given to:

- students with no other source of funding
- students working on exploration geochemistry projects
- projects no or very minimal confidentiality requirements

The ioStipend is international. Applications are welcome from qualified institutions globally.

Some technical input may be provided by ioGlobal on request.

Requirements for receiving the ioStipend

Firstly, there are minimal strings attached. Recipients would have to agree to

1. Have their project promoted on the ioGlobal web site in an area devoted to R&D carried out under the program (couple of passport photo shots, brief description)
2. Acknowledge ACME Labs and ioGlobal for support in technical and public presentations of results
3. Write a short article for Explore describing the project outcomes, and allow this to be published on the ioGlobal web site.

David Lawie, John Gravel

EXPLORE

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Quarterly newsletters in March, June, September, December

Deadlines for submission of articles or advertisements:
March newsletter: January 15
June newsletter: April 15
September newsletter: July 15
December newsletter: October 15

Information for Contributors

Manuscripts should be double-spaced and submitted in digital format using WORD. Photos and figures (colour or black and white) should be submitted as separate digital files and as high resolution jpeg or PDF files. Tables should be submitted as separate digital files in EXCEL format. All scientific/technical articles will be reviewed. All contributions may be edited for clarity or brevity.

Formats for headings, abbreviations, scientific notations, references and figures must follow the Guide to Authors for *Geochemistry: Exploration, Environment, Analysis* (GEEA) that are posted on the GEEA website at: http://www.geolsoc.org.uk/template.cfm?name=geea_instructions_for_authors

Submissions should be sent to:
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LIST OF ADVERTISERS

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