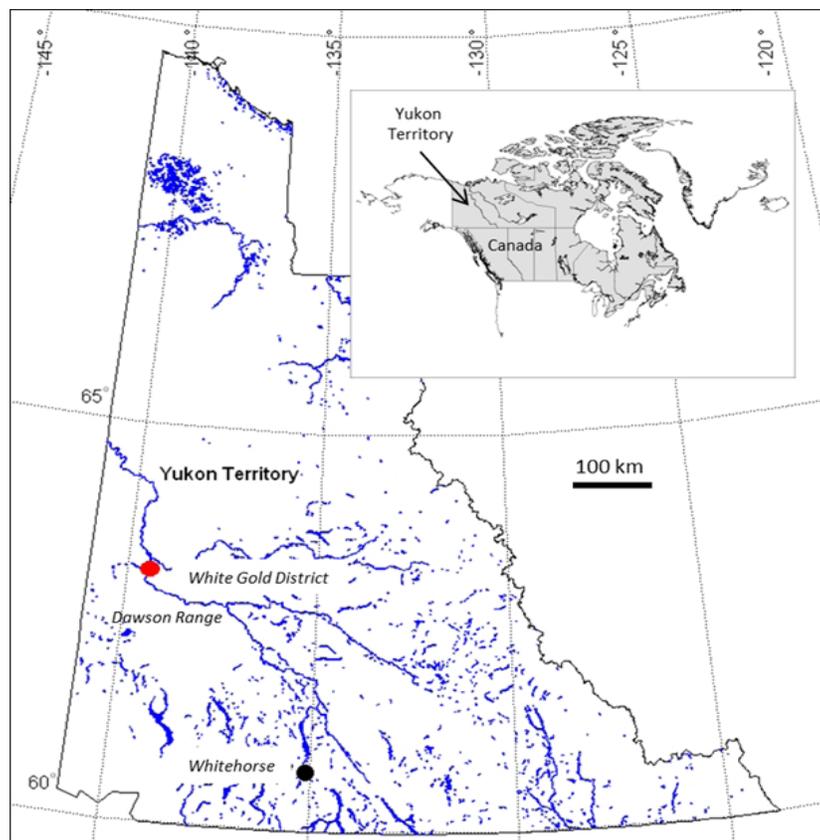


## Reproducibility of Gold Analyses in Stream Sediment Samples from the White Gold District and Dawson Range, Yukon Territory, Canada.

### Introduction

A number of significant bedrock Au discoveries have been made in the western Yukon Territory, Canada in recent years (Fig. 1).



**Figure 1.** Location of the White Gold District and Dawson Range in the Yukon Territory, Canada. Rivers and lakes are shown in blue.

Underworld Resources announced the discovery of the Golden Saddle deposit in 2008 in what has subsequently become known as the White Gold District (MacKenzie et al. 2010), which is named after the White River where it enters the Yukon River in the vicinity of the Golden Saddle deposit. A resource of 1.0 M oz of indicated Au mineralization at 3.2 g/t with a total resource of 1.5 M oz at 2.7 g/t was delineated by Underworld Resources prior to purchase of the company by Kinross Gold Corporation in 2010 (Underworld Resources press release, January 19, 2010). There are also a number of other known bedrock Au occurrences on the property. Kaminak Gold Corporation announced the

discovery of the Coffee Au deposit in 2010 to the south of the White Gold District in the Dawson Range. This deposit currently has a defined resource of 3.4 M oz inferred at 1.36 g/t and 0.7 M oz indicated at 1.56 g/t, comprised mainly of oxide mineralisation (Sim & Kappes 2014). Comstock Metals Ltd. announced the discovery of significant Au mineralisation on their QV project approximately 10 km north of the Golden Saddle deposit in 2012 and recently announced an inferred resource of 0.23 M oz at 1.65 g/t (<http://www.comstock-metals.com>). Taken together, these discoveries have defined a new metallogenic province in the west-central Yukon Territory (Allan et al. 2013)

All three discoveries were the result of reconnaissance and follow-up soil sampling of C-horizon material developed on residual bedrock. The region is characterized by preglacial soils that were largely unaffected by the major glaciations in North America that spanned the last 2 million years, although they have been disturbed by periglacial processes and internal mixing of loess related to the most recent glacial advance in the region (McKillop et al. 2013). The collection of stream sediments and the interpretation of new and/or existing government survey data appear to have played little or no role in these discoveries, in spite of the fact that the terrain is favourable for such surveys and an extensive Regional Geochemical Sample (RGS) government database exists for the region (Héon 2003). One possible reason for the apparent lack of stream sediment sampling in exploration programs in the area may lie in the poor quality of the Au data from the Yukon RGS programs. The samples from central and

western Yukon Territory generally consisted of a maximum of 10 g of -80 mesh (<0.177 mm) material, some of which contained particulate Au. Sampling theory suggests that such material will produce inherently imprecise results (e.g. Abzalov 2008).

Of a total of 1609 duplicate Au fire assay analyses from the 2003 Yukon regional geochemical stream sediment database, a subset of 898 sample pairs with average Au contents greater than 10 ppb (i.e. more than 10 x the lower limit of detection for most analyses) has a global root mean square coefficient of variation of  $\pm 94\%$ , which indicates very poor repeatability (Fig. 2). In extreme cases, an original sample contained no detectable Au at a lower limit of

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EXPLORE NEWSLETTER WISHES TO THANK OUR CORPORATE SPONSORS FOR THEIR SUPPORT



## President's Message

Planning and execution of the 27th IAGS meeting continues apace – in addition to the fully active website ([www.27iags.com](http://www.27iags.com)), abstracts are now beginning to be received by the organizers. This meeting will differ somewhat from the previous meetings in that there will only be two concurrent technical sessions at any one time, and each talk is scheduled to be 20 minutes in length. As a result, there will only be about 88 talks in total – so get your abstracts in early! Sponsorships are also starting to be filled, with sponsors already committed at all four levels of sponsorship (Copper, Gold, Silver and Bronze) – so let the committee know soon if your company/organization is planning on sponsoring.

Keep an eye out for changes to the website in the near future. Our website coordinator, Bruno Lemiere, is developing a section on “hot topics”, intended to foster informed, collegial debate about topics of interest/significance to the applied geochemical community. At the last council meeting it was agreed that Bruno would moderate an initial discussion on “An applied geochemist's view on fracking”. The role of the moderator is not to censor any point of view, but rather to ensure that the debate is kept within a scientific (and respectful) context. This initial topic will, I think, produce some very lively debate.

As noted in the last newsletter, our journal “*Geochemistry: Exploration, Environment, Analysis*” is on the hunt for a new Editor in Chief. Please see the website for details if you are interested in this important role within the organization. Also note that the last two issues have been special issues – an outstanding collection of papers on portable XRF analysis. Portable XRF is a relatively new and rapidly growing analytical method in exploration geochemistry. However, although the technique looks futuristic with most models looking like a laser device from a science fiction

movie, there are a lot of important caveats to the effective use of these tools, and the papers in these two issues will serve the community well in ensuring that the data generated by pXRF are used appropriately.

As the two pXRF special issues attest, as do all the papers in GEEA over the last fourteen volumes, our journal has come to occupy a critical space within the overall geochemistry research space. I encourage you to consider our journal as the venue to showcase your research efforts and help expand the reach and impact of our journal and our science.

Finally, on a personal note, I have left ALS Geochemistry (a great organization) and am now an Associate Professor at Laurentian University in Sudbury, Ontario, Canada.

**Matt Leybourne, President**



## June 2014 Issue of Elements

This issue of Elements focuses on kaolin-group minerals and emphasizes their special place in the early cultural history of China, which is well known for developing porcelain-making techniques. It also discusses the atomic-level structure and polytypism (different layer stacking sequences) of kaolin-group minerals, high-pressure kaolinite polytypes, the importance of defects and impurities in kaolinite, and the ability of kaolinite to reveal its environmental history through its defects induced by radiation damage. Another important process discussed in this issue is the interaction of kaolin-group minerals with the environment, especially with ions in aqueous solutions and bacteria. Particularly fascinating are the articles on the history of mining and processing of kaolin-group minerals, the development of environmentally sensitive modern mining practices, and the many uses of kaolin-group minerals in modern technology and medicine. After reading these articles, it should be clear that kaolin-group minerals had a major impact on early humans and that they continue to impact modern humans through their many and varied uses.” Excerpt from Gordon E. Brown’s editorial *Kaolins: Nanominerals with a Proud Heritage*.



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## Notes from the Editor

The September 2014 issue of **EXPLORE** features one technical article by Dennis Arne and Bill McFarlane that describes the reproducibility of gold analyses in stream sediment samples in northwestern Canada. **EXPLORE** thanks all contributors and reviewers for this third issue of 2014 including: Steve Amor, Dennis Arne, Al Arseneault, Patrice de Caritat, Bob Garrett, Gwendy Hall, Dianne Hanano, Mike Leshner, Matt Leybourne, Bill McFarlane, Clemens Reimann, Emilie Refiange, Dave Smith, and Erick Weiland.

**Beth McClenaghan**  
Editor



Reproducibility of Gold Analyses in Stream Sediment Samples from the White Gold ...

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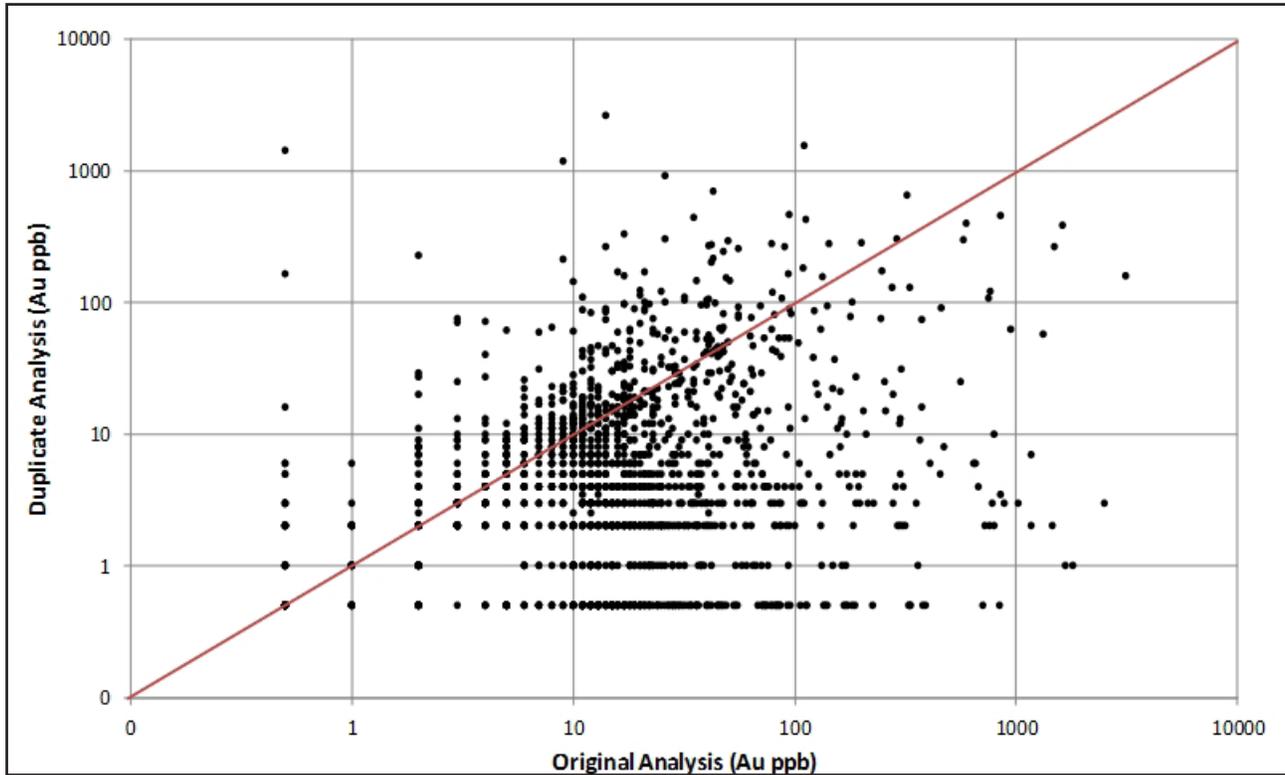


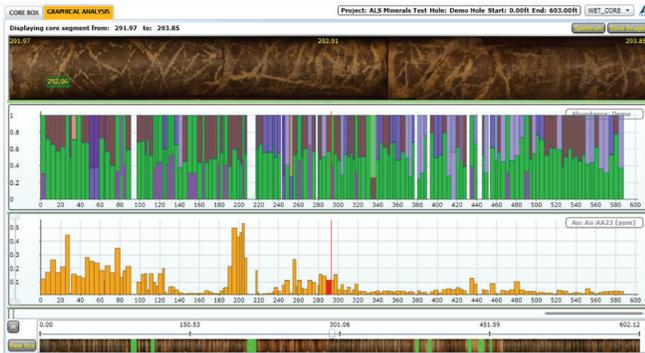
Figure 2. Gold data from 1609 duplicate pairs from the 2003 Yukon Territory RGS (Héon 2003) data set.

