EXPLORE
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Newsletter for the Association of Applied Geochemists

Application of heavy stable isotopes to explain (bio)geochemical processes occurring during the formation, transport and remediation of metalliferous mine waters

INTRODUCTION

The exploitation of mineral resources is critical for economic growth and development. At the same time, mineral extraction and processing bear the risk of negatively affecting the environment. When mine wastes such as waste rock and tailings are exposed to ambient conditions, naturally occurring weathering processes such as mineral sulfide oxidation may be accelerated and generate metalliferous potentially acidic mine waters (acid mine drainage, AMD). AMD has been known for centuries (Agricola 1556) and can adversely affect environmental receptors even decades or centuries after mine closure. Therefore, AMD formation, as well as metal mobility, transport and remediation are widely investigated (Khorasanipour *et al.* 2011; Macias *et al.* 2012; Silva *et al.* 2013). Nonetheless, despite decades of intensive research, many (bio) geochemical processes surrounding AMD are still poorly defined with potentially negative implications for the successful application of AMD prevention and remediation measures. For this reason, the mine water research community has started to apply novel analytical techniques to improve our understanding about these processes that may ultimately also lead us to develop more successful techniques to prevent the formation of acidic mine waters and develop better remediation techniques.

THEORETICAL BACKGROUND

The stable isotopes of an element are characterized by the same number of protons but different numbers of neutrons and consequently different atomic masses. These mass differences may cause a different chemical and physical behaviour of the isotopes and their compounds, leading to mass dependent isotope fractionation. We have been monitoring light stable isotopes (LSI, e.g. H, O, S, C, N) for a number of decades and therefore typically also call them traditional stable isotopes. The lower percentage mass dif-