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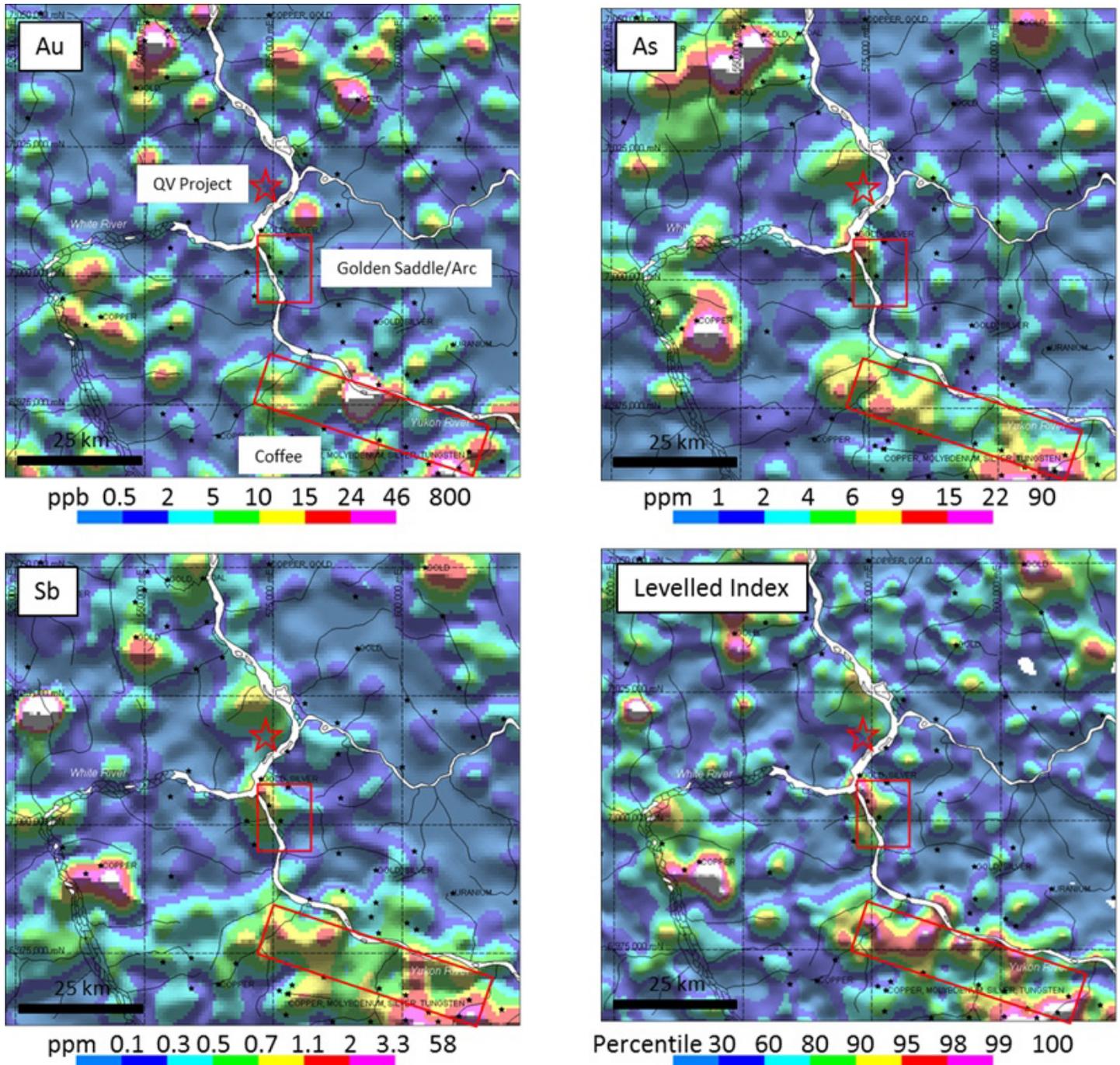
# Reproducibility of Gold Analyses in Stream Sediment Samples from the White Gold ...

*continued from page 3*

detection of 1 ppb, whereas the repeat contained over 1,000 ppb! In a specific example from the White Gold District, the original Au value in a stream sediment sample collected downstream of the Golden Saddle deposit was 10 ppb, slightly less than the anomalous threshold value of 15 ppb determined from 951 RGS samples in the area. The repeat Au analysis for this sample is 42 ppb, but normally only the original analyses would be plotted in thematic maps and so a subtle Au anomaly might be missed. The poor quality of

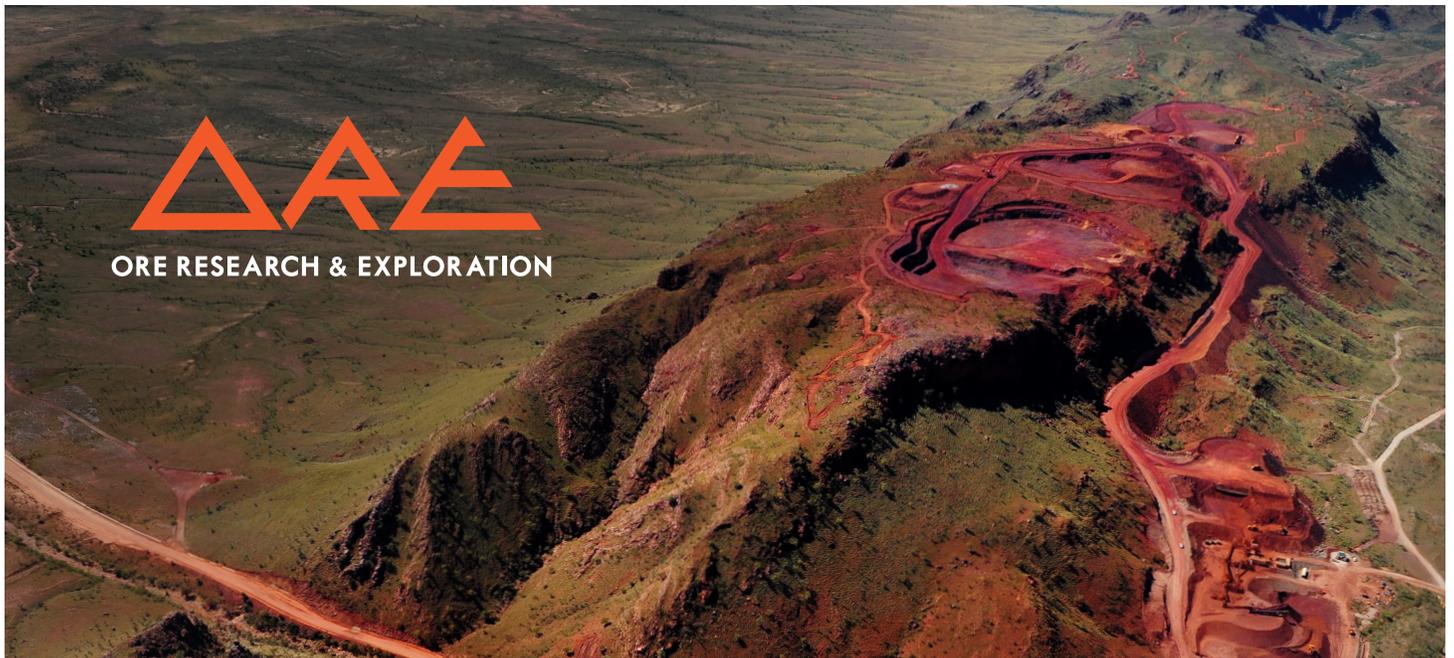
the publicly available Au data appears to have resulted in a loss of confidence in the use of stream sediment sampling in parts of the Yukon Territory, leading to a preference for a more costly, albeit effective, approach involving ridge and spur soil sampling followed by extensive gridded soil sample collection.

The Au data from near the Golden Saddle deposit produce only a subtle anomaly in the Yukon (RGS) dataset (Fig. 3). However, As and Sb contents in stream sediments



**Figure 3.** Percentile gridded images of Au, As, Sb and an additive levelled index for the three elements using the <0.177 mm fraction of stream sediment sample data of Héon (2003) from the White Gold District, Yukon Territory. The approximate locations of the main discovery areas are outlined by red polygons.

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## Reproducibility of Gold Analyses in Stream Sediment Samples from the White Gold ...

*continued from page 4*

do provide a positive response using raw data presented in the form of gridded percentile images, and the presence of the Golden Saddle deposit, along with associated mineralisation in the adjacent Arc deposit, is clearly evident using an additive index of Au plus As and Sb levelled for dominant catchment lithology (see Arne & Bluemel 2011 for a recent discussion of catchment analysis applied to regional stream sediment data). The presence of the Coffee deposit is also evident in the raw As and Sb data, as well as from a single Au analysis, but the extent of the anomaly associated with this mineralised system is best illustrated by the levelled additive index. The Comstock discovery is not evident at all in the data because the catchment this deposit lies in was not sampled during the Yukon RGS program. Therefore, while we would argue that clear evidence for Au mineralization in the White Gold District and Dawson Range lies within the historical RGS data (provided the streams draining the mineralised catchments were sampled), the interpretation of those data requires examination of the distribution of suitable pathfinder elements and less reliance on the Au data. Unfortunately, most explorers tend to focus on the element for which the data are least precise (i.e. Au).

The issues associated with sampling particulate Au in stream sediments are widely known and have been discussed exhaustively elsewhere. It is not our intention to review sampling theory other than to point out that there are only two practical ways to increase the precision of Au data in stream sediment samples containing particulate Au. The first and most common approach is to increase the sample size, either through the use of bulk leach-extractable gold (BLEG) methods or by concentrating heavy minerals by panning in the field or heavy liquid separation in the laboratory. These methods generally involve the collection of large samples of up to 10 kg of relatively coarse-grained material up to 1 or 2 mm in diameter. The BLEG samples are then treated with a cyanide solution in order to dissolve the particulate Au which is then concentrated onto a collector (an organic solvent) or precipitated using zinc sulphide. Alternatively, Au grains can be physically concentrated and the heavy mineral fraction either assayed or the actual Au grains sized and counted. Such an approach also effectively reduces the detection limit of the overall analysis.

The problem with both approaches involving a larger sample is that the benefit generated by a greater sample mass is offset by the use of a coarser grain size that allows incorporation of larger Au particles and thus exacerbates the nugget effect in analysis of the material, particularly if the cyanide extraction is too aggressive. Furthermore, given the size of the sample used for the traditional BLEG approach, the use of laboratory duplicates is seldom undertaken and generally only field duplicates are available to assess total variability in the data. Bulk methods also introduce extra logistical costs in the collection and transport of large samples from remote locations.

The second approach involves either the use of finer grained material, where the possibility of aeolian dilution can be discounted (e.g. Bugrov 1974), or the use of very weak cyanide digestions on smaller BLEG samples to ensure that only the smallest Au grains are dissolved (i.e. a “chemical sieve”). Traditionally, this approach has been incorporated into stream sediment programs either through sieving in the field or in the laboratory, typically using 80 or 100 mesh screens (<0.177 or <0.150 mm), or decanting sediment-laden stream water in the field with or without the use of a flocculant to settle clays out of suspension. An alternative to these approaches is now available at commercial laboratories that involves the use of a centrifuge to isolate a clay-sized fraction <2 µm in diameter from the sample. Use of this fraction allows a smaller aliquot size to be used for analysis but does require careful sampling in the field to ensure the collection of sufficient volume of fine grained material. The use of the clay-sized fraction has been previously reported for till samples (e.g. Shilts 1977 and many others at the Geological Survey of Canada since the 1970s) but its use in analysis of stream sediment samples is rare, as is its use in this particular medium for Au determination. Another advantage of using the clay-sized fraction is that a representative aliquot size of 0.5 g is small enough to allow routine use of analytical duplicates that can be used to assess preparation and analytical variances, and thus allow estimation of sampling variances from field duplicates.

Extraction of clay-sized material from soils and sediments is also often undertaken to isolate clay minerals that are excellent secondary traps for mobile pathfinder elements due to the high cation exchange capacities of some clay minerals (Rose et al. 1979). Elimination of signal dilution from barren silicates and the consistent matrix presented to the leaching procedure also produces better anomaly to background contrast and fewer analyses that are too close to the method lower detection limit to provide reproducible results. The reduction in nugget effect can often be as significant as the improvement in pathfinder anomaly to background contrast in the case of Au-focused projects.

In this article we present data from six sample sites in the White Gold district and Dawson Range to test the reproducibility of three approaches to the analysis of particulate Au in stream sediment samples. Catchments that included portions of the Golden Saddle, Arc, and Coffee deposits were sampled. The data are compared to arithmetic means calculated from three background samples. Although this is a small number of samples to define background, proprietary data collected elsewhere in the region but not presented here for reasons of confidentiality suggest the values are reasonable. In addition, the effects of concentrating various pathfinder elements (As, Sb, Mo) in the clay-sized fraction are also discussed.

*continued on page 7*

## Reproducibility of Gold Analyses in Stream Sediment Samples from the White Gold ...

*continued from page 6*

### Methodology

Samples collected in the field consisted of ~5 kg of -20 mesh (<0.84 mm) material obtained from a number of trap locations within the creek over a stream length of about 10 m. The samples were initially collected in a 10 L plastic bucket and then decanted into large polypropylene bags purchased from Legend Inc. in the USA. These bags were specifically chosen because of their tight fabric and double stitching of the seams which limits the amount of clay-sized material lost from the bag when the water is squeezed out. They also allow drying of the sample in the field prior to transport. Separate field duplicate samples were collected at each site.

The samples were processed by three separate methods in most instances:

- Acid digestion of the <0.177 mm fraction
- Acid digestion of the <2  $\mu\text{m}$  fraction
- BLEG of the <0.177 mm fraction

After drying, a -80 mesh fraction (<0.177 mm) was prepared at the laboratory and a 30 g aliquot digested using modified aqua regia consisting of a 1:1:1 mixture of  $\text{H}_2\text{O}:\text{HNO}_3:\text{HCl}$ , followed by ICP-MS analysis for 37 elements, including Au, at AcmeLabs in Vancouver. This method is similar to that employed for some of the historical Yukon RGS data, albeit with a larger aliquot weight, and so would be expected to yield more representative Au data than obtained historically. One kg of the -80 mesh material was shipped to the AcmeLabs facility in Santiago, Chile for BLEG analysis for Au only using gentle agitation for 12 hours. A reduction in the grain size used for the BLEG analysis would be expected to produce more precise results than a standard BLEG done on a coarser grain size fraction. In addition, 300 g of the -80 mesh material was suspended in water and centrifuged to isolate the <2  $\mu\text{m}$  clay fraction and 0.5 g of this material was analyzed by ICP-MS for 31 elements at AcmeLabs in Vancouver, also following a modified aqua regia digestion.

Problems were encountered with the routine use of BLEG analysis on some samples from the region, presumably due to interferences caused by the presence of charcoal in stream sediments derived from catchments affected by recent forest fires. The organic solvent (DIBK) used to collect the Au in solution was adsorbed by some of the samples, although this is not considered to have affected the orientation data presented here. No BLEG determinations were made on the background samples for this reason, as they were collected in an area recently burnt by forest fires. The possibility of charcoal from bush fires in Western Australia preferentially attracting Au in solution (“preg-robbing”) has previously been assessed and found not to be an issue, although zinc sulphide was used as a collector in those trials (S. Harrison, pers. comm., 2013). In general, samples should be roasted prior to treatment with cyanide where charcoal from forest fires could potentially be an issue.

To extract the clay-sized fraction, 300 g of -80 mesh material was suspended in deionised water using ultrasonic agitation and the addition of an anti-flocculant. After a brief settling period the solution was decanted and centrifuged, first at low speed to remove coarse material, and then again at high speed to remove the clay-sized fraction from the water column for collection. It should be noted that for many samples, the resulting fraction consists dominantly of clay minerals, but the separation process is not phase-specific meaning that any clay-sized mineral grain will be captured. This can have important implications for the relative abundances of trace elements from sample to sample, but for Au determinations this is not of concern. In samples containing coarse Au, clay separation effectively removes the larger particles responsible for poor precision allowing more reliable determination of the ultra-fine Au content. Since anomalous sites should contain elevated Au across all particle sizes, targeting the ultra-fine fraction should yield full contrast with background data, while eliminating noise associated with the analysis of large Au particles in more traditional test methods.

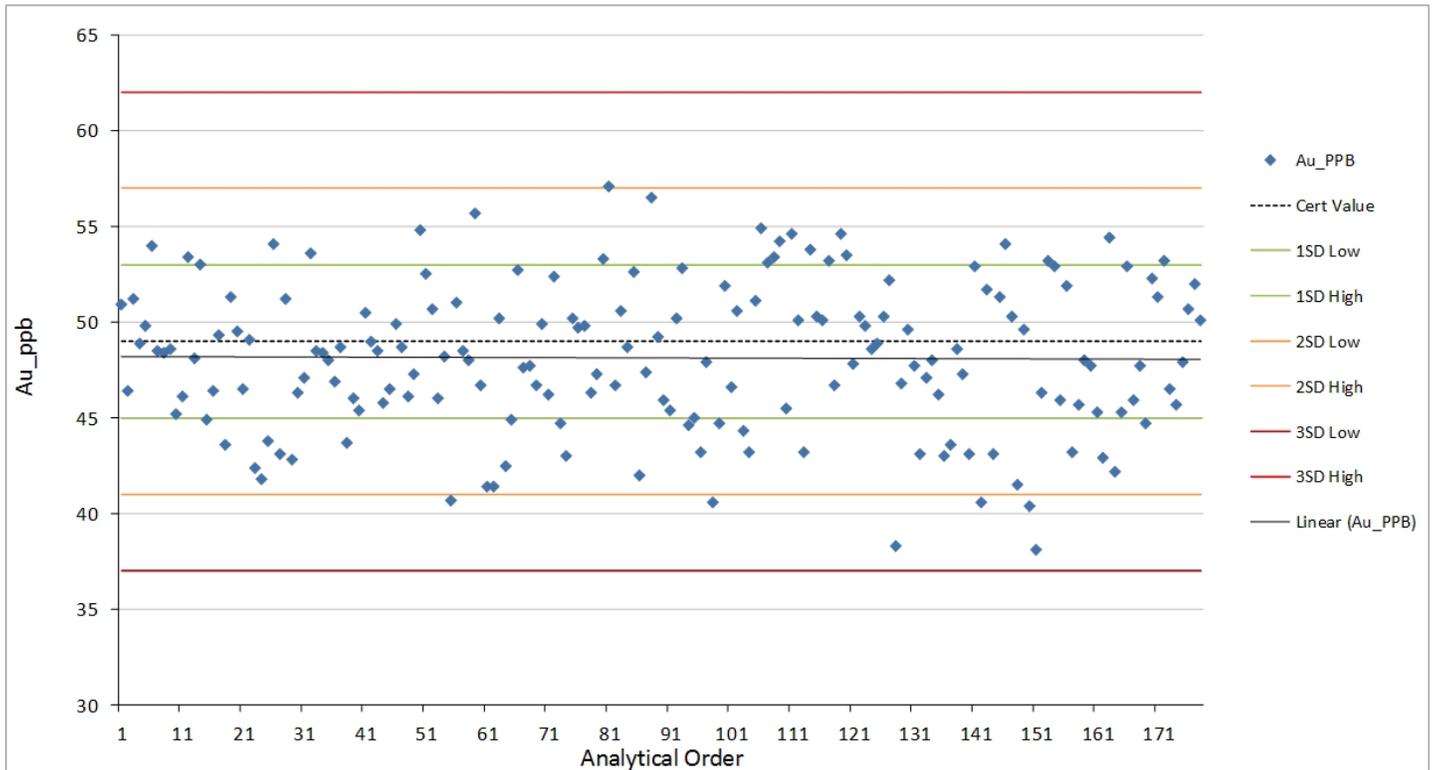
Quality of the sample preparation and analytical data was monitored using both external (blind) and internal (laboratory) certified (Ore Research & Exploration OREAS 45p) and standard (Acme DS8) reference materials (CRM & SRM), the use of both field and pulp duplicate analyses, and analysis of both field (Au-only) and instrumental blanks. Packets of OREAS 45p were diluted by physically mixing it with sufficient certified blank pulp (CDN Resource Laboratories BL8) in a large plastic bag to make 1 kg standards for BLEG analysis. OREAS 45p was manufactured using oxide material only, and is therefore suitable for this purpose.

The stream sediment analyses were part of a geochemical program predominantly comprising soil samples described by Arne et al. (2014) and data quality can be evaluated within the context of the broader QA/QC program implemented during the overall sampling program. For example, the Au data from OREAS 45p submitted as external controls are illustrated in Figure 4 from the portion of the field program that overlapped with analysis of the stream sediment samples. The results generally lie within one standard deviation (SD – as calculated from the certification round-robin data) of the expected value. The number of analyses lying outside of two SD from the certified value is consistent with the expected spread in data for a normal distribution of the results. Overall, the coefficient of variation (CV) for the analysis of Au in OREAS 45p is  $\pm 8.0\%$ , similar to the CV for Au in this CRM of 8.2%, and providing a benchmark by which to evaluate the Au data from the orientation samples. Overall, the Au analyses provided by the laboratory are considered to be excellent.

*continued on page 8*

# Reproducibility of Gold Analyses in Stream Sediment Samples from the White Gold ...

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**Figure 4.** Gold analyses of Ore Research & Exploration CRM 45p by ICP-MS following a modified aqua regia digestion at Acme Labs from May until August, 2011. A linear regression fit to the data is also shown.

## Results

Summaries of the Au results and data for selected pathfinder elements are presented in Table 1. Field duplicate pairs are presented in sequential order, with -80 mesh data, Au data from BLEG, and data from a clay-fraction separate. Only data for Au and a few important regional pathfinder elements are presented. Note also that the

presence of clay-sized material was not recognized in all samples at the time of collection as they were dominated by silt and sand-sized material. In spite of this, sufficient clay-sized material (a minimum of 0.5 g) was separated from all samples to allow digestion and analysis by ICP-MS.

**Table 1.** Summary of selected analytical results for stream sediment samples in this study

Sample	Clay%	Silt%	Sand%	Organics%	Color	Au_ppb*	BLEG_Au	Au_ppb**	Mo_ppm*	Mo_ppm**	As_ppm*	As_ppm**	Sb_ppm*	Sb_ppm**
5125	10	80	10	0	gray brown	2.5	4.5	10.8	0.51	2.56	4.8	34.5	0.31	0.7
5125Dup	10	80	10	0	gray brown	2.7	11.3	10.3	0.46	2.75	5.1	35.9	0.30	0.69
5133	5	60	30	5	gray brown	12.5	6.4	70.3	0.75	3.96	15.5	117.6	0.67	1.63
5133Dup	5	60	30	5	gray brown	6.7	6.6	70.3	0.79	3.71	16.1	112.1	0.75	1.47
5135	5	70	20	5	gray brown	7.2	20.3	69.1	0.62	4.43	47.8	530.9	1.63	4.53
5135Dup	5	70	20	5	gray brown	101.1	86.3	65.5	0.64	4.38	48.0	498.6	1.66	4.64
5127	0	40	60	0	brown	17.0	2.5	7.9	0.95	5.69	10.7	77.9	0.56	1.18
5127Dup	0	40	60	0	brown	1.9	28.9	7.3	0.92	6.01	9.8	77	0.56	1.14
5129	0	60	30	10	brown	77.6	9.3	47.8	0.62	2.61	16.6	84.1	0.98	1.72
5129Dup	0	60	30	10	brown	9.9	3.9	42.5	0.64	2.7	16.5	87.9	0.96	1.68
5129Dup	Laboratory pulp duplicate							42.5	2.67	85.9	1.63			
5131	5	50	45	0	gray brown	4.5	<0.1	14.8	0.84	3.63	13.5	65	0.68	1.01
5131Dup	5	50	45	0	gray brown	3.5	22.6	15.7	0.96	3.36	14.3	58.3	0.65	1.02
Bkgd	7	82	7	5		2.5	n/a	9.2	0.38	1.34	3.73	23.9	0.23	0.33

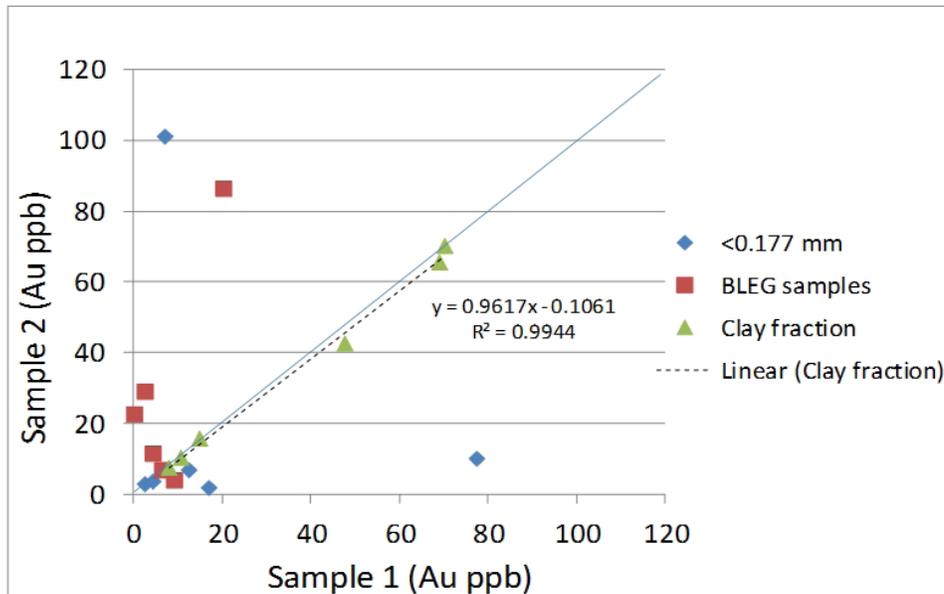
\* < 177 µm grain size fraction; \*\* < 2 µm grain size fraction; n/a not applicable. Field duplicates are in order and pairs are shaded consistently. Background (Bkgd) values are estimated from an arithmetic average of three samples.

## Reproducibility of Gold Analyses in Stream Sediment Samples from the White Gold ...

continued from page 8

What is immediately clear in the Au data for the -80 mesh 30 g aliquot and the BLEG analyses is that the results for the field duplicate samples are inconsistent (Fig. 5). The

silicates. The anomaly/background ratios are also slightly improved in the clay-sized separates.



**Figure 5.** Comparison of Au data from field duplicate stream sediment samples analyzed by three different methods. A linear regression fit to the clay fraction is also shown.

differences are so significant that if the 15 ppb threshold from the RGS data set were applied to the data, several anomalous streams would potentially be overlooked depending on which sample was analyzed. There are also inconsistencies in which samples are higher from the two methods. In some cases the 30 g aqua regia analysis gives the higher result for one of the field duplicates, but the order is reversed for the BLEG results (Table 1). Clearly, both types of analyses suffer from poor precision.

By contrast, the field duplicates for the clay separates give Au results that show a relative difference of less than  $\pm 5\%$ , which is a reproducibility seldom found in field duplicate analyses for Au, and well within the overall precision of the Au data produced by the laboratory for this method over the relevant time period (Fig. 5). A single analytical repeat of the clay separates gave an identical Au value. Four of the six sites gave Au values that are significantly above background, which is estimated from data for three samples not considered to carry a mineralized signature. In a large orientation survey, these samples should also give a more realistic estimate of background levels for Au since erroneously high values produced by any nugget effect are removed from the population.

The base metals and potential Au pathfinder elements, Mo, As, and Sb also show good reproducibility in both the -80 mesh and clay fraction data, as do most other analyzed elements that are not discussed here. An additional advantage of clay separate data is that the base metals and potential pathfinder elements report higher concentrations due to adsorption onto clay minerals and significantly less dilution from barren and coarse grained non-reactive

### Conclusions

Poor data precision for Au in historical, publicly available stream sediment data sets from the Yukon Territory has led to a loss of confidence in this medium for Au exploration in some instances and an underutilisation in exploration programs where the geochemical focus has been solely on Au. The traditional approach of taking large samples for bulk analytical treatment or heavy mineral concentration has issues related to reproducibility from field duplicates due to the generally coarse-grained Au collected in the field, particularly where aggressive cyanide digestions are employed. Bulk cyanide leach methods using an organic solvent for Au collection are also potentially subject to the interfering effects of charcoal in the samples from forest fires. In contrast, an alternative approach to obtaining representative Au data in samples described here involves the analysis of the clay-sized fraction to provide more reproducible data for Au than conventional aqua regia digestion and analysis of the <0.177 mm fraction, as well as providing data for other potential pathfinder elements. This approach appears to be successful even in samples that are not found to be particularly clay-rich in the field, as only 0.5 g of clay-sized material is sufficient for analysis. However, 1 g is preferable and allows for a laboratory duplicate analysis. Special care must be taken in the field to ensure the collection of sufficient volume of the finest-grained material available. The approach may not be applicable in areas where contamination/dilution by aeolian dust has occurred. The evaluation of reliable Au data for stream sediment samples, coupled with low-level multi-element analysis for potential pathfinder elements, is a cost-effective way to undertake regional exploration over large areas and should not be discarded simply because of issues with the reproducibility of historical Au analyses.

The authors would like to thank Adrian Fleming of Prosperity Goldfields Corporation for support to undertake this orientation work, assistance in obtaining the samples, for permission to publish the outcome and for helpful comments on an early draft of this contribution. We would also like to thank Kinross Gold Corporation for permission to sample within their exploration claims. Samples were collected in a very professional manner by Andrew Molnar and the team from Rios Minerals Limited. This article was greatly improved in the review process by

### Acknowledgements

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## Reproducibility of Gold Analyses in Stream Sediment Samples from the White Gold ...

continued from page 9

Steve Amor, Beth McClenaghan, and Bob Garrett.

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## Multidisciplinary MAGNET Applied Geochemistry Network

The Multidisciplinary Applied Geochemistry Network (MAGNET), is a Canadian NSERC-funded industrial stream Collaborative Research and Training Experience (CREATE) program devoted to geochemistry. MAGNET connects trainees with leading scientists and state-of-the-art analytical laboratories across Canada to address challenges in analytical, environmental and exploration geochemistry. MAGNET's cohesive learning environment, combined with industry internships, professional skills training and networking opportunities, offers trainees a significant competitive advantage and represents a novel and much needed approach to geochemistry education in Canada.

The field of geochemistry has taken a major leap forward in recent years due to innovative analytical developments, such as multi-collector inductively-coupled plasma mass spectrometry (MC-ICP-MS) and in-situ laser ablation. Geochemical techniques, data analysis principles and analytical tools are evolving rapidly and increasingly used in a wide range of applications in resource exploration, mineral extraction, environmental monitoring, mitigation and remediation. As a result, demand in industry, government and academic settings for highly qualified personnel with strong backgrounds in geochemistry is at an all-time high.

### Mission

The main objectives of MAGNET are to:



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## Multidisciplinary Applied Geochemistry Network... *continued from page 10*



- Provide an integrated research and training environment, designed specifically to address global challenges in applied geochemistry;
- Generate and distribute leading-edge geochemical research of scientific and societal importance that will benefit the scientific community, industry, policy-makers and the general public (locally and internationally);
- Promote techniques and developments that meet or exceed the highest standards of quality assurance and quality control (QA/QC) protocols and industry best practices;
- Produce job-ready graduates to fill the immediate need for HQP in the analytical, environmental and exploration industries, and sustain this important HQP resource into the future.

### Research Themes

Geochemistry provides tools for the fundamental understanding of our planet and has numerous applications to the environment, global change, natural resources, human health and natural hazards. For example, MAGNET research will promote the development of new techniques to:

- detect, trace, and mitigate contaminants in the environment
- document geochemical fluxes and cycles in the world's oceans
- determine the timing and recurrence of major geohazards
- identify and quantify components (and their distribution) in the Earth's mantle
- improve geochemical indices/vectors in previously under-explored terrains

The MAGNET program supports high-impact research in analytical, environmental and exploration geo-

chemistry within three themes:

### 1) *Fragile ecosystems*

Geochemical tools contribute to the detection and remediation of anthropogenic impacts on the environment by tracing the sources and migration of contamination in the soil, groundwater, and atmosphere. For example, MAGNET research is involved in developing an analytical method for the measurement of molybdenum (Mo) stable isotopes. In this study, Mo isotope systematics are being used to characterize Mo release and attenuation reactions occurring within waste rock piles at an active mine site. Implications from this project include improved remediation of Mo as an environmental contaminant and improved management of mining waste rock.

### 2) *Windows into the earth*

The chemical and physical processes that occur within the Earth's crust and mantle often remain hidden and difficult to investigate. Geochemical studies ranging from shallow magma chambers to deep mantle plumes provide valuable information about the nature of the subsurface. In this theme, MAGNET is investigating magma plumbing dynamics and degassing during the 2011-2012 submarine eruption at El Hierro, Canary Islands. Results reveal that deep magma mixing events preceded the eruption and coincided in time and space with volcano-tectonic earthquakes. Geochemical analyses also show that the mafic alkaline magmas are exceptionally rich in volatile compounds, particularly carbon dioxide and sulphur. This work is helping to improve understanding of the conditions that cause large explosive eruptions.

### 3) *Hidden resources*

Geochemistry is a major contributor to mineral exploration programs at all scales, and the development of new geochemical techniques has allowed exploration activity to expand in previously under-explored terrains and poorly understood deposits. Currently, MAGNET trainees are carrying out high-precision isotopic and trace element measurements in a detailed transect across the J-M Reef of the Stillwater Complex, the Western Hemisphere's largest known source of palladium. The origin of these ore-bearing zones remains controversial. This research is helping to determine if the mineralization is related to new magma influx, and will have implications for platinum group element deposits in other layered mafic intrusions worldwide.

MAGNET trainees will benefit from

- Research projects that are highly innovative and likely to have significant scientific and/or societal impact;
- Mentorship from some of Canada's leading scientists who are internationally recognized for their geochemistry expertise;
- Hands-on training in the latest techniques using state-of-the-art equipment and instrumentation;
- Internships with some of the top analytical, environmental, mining and mineral exploration companies in Canada and the world.

*continued on page 12*

## Multidisciplinary Applied Geochemistry Network... *continued from page 11*

Additional training is provided by seminars, professional development workshops and summer schools. MAGNET trainees will also have many opportunities for travel through fieldwork, university/laboratory exchanges, conferences and annual networking events. Recent highlights include an online course in applied geochemistry, two teaching workshops at the 2014 Goldschmidt conference, and a volcanology training workshop in the Long Valley caldera and Medicine Lake Highlands volcanic areas this summer in California.

### Industry Internships

Through practical work experience and interactions with industry representatives, MAGNET trainees will have a significant competitive advantage, being equipped with technical and professional skills that will improve job readiness, facilitate transition to the workforce and expand their possible career trajectories. MAGNET industry partners represent some of the largest and most respected analytical laboratories, environmental consulting firms, mining and mineral exploration companies in Canada and abroad. To improve the exposure of the trainees, host companies are not limited to these partners. MAGNET allows, and encourages, trainees to participate in multiple internships with different companies. Please contact the Program Coordinator if you would like more information about hosting a MAGNET intern.

The timing of the internship is flexible and may be carried out all at once, divided into multiple stages, or even spread throughout the year. This will depend on the requirements of the specific internship and the availability of the trainee. Trainees should spend a minimum of 20% of their time at the industrial collaborator premises (for example, 2-4 months at the MSc level and 8-10 months at the PhD level) over the duration of their involvement in the MAGNET program.

### Research Facilities

- Research Center in Geochemistry and Geodynamics (Université du Québec à Montréal, Université du Québec à Chicoutimi, and McGill University)
- Earth Materials Laboratory (Université du Québec à Chicoutimi)
- Volcanology Research Laboratory (McGill University)
- G.G. Hatch Stable Isotope Laboratory (University of Ottawa)
- Noble Gas Laboratory (University of Ottawa)
- André E. Lalonde Accelerator Mass Spectrometry Laboratory (University of Ottawa)
- Stable Isotope Laboratory (University of Toronto)
- Trace Metal and Metal Isotope Laboratory (University of Toronto)
- Pacific Centre for Isotopic and Geochemical Research (University of British Columbia)
- Environmental Interfaces Laboratory (University of British Columbia)

### Industry Partners

- Acme Analytical Laboratories
- Activation Laboratories
- ALS Minerals
- Anglo American
- Barrick Gold
- Lorax Environmental Services
- Nu Instruments (UK)
- Rescan Environmental Services
- Teck Resources

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## Obituary

### Eion Matheson Cameron 1933-2014



On May 30<sup>th</sup> of this year we lost a truly gifted and outstanding geochemist, pioneer, loyal friend, co-founder of our Association, at the time known as the Association of Exploration Geochemists (AEG) and now as the AAG, and founder of the Association's journal, the *Journal of Exploration Geochemistry (JGE)*: *Eion M. Cameron*.

Most of Eion's long and illustrious career was spent at the Geological Survey of Canada (1966-2000) as both a research geochemist and as Head of the Applied Geochemistry Subdivision comprising some 32 scientists and technical staff. A major emphasis of Eion's research was on the development, testing, and application of new and improved methods of detecting ore deposits both at surface and buried at depth. His accomplishments in this area are diverse. For example, he established lake sediment and water geochemistry as an effective mineral exploration tool in Canada's north. Back in 1972, Eion carried out the first regional-scale geochemical survey in Canada, sampling lake sediments and waters over 93,000 km<sup>2</sup> of the Northwest Territories in only six weeks using three helicopters and one float plane. Some of the discoveries, as a result of the survey include the Yava and Hackett River VMS deposits. This survey paved the way for Canada's National Geochemical Reconnaissance Program (NGR). Also in the 1970s, he led the first GSC multi-disciplinary multi-agency project – Uranium Exploration in the Athabasca Basin.

Through his extensive research globally on the genesis of different mineral deposit types, Eion developed new rock geochemical techniques for locating lode gold, porphyry copper, and VMS/SEDEX base metal deposits. Other areas where Eion made major scientific advances are too numerous to mention here but he is highly acclaimed for his ground-breaking research on the sulphur cycle during the Archean-Proterozoic transition, which is critical to our understanding of ocean and atmosphere evolution. This seminal research, published in journals such as *Nature*, is still quoted extensively today and forms the basis of recent research on the sulphur cycle employing other isotopes, particularly <sup>33</sup>S.

Eion's contributions to the AEG/AAG continued from its founding up to his passing, not only in formal roles such as Editor-in-Chief (JGE), and later as the AAG's Investment Manager, but in putting forth ideas to make AAG an active, stimulating, and highly useful organisation. Over the years, he was awarded all the

AAG honours: the silver and gold medals, and honorary lifelong membership.

Eion, as Head of the Applied Geochemistry Section at GSC, hired me as a research chemist and I was delighted to join such a dynamic group at the GSC. He encouraged all of us to question, to think outside the box, to interact with scientists within and outside the GSC, and he gave us the opportunities to make real progress. For example, I had hardly arrived at GSC when he sent me down to Los Alamos to see and evaluate how the USA was planning its country-wide uranium reconnaissance programme and associated analytical procedures. Thanks to his leadership, our Geochemistry Group became a world leader in establishing this exploration methodology, alongside the US and British Geological Surveys. It was through his encouragement that we formed partnerships with such leading-edge companies as Barringer Research, Scintrex, and Sciex. He ensured we all communicated well and that we worked as a team.

Eion was an Adjunct Professor at the University of Ottawa (1983-2000) where he mentored 10 lucky graduate students. He enjoyed this enormously, mostly because of the collegial and stimulating environment in the Department of Earth Sciences. There he worked with and made a very good friend of Keiko Hattori. In his honour, Keiko is putting together a special issue of the successor journal to the JGE, GEEA. Eion knew this before he died and was very pleased.

One of the key factors that led to such success in Eion's research is his early recognition that one needs to incorporate knowledge or technology from peripheral fields of study such as soil science, analytical chemistry, statistics, physics, oceanography, and microbiology. There are very few scientists who can or would have the foresight to delve into quite different fields to obtain this much more comprehensive view. I think another of Eion's talents, demonstrated so well in all the publications from his 'Deep Penetrating Geochemistry' (he coined this phrase) research, was his ability to analyse, unravel, and describe, in fairly simple terms, processes of complex geochemical phenomena. His *ca.* 200 publications are superb, in their clarity, organisation, and brilliance. In the CAMIRO (Canadian Mining Industry Research Organisation) study that Eion led, where Stew Hamilton, Beth McClenaghan, and I worked with him as a team, he produced about 30 individual reports which were unique in that they could be read and understood by the highly trained geochemist and the field-oriented prospector alike. He extracted the essence of each piece of the puzzle to complete it. He was great fun to be with in the field; his love for the science of geochemistry was infectious and stimulating.

Regardless of these gifts, Eion was very modest. I learned a lot from him, as did others. He never stopped learning; whether it was in science, business, financial investments, people, world affairs, cultural matters etc, his curiosity did not wane. Eion, we will miss you enormously and we are so grateful for your long lasting legacy in exploration geochemistry.

**Gwendy E.M. Hall, Ottawa.**

# Chemistry of Europe's Agricultural Soils

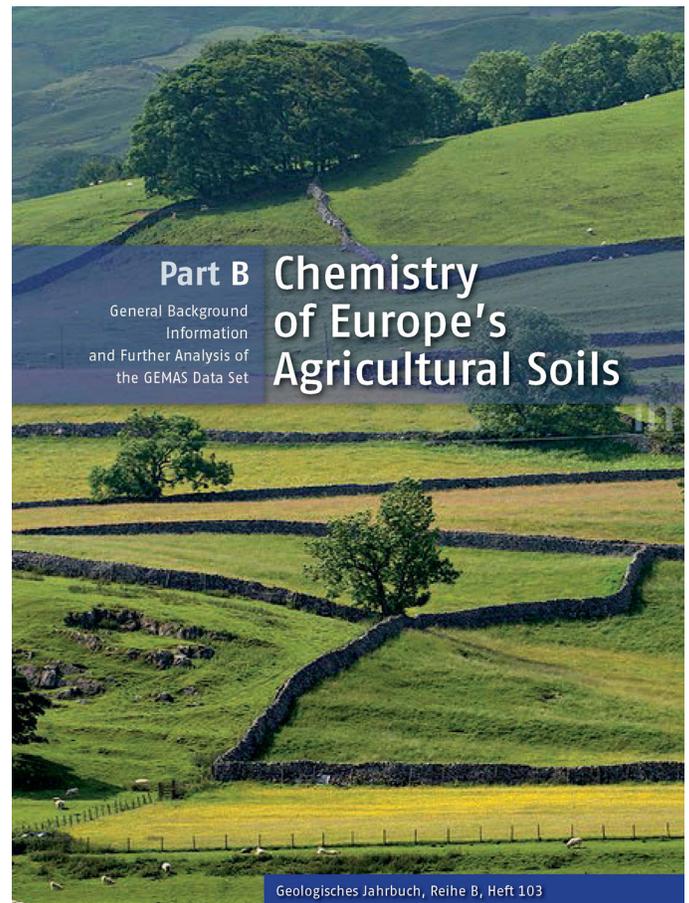
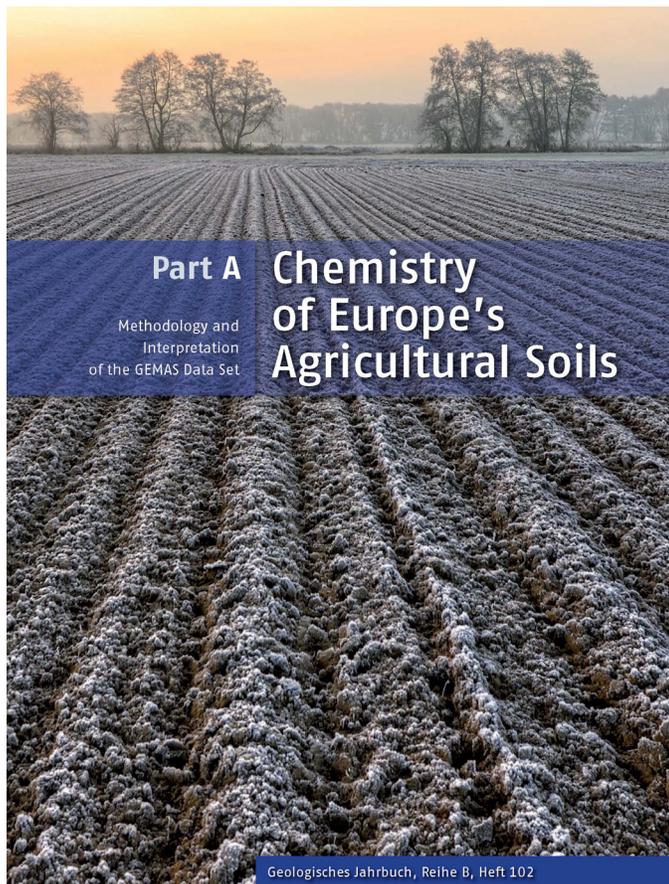
By C. Reimann, M. Birke, A. Demetriades, P. Filzmoser and P. O'Connor (Eds.)

**Part A: Methodology and Interpretation of the GEMAS data set.** Geologisches Jahrbuch B102. 2014. Schweizerbart. ISBN 978-3-510-96866-6. Hardcover 528 pages. Price 118 Euro.

**Part B: General Background Information and Further Analysis of the GEMAS Data set.** Geologisches Jahrbuch B103. 2014. Schweizerbart. ISBN 978-3-510-96847-3.

Hardcover 352 pages. Price 78 Euro  
(both volumes together: 150 Euro).

**EXPLORE** issue 165 in March, 2015 will feature a detailed book review.



## Workshops / Short Courses Planned for the 2015 International Applied Geochemistry Symposium (IAGS)

The heart of an IAGS is the conveyance of current technology and science behind applied geochemistry. We have a full set of technical presentations and keynote speakers being developed to stimulate the mind and enhance our understanding of applied geochemistry.

In addition to the technical presentation we currently have six (6) workshops / short courses planned for the April 2015 IAGS to be held in Tucson, Arizona, USA. These will be conducted on the Saturday and Sunday prior to the IAGS week and follow the pre-IAGS field trips (except the Colorado / New Mexico field trip which arrives in Tucson on the Saturday).

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## Workshops / Short Courses Planned...

continued from page 14

### Saturday (April 18, 2015)

**Short Course #1: Acid Rock Drainage, Geochemical Processes, Modeling and Natural Systems (Bill Deutsch).** The natural geochemical system adjusts to the impact of acid rock drainage (ARD) through water/rock interactions that tend to neutralize the acidic pH and immobilize a portion of the metal contaminant mass within the solid phase. In this short course, a discussion will be provided to the geochemical processes (neutralization, mineral dissolution/precipitation, oxidation/reduction, and adsorption/desorption) that affect acidic waters and dissolved metal contaminants as the acidic water migrates from its source and interacts with the natural environment. The process of developing conceptual geochemical models for a site will be explained and examples of computer simulations of natural attenuation and applied remedial action of ARD will be provided. Use of comprehensive computer geochemical models for estimating the long-term stability of remediation methods will be discussed.

### Short Course #2: Application of Indicator Mineral Methods to Exploration (Beth McClenaghan & Dan Layton-Matthews).

This one-day workshop builds on the success of the indicator mineral workshops held at the 24th, 25th and 26th International Applied Geochemistry Symposia (IAGS). Indicator mineral methods can now be applied to exploration for a broad range of deposit types. This one-day workshop will review principles, methods, and developments in indicator mineral methods in mineral exploration around the world and consists of presentations by some of the most experienced practitioners in industry, academia, and government. Topics will include indicator minerals for porphyry Cu, VMS, Sn-W-Mo, MVT, and REE, Ta, Nb deposits, specific minerals such as tourmaline, titanite, and scheelite, and mineral chemistry techniques.

### Short Course #3: Metal Mobility in Hydrothermal and Supergene Environments (Bill Chavez & Erich Peterson).

This workshop presents practical applications of metals geochemistry characterizing hydrothermal and supergene environments, including the use of activity and Eh-pH diagrams to interpret metal occurrence and distribution. Examples from hydrothermal ore deposits provide reinforcement of the general principles presented, and examples from supergene ores emphasize the importance of weathering-related metals mobility (or lack thereof) and geochemical processes associated with their weathering. In-class examples shall provide for group discussions and question-answer sessions.

### Sunday (April 19, 2015)

**Short Course #4: Adding Value in Exploration and Remediation with Isotope Geochemistry (Kurt Kyser & Matt Leybourne).** Elemental geochemistry has proven invaluable in exploring for undercover ore deposits using a multitude of

surface media. The challenge in exploration geochemistry is in finding those particular elements that reflect the ore deposits at depth, but also to understand the processes involved in mobilizing and fixing these elements at the surface. Similarly, the challenge in remediation is in understanding element cycles in the near surface environment and how these can be exploited to our benefit.

Most elements of interest have more than one isotope whose ratios can provide the most sensitive and precise way to fingerprint the source of an element and record the influence of buried and altered ores alternation and processes by which elements migrate. This information can be used to guide both exploration and remediation at regional and local scales. The purpose of this workshop is to examine how isotopes can add value to understanding the processes by which elements migrate in the near surface environment and provide new avenues to enhance learning for both effective exploration and formulating remediation strategies.

### Short Course #5: Regolith and Terrain Mapping (Simon Bolster).

Near-surface exploration geochemistry in regolith-dominated environments will be introduced and examined. This workshop provides an overview of the importance of understanding the regolith and includes practical examples in mapping regolith terrain, field logging, interpreting geochemical datasets, and data validation systems. Case studies will cover exploration programs that have succeeded through regolith analysis and others that have failed due to lack of attention to the regolith. Australia and Africa, as well as other continents, will be considered.

### Short Course #6: Application of Field Portable X-Ray Fluorescence in Exploration and Mining (Gwendy Hall).

The previous pXRF workshop at the 26th IAGS in Rotorua was highly successful and, given the large number of enthusiastic attendees, we are offering an updated version in Tucson. As the user of the now widely adopted technique is most often not an analyst, it is important to understand the strengths and weaknesses of this field analytical methodology. Presenters are from industry, government surveys, and academia.

Presentations will cover:

- theory and merits of pXRF, including interferences;
- best practices in pXRF;
- needs (or not) of sample preparation for various media;
- lithological characterization in exploration for different rock/ore types;
- applications to the analysis of cores;
- soil and sediment analysis;
- use of pXRF in environmental geochemistry; and,
- recent advances in the software and hardware associated with these instruments.





## 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](http://www.appliedgeochemists.org)

17-19 September 2014. ERA12: An International Symposium on Nuclear & Environmental Radiochemical Analysis. Bath UK. Website: [tinyurl.com/on9vn9p](http://tinyurl.com/on9vn9p)

20-28 September 2014. Association of Environmental & Engineering Geologists 57th Annual Meeting. Scottsdale AZ USA. Website: [tinyurl.com/pv29nw8](http://tinyurl.com/pv29nw8)

21-25 September 2014. Uranium Mining and Hydrogeology 2014 International Conference. Freiberg Germany. Website: [tu-freiberg.de/umh-vii-2014](http://tu-freiberg.de/umh-vii-2014)

21-26 September 2014. IWA World Water Congress and Exhibition. Lisbon Portugal. Website: [www.iwa2014lisbon.org](http://www.iwa2014lisbon.org)

22-23 September 2014. Annual International Conference on Geological & Earth Sciences (GEOS 2012). Singapore. Website: [www.geoeearth.org](http://www.geoeearth.org)

22-26 September 2014. 17th International Conference on Heavy Metals in the Environment. Guiyang China. Website: [ichmet2014.gyg.ac.cn](http://ichmet2014.gyg.ac.cn)

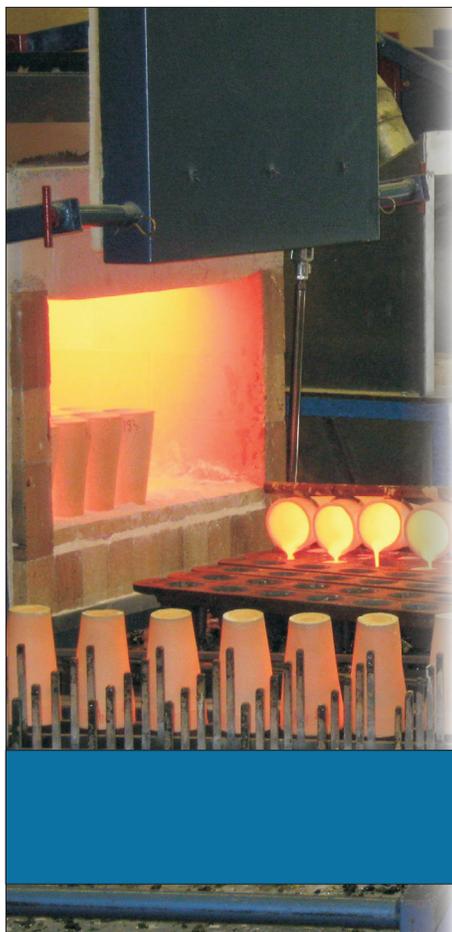
24-26 September 2014. XX Congress of Carpathian Balkan Geological Association. Tirana Albania. [tinyurl.com/kxegtd8](http://tinyurl.com/kxegtd8) (Facebook)

27-30 September 2014. SEG 2014: Building Exploration Capability for the 21st Century. Keystone CO USA. Website: [www.seg2014.org](http://www.seg2014.org)

29 September – 2 October 2014. 30th International Conference on Ore Potential of Alkaline, Kimberlite and Carbonatite Magmatism. Antalya Turkey. Website: [alkaline2014.com](http://alkaline2014.com)

17-20 October 2014. 16th Annual Conference of the International Association for Mathematical Geosciences. New Delhi India. Website: [www.jnu.ac.in/Conference/IAMG2014](http://www.jnu.ac.in/Conference/IAMG2014)

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## CALENDAR OF EVENTS

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19-22 October 2014. GSA 2014 Annual Meeting. Vancouver BC Canada. Website: [www.geosociety.org/meetings/2014](http://www.geosociety.org/meetings/2014)

17-22 November 2014 5th International Maar Conference. Queretaro Mexico. Website: [maar2014.geociencias.unam.mx](http://maar2014.geociencias.unam.mx)

1-5 December 2014. American Exploration and Mining Association (formerly NWMA) Annual Meeting. Sparks NV USA. Website: [www.miningamerica.org/annual-meeting-exposition/](http://www.miningamerica.org/annual-meeting-exposition/)

3-6 December 2014. 15th European Meeting on Environmental Chemistry. Brno Czech Republic. Website: [www.emec15.cz](http://www.emec15.cz)

26-29 January 2015. Mineral Exploration Roundup. Vancouver BC Canada. Website: [www.amebc.ca/roundup/2015](http://www.amebc.ca/roundup/2015)

31 January – 7 February 2015. 11th International Eclogite Conference. Rio San Juan Dominican Republic. Website: [www.ruhr-uni-bochum.de/eclogite/iec11.html](http://www.ruhr-uni-bochum.de/eclogite/iec11.html)

1-4 March 2015. Prospectors and Developers Association of Canada Annual Convention. Toronto ON Canada. Website: [www.pdac.ca/convention](http://www.pdac.ca/convention)

20-24 April 2015. 27th International Applied Geochemistry Symposium. Tucson AZ USA. Website: [www.27iags.com](http://www.27iags.com)

3-7 May 2015. Joint GAC-MAC-CGU-AGU Meeting. Montréal QC Canada. Website: [ja.agu.org/2015](http://ja.agu.org/2015)

14-19 June 2015. 12th International Conference on Mercury as a Global Pollutant. Jeju Korea. Website: <http://mercury2015.com>

27 July -2 August 2015. 19th INQUA Congress (Quaternary Perspectives on Climate Change, Natural Hazards and Civilization). Nagoya, Japan. Website: [inqua2015.jp](http://inqua2015.jp)

8-14 August 2015. Geoanalysis 2015. Leoben, Austria. Website: [geoanalysis.info](http://geoanalysis.info)

16-21 August 2015. Goldschmidt 2015. Prague Czech Republic. Website: [goldschmidt.info/2015/](http://goldschmidt.info/2015/)

17-20 August 2015. CANQUA 2015 Meeting. St. John's NL Canada. Website: [www.canqua.com/meetings](http://www.canqua.com/meetings)

20-25 September 2015. 8th Hutton Symposium on Granites and Related Rocks. Florianopolis Brazil. Website: [www.hutton8.com.br](http://www.hutton8.com.br)

1-5 November 2015. GSA 2014 Annual Meeting. Baltimore MD USA. Website: [www.geosociety.org/meetings/2015](http://www.geosociety.org/meetings/2015)

3-5 November 2015. 10th Fennoscandian Exploration and Mining. Levi Finland. Website: [10times.com/fem-levi](http://10times.com/fem-levi)

27 August – 4 September 2016. 35th International Geological Congress. Cape Town South Africa. Website: [www.35igc.org](http://www.35igc.org)

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

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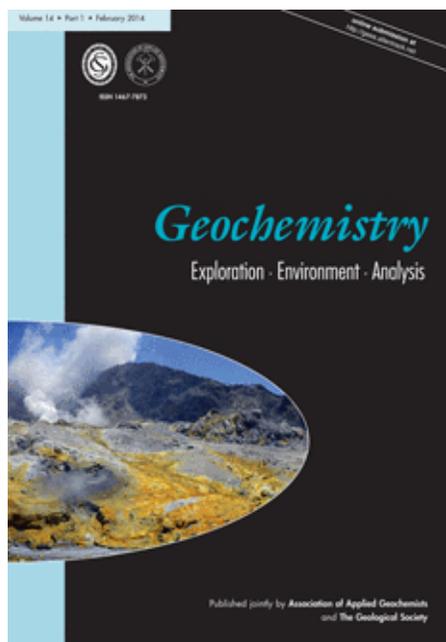
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### **Editor-in-Chief**

#### ***Geochemistry: Exploration, Environment, Analysis***

The Association of Applied Geochemists (AAG) and the Geological Society of London (GSL) are seeking to fill the position of Editor-in-Chief of their co-owned journal, *Geochemistry: Exploration, Environment, Analysis (GEEA)*. There would be a period of overlap with the current Editor early in 2015, with the new Editor taking full management in the later months of the year. GEEA is available online through GSL's Lyell Collection, GeoScienceWorld or the AAG; it was established in 2001 and is published quarterly (<http://www.geolsoc.org.uk/geea>). The Journal covers all aspects of the application of geochemistry relating to exploration for mineral deposits. Topics include: new and improved methods of geochemical exploration; geochemical mapping; sampling and analytical

techniques; processes of dispersion of elements in rocks, soils, vegetation, water and the atmosphere; differentiation of geogenic and anthropogenic sources; statistical methods applied to interpretation; and related environmental aspects.

The position requires a strong background in research in this field together with a substantial publication record. The Editor will be a good communicator and have a high degree of organizational skills and leadership ability. Building a network with geochemists in academia, industry and government is vital. The Editor is free to build their editorial team and to develop the optimal arrangement of associate Editors and board members to carry out a balanced and efficient procedure for reviewing, editing and general processing of papers. The Editor will be in frequent email communication with the journal's Production Editor in Bath, UK and will interact with the Director of Publishing of GSL and also with other journal Editors within the GSL to aid in the establishment of an integrated policy and publishing system.

This is an exciting, evolving time in publishing globally and you can make your mark! The rewards are many, such as the opportunities to: create your vision of GEEA and take the journal in new directions; produce special thematic issues on emerging technologies/methods; develop an extensive network and new relationships within the broad community of geoscientists; and foster integration of related disciplines.

Please send expressions of interest to Gwendy Hall ([gwendyhall@gmail.com](mailto:gwendyhall@gmail.com)) for eventual review by a selection committee.



## Modular Course in Exploration Geochemistry

03-16 December 2014

Mineral Exploration Research Centre  
Department of Earth Sciences – Goodman School of Mines  
Laurentian University

**Course Description:** 12-day intensive course in Exploration Geochemistry including a **pre-course tutorial on ioGas® geochemical plotting and analysis software** (no extra cost but required for those not proficient in ioGas), **Analytical Methods including portable XRF, Quality Control and Quality Assurance, Lithochemical and Surficial Geochemical Methods, Radiogenic and Stable Isotopes, Alteration Geochemistry, and Alteration Indices, Applications and Case Studies in Lithochemical, Drift Prospecting, and a 2-day Workshop on Surficial Geochemistry**

**Presenters (tentative):** Dr. Marcus Burnham (OGS), Dave Crabtree (OGS), Richard Dyer (OGS), Dr. Harold Gibson (LU), Dr. Wayne Goodfellow (GSC), Dr. Eric Grunsky (GSC), Gwendy Hall (GSC), Dr. Stewart Hamilton (OGS), Dr. Jennifer Hargreaves (OGS), Dr. Daniel Kontak (LU), Dr. Kurt Kyser (Queen's U), Dr. Michael Leshner (LU), Dr. Matt Leybourne (LU), Beth McClenaghan (GSC), Dr. Tom Morris (Northern Superior Resources), Dr. Jan Peter (GSC)

**Prerequisites:** Advanced undergraduate-level courses in *Geochemistry, Petrology, and Ore Deposits*

**Course Format:** lectures, laboratory practicals, and problem sets

**Grading:** Laboratory practicals and problem sets 100%

**Course Credit:** 3 credits, applicable toward thesis-based or coursework-based MSc and PhD programs; applicable toward continuing education and professional development requirements for Professional Registration

**Course Costs:** *LU Students:* tuition included in regular course fees. *Ontario Students:* tuition dictated by terms of *Ontario Visiting Graduate Student* agreement. *Non-Ontario Canadian Students:* tuition CDN\$1128 (see <http://laurentian.ca/graduate-fees> for most recent rates) with *Letter of Permission* from Canadian university. *Foreign Students:* tuition CDN\$2776 (see <http://laurentian.ca/graduate-fees> for most recent rates) with *Letter of Permission* from Foreign university. *Non-Students:* CDN\$2250 + GST for the entire course or CDN\$275 + GST per day - MERC Foundation and Corporate members are eligible for discounts.

**Student Registrations:** contact Roxane Mehes [rmehes@laurentian.ca](mailto:rmehes@laurentian.ca)

**Non-Student Registrations:** contact Char Mosher [cmosher@laurentian.ca](mailto:cmosher@laurentian.ca)

**Hard Copies of Course Notes:** *Students:* \$85 (must be paid in advance). *Non-Students:* included in course fees

**Travel/Accommodation/Meals:** All participants are responsible for their own travel, lodging, and meals.

*For additional information please contact:* [mlesher@laurentian.ca](mailto:mlesher@laurentian.ca)

## Minutes of the 2013 Annual General Meeting of the Association of Applied Geochemists Held at the 26<sup>th</sup> International Applied Geochemistry Symposium, Rotorua, New Zealand, November 18, 2013

### I. Call to Order – Establishment of Quorum

President Eppinger called the Annual General Meeting (AGM) to order and determined that more than the necessary 15 AAG Fellows required for a quorum were present. Fifty-two (52) AAG members attended. The minutes were taken by B. McClenaghan.

### II. President's report (B. Eppinger)

First, I want to thank the AAG Executive, Matt Leybourne, Gwendy Hall, and Dave Smith, and Past President Paul Morris for all of their help and sage advice over the last couple of years. Also, thank you to all Regular and Regional Council Members for participating in the running of our society. Thanks to Gwendy, Beth McClenaghan, and Patrice de Caritat for their editorship responsibilities for GEEA, EXPLORE, and Elements, respectively, and to Sarah

Lincoln as EXPLORE's Business Manager. Thanks also to Gemma Bonham-Carter, who has been AAG's Website Coordinator and Webmaster. Finally, Betty Arseneault, AAG's Business Manager, deserves a huge thank you for her day-to-day activities in keeping the AAG cogs turning smoothly. Betty's role is absolutely critical.

In this message I'm going to summarize a few of the important accomplishments over the last couple of years. Then Gwendy, Beth, and Patrice will present brief reports on our financial status, GEEA, Explore, and Elements. Following that we'll open up the floor for questions or comments from you. It is good to see familiar faces and attach names to faces in this one-on-one type of meeting.

AAG's membership numbers are holding fairly steady at 530 members, including 166 Fellows, 310 Members, and 54 students. We have 52 new members for 2013, including 21 students and 31 regular members. We typically get membership spikes following AAG symposia, but then settle back down to roughly these numbers.

Over the last couple of years, probably the biggest change for AAG has been the migration to the new website. The programmatic underpinnings for the old website used old and outdated technology and it was important to migrate for security reasons and to give the website a more modern feel. This was accomplished under the stellar work of Gemma Bonham-Carter. Another change that you will notice with this year's renewal process is the move to using PayPal for processing credit card payments. This change is also being done as an enhanced security measure. As a new Mother, Gemma has requested stepping down from the Website Coordinator role, but will still continue as our Webmaster. Having completed his term as a Councillor, Bruno Lemi re has agreed to take over as our Website Coordinator and will be bringing some new ideas for spicing up our website. Thank you Bruno! Bruno is looking for new ideas and content, so please contact him if you

*continued on page 21*



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## Minutes of the 2013 Annual General Meeting ... *continued from page 20*

have something to share on the website (B.Lemiere@brgm.fr). As always, we are looking for news items for What's News and Latest News sections. A glance at Latest News shows that it is outdated. I charge all of you to help Bruno in providing new, relevant content for our website—our principal gateway to the world. Good content doesn't just appear magically.

Another important completion over the last couple years is the formal establishment of a program for analytical support for BS, MS, and PhD students of applied geochemistry. By using a set of simple criteria, AAG identifies students, matches them with a participating commercial analytical laboratory, and coordinates support in terms of geochemical analysis and/or software support. A condition of this support is that these students are required to publish aspects of their work in either GEEA or EXPLORE, and acknowledge support of the laboratory in any presentation or published papers. From the lab's perspective, today's students are tomorrow's clients. Thanks to Paul Morris for planting the seed and to Erick Weiland for finalizing and administering this program. And to the various analytical labs for offering their services. Labs for 2012-2013 include ALS Minerals, Becquerel, Intertek Genalysis, and Ultra Trace/Bureau Veritas.

The above program complements three additional student funding activities that are available through AAG. These are (1) our Best Paper Award that is sponsored by SGS Minerals (to be presented at the Symposium Dinner), (2) the ioStipend, which is a grant for analytical services available to students conducting exploration-related geochemical studies, sponsored by Acme Analytical Laboratories Ltd. and ioGlobal, and (3) the Distinguished Applied Geochemists fund, which is used for providing direct financial support to students attending AAG-sponsored meetings, such as this IAGS. Students and/or their teachers/advisors can apply for these funding opportunities through the AAG website.

Another important initiative that has begun is the documentation of the history of AAG, and its predecessor, AEG. With our aging senior members, the continued passing of key founding members, and with new young and energetic geochemists entering our ranks, it is important to document how the organization came about over 40 years ago around 1972. This initiative is being coordinated by Beth McClenaghan and she is getting help on documenting our earliest years, an effort started by Gerry Govett and continued by John Hansuld and Bob Garrett. This effort is a major undertaking that will take a while to complete. Once done, this content-rich document will be available for download from our website. If

you have stories and/or photos of our rich past, please let Beth know. Thank you, Beth, for taking this on.

Our next IAGS will be held in April, 2015 in Tucson, Arizona. Erick Weiland is heading this up and has a strong local organizing committee. He will present more details on the last day of this conference. April is a perfect time to visit the Sonoran Desert and perhaps take a float trip down the Grand Canyon! We need to start thinking about the locale for the IAGS to follow in 2017. So far, we have not received any proposals, although we are still early in the process. Hosting an IAGS is a lot of work, as Tony Christie can attest, but it has a lot of local benefits as well. Please consider showcasing your part of the world to our geologists, geochemists, and their partners!

Other items that have been completed, but that I won't dwell on, include a revised Code of Practice for AAG Symposia undertaken by David Cohen and revisions and simplification of our Awards and Medals process led by Paul Morris. To replenish our dwindling copies, a .PDF book scanning effort is now nearly completed, with the *Probability Plots* booklet by A.J. Sinclair done and available from the AAG website, and the *Practical Problems in Exploration Geochemistry* book by A.A. Levinson, P.M.D. Bradshaw and I. Thomson that is near completion. And of course we still have our AAG Distinguished Lecturer, Ravi Anand, giving varied presentations worldwide through 2014.

AAG needs to start thinking about succession planning. We have critical roles in our society that are filled by long-standing AAG members. Who will replace Treasurer and GEEA Editor Wendy Hall, Secretary Dave Smith, and Office Manager Betty Arsenaault when they decide to step down? How can we plan for a smooth transition? Fortunately, they are not leaving any time in the near future, but we need to start planning for this eventual certainty now.

Finally, as I have done with every President's Message in Explore, I ask all Members who have remained in the background to step forward and help run our organization. Like all societies, it needs continued replenishment with new ideas and infusions of energy. If you've been a Member for a few years, consider converting to Fellow so you have voting privileges. If you are a Fellow, consider running for Councillor; each year we have Councillors rotating off their terms. Help out a Committee Chair. Get involved. As Dave Smith will soon be announcing, we have a full slate of Councillors for 2013, including a few new names.

At this point, I want to introduce our new President for 2014-2015, Matt Leybourne, who takes over in January. Matt will be assisted by our new Vice President, Ryan Noble. Thank you Matt and Ryan for taking over the helm.

*continued on page 22*

## Minutes of the 2013 Annual General Meeting ... *continued from page 21*

It has been a pleasure to serve you as President over the last two years. I hope I have steered the ship forward without too many wanderings from a straight course.

### III. Treasurer's report (G. Hall)

The main point to raise at this AGM is the fact that we are moving our investment funds from the Moneymarket at TD to the firm of MacDougall, MacDougall and MacTier (<http://www.3macs.com/3macs/en/home>) in Montreal. This firm has operated since 1849 (!), has an excellent reputation and offers a comprehensive investment management approach. It is a member of the Investment Industry Regulatory Organisation of Canada (IIROC) which sets high quality regulatory and investment standards to protect investors and monitors and enforces rules regarding the proficiency, business and financial conduct of its member firms and their advisors. I have a hard copy package from '3 Macs' which contains a lot of information including the (impressive) performance of their core list of companies. They devise and manage portfolios tailor-made for an individual, corporation or foundation, based on the requirements of income and capital appreciation and level of risk. I know people who have done (and continue to do) very well with them as their investment managers over many years; even during the 2008 debacle they did not suffer as much as most. I have recently had a meeting with 3Macs in Montreal outlining our strategy which would clearly be low-risk and diversified with an emphasis on dividend growth stocks (e.g. several Cdn banks, Sun Life Financial, Suncor etc). Early in 2014 we will transfer our TD funds (~ \$600K) and \$100K in our CIBC US account to 3Macs.

We need to revive our income from our investments as our excess revenue over expenditures in 2012, as outlined in our audit by Andrews and Co., was only ~ \$8K (US).

The current bank numbers are:

CIBC Cdn \$27,166.79

CIBC US \$117,326.90

Developing Countries Membership Fund: \$17,625

Alan Coope/Dist. Geochemists Fund: \$5622 (was reduced recently by \$6.9K used to aid students attending the 26<sup>th</sup> IAGS)

We are investigating ways to reduce our Bell phone charges (\$5353 in 2012 for 4 meetings) which seem exorbitant given the cost of long-distance calls these days.

### IV. GEEA report (G. Hall)

Several changes have taken place with respect to GEEA. Firstly, Open Access is now in force, though it will have little impact for GEEA currently as not many of our papers are submitted by UK/European government-funded authors. Information on this can be found at <http://www.geolsoc.org.uk/Open-Access> and more information at GEEA's own site, <http://geea.lyellcollection.org/>. Secondly, 'Online first' is now in operation, so that once a paper is accepted, typeset and proofed, it is put onto the Geological Society website through the Lyell Collection (<http://www.geolsoc.org.uk/onlinefirst>). The Online First release date serves as the official publication date. This action is extremely beneficial for a journal such as ours which publishes only quarterly and handles a fair number of special issues which implies that regular papers can be significantly delayed.

In 2013, in addition to regular papers, GEEA published papers from the 25<sup>th</sup> IAGS in Finland, and a special issue on Canadian Sampling Protocols edited by Eric Grunsky. Early in 2014, a double issue will be released on portable XRF in the exploration and mining industry. The titles of the papers online currently can be viewed at <http://geea.lyellcollection.org/content/early/recent>. AAG members should go to [http://www.geolsoc.org.uk/journal\\_alerts](http://www.geolsoc.org.uk/journal_alerts) to sign up for online alerts as they come out.

Our net profit for 2012 was £23,916, half of which comes to the AAG. This number is down from the £35K in 2011 due mainly to: Lyell development costs for Online First and Mobile Optimisation, and a Lyell collection specific charge not previously charged but incurred.

Our Impact Factor for 2012 is 1.00, not shabby but not as high as we would like.

I would be delighted to hear from anyone who would organise a thematic issue for the future!

There was a general discussion of GEEA's impact factor and the challenges of this measurement for scientists that publish in GEEA.

G. Hall will email a call for papers for GEEA to all speaker and poster presenters for IAGS. The manuscript deadline will be the end of January 2014.

### V. EXPLORE (B. McClenaghan)

EXPLORE 161 (December 2013 issue) will be mailed out in early December. Content for the first 2 issues of EXPLORE in 2014 is booked and I am looking for content for 3<sup>rd</sup> and 4<sup>th</sup> issues. While in New Zealand to attend the 26<sup>th</sup> IAGS, I am gathering photographs and

## Minutes of the 2013 Annual General Meeting ... *continued from page 22*

other material about the Symposium for the March 2014 issue of EXPLORE.

Sarah Lincoln, a geochemist with MMG, has been the EXPLORE Business Manager since 2007. Sarah has done a great job, but is stepping down from the position at the end of 2013. EXPLORE is searching for a new Business Manager for 2014.

EXPLORE lost Geosoft as a corporate sponsor in 2013. We thank our 3 loyal and long term corporate sponsors, Actlabs, ALS, and SGS for their continuing financial commitment to EXPLORE. In addition to these corporate sponsors, EXPLORE has several long term advertizers. All of this financial support allows us to continue to publish EXPLORE.

### VI. ELEMENTS (P. de Caritat)

Next year (2014) the AAG will have 6 pages of news published in the 6 issues of Volume 10 of ELEMENTS (1 page/issue on average).

The deadlines for submissions of materials are as follows (grey = done):

Issue/Month/Theme	Deadline	Reaches members
1/Feb/Asteroids	Dec 15	Mid-March
2/Apr/Unconventional hydrocarbons	Feb 15	End of Apr
3/Jun/Kaolin	Apr 15	End of Jun
4/Aug/Ophiolites	Jun 15	End of Aug
5/Oct/Cosmogenic nuclides	Aug 15	End of Oct
6/Dec/Graphitic carbon	Oct 15	End of Jan

This year's content for the AAG News page in ELEMENTS follows the plan below:

Feb: New Councillors + Dec Explore article synopsis  
 Apr: President's report + IAGS 2013 article  
 Jun: Regional report (TBC) + Mar Explore article synopsis  
 Aug: President's report + Jun Explore article synopsis  
 Oct: Regional report (TBC) + Committee report/AAG business (TBC)  
 Dec: President's report + Sep Explore article synopsis

Any good ideas about content for the Regional Reports, Committee Reports, AAG Business, Advertisements (student support) most welcome...

### VII. Other business (B. Eppinger)

G. Govett raised the issue of Elsevier and the possible republishing of the Handbook of Exploration

Geochemistry; he has written 3 emails to Elsevier but received no reply. C. Butt has received some reply from Elsevier to confirm they do intend to republish the books, but no indication of what will be republished or when. Colin Dunn was contacted by Elsevier recently to inform him they would like to publish a 2<sup>nd</sup> edition of his biogeochemistry handbook, perhaps as a digital e-book

Pim van Geffen suggested at future IAGS, that students automatically become AAG members for a year if they attend an IAGS conference; AAG could do this as means of encouraging students to join AAG and stay on as members. Following a general discussion, it was agreed that this could be considered for next IAGS.

B. Smee passed on the news that B. Coker, longtime AAG member, is losing the battle with cancer. Thursday's IAGS program includes acknowledgement of B. Coker and his significant contributions to AAG and exploration geochemistry

G. Hall and B. Eppinger raised the issue that the AAG web site needs new content, especially in the "What's new" area

### IV. Adjournment (B. Eppinger)

President Eppinger thanked all attendees and declared the 2013 Annual General Meeting adjourned at 5:40 PM local time.



## GSA 2014 Vancouver Meeting

The Geological Society of America annual meeting will be held October 19th to 22nd at the Vancouver Convention center this year. While the technical sessions are many and varied, there are a number that may be of interest to the geochemical community. A search of the topical sessions on the conference web site (<http://www.geosociety.org/meetings/2014/sessions/topical.asp>) reveals 49 sessions in which geochemistry is listed as an aspect to be covered. These vary from "Magmatism, tectonics, and metallogeny of the central Asian orogenic belt" and "Urban pollutants and their effects on environmental and human health", to my personal favorite, "Apatites I have known: from Man to Mars". In addition to these topical sessions, there will likely be a discipline session based on geochemistry, based on previous conventions. Abstracts were due at the end of July, so at the time of writing content for this session could not be confirmed. This session is sponsored by our brethren at the Geochemical Society. It looks like it will be a very successful meeting and I would encourage our members to visit the convention web site to find out more about what will be on offer.

**Dennis Arne**

*Managing Director – CSA Global Canada Geosciences Ltd.  
 Email: [Dennis.Arne@csaglobal.com](mailto:Dennis.Arne@csaglobal.com)*



## Special issue of Geochemistry: Exploration, Environment, Analysis

Volume 14, issue 2, May 2014 of Geochemistry: Exploration, Environment, Analysis (GEEA) is focused on the testing and application of pXRF to mineral exploration. This special issue of GEEA contains seven papers, the titles of which are listed below:

- Evaluation of portable X-ray fluorescence (pXRF) in exploration and mining: Phase 1, control reference materials
- Performance comparison of portable XRF instruments
- Analysis of powdered reference materials and known samples with a benchtop, field portable X-ray fluorescence (pXRF) spectrometer: evaluation of performance

- and potential applications for exploration lithochemistry
- Resolution of geochemical and lithostratigraphic complexity: a workflow for application of portable X-ray fluorescence to mineral exploration
- Portable X-ray fluorescence in the assessment of rare earth element-enriched sedimentary phosphate deposits
- Improving lithological discrimination in exploration drill-cores using portable X-ray fluorescence measurements: (2) applications to the Zn-Cu Matagami mining camp, Canada
- Improving lithological discrimination in exploration drill-cores using portable X-ray fluorescence measurements: (1) testing three Olympus Innov-X analysers on unprepared cores.



## New Members

### Regular Members:

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Blacksburg, VA 24060 USA  
Membership # 4252





## Association of Applied Geochemists 27<sup>th</sup> INTERNATIONAL APPLIED GEOCHEMISTRY SYMPOSIUM

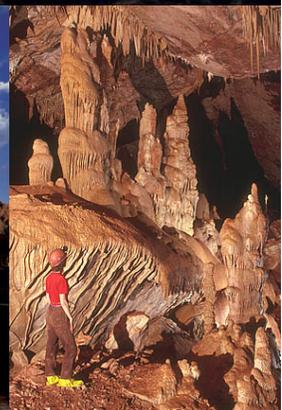


Registration begins May 2014

Pre-symposium field trips and short courses, keynote and technical presentations, plus an active social program will make this an IAGS to remember.



The Venue – Hilton El Conquistador



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for detailed information.*



## 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

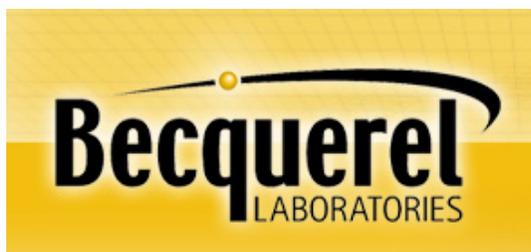
Four laboratories generously signed on to provide the analytical support to students during 2012; committing over \$35,000 in terms of analytical support:

- 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](mailto: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)



# EXPLORE

Newsletter No. 164

SEPTEMBER 2014

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## EXPLORE Publication Schedule

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 Microsoft® WORD. Do NOT embed figures or tables in the text document. Each photo and/or figure (colour or black and white) should be submitted as separate high resolution tiff, jpeg or PDF (2400 resolution or better) file. Each table should be submitted as separate digital file in Microsoft® EXCEL format. All scientific/technical articles will be reviewed. All contributions may be edited for clarity or brevity.

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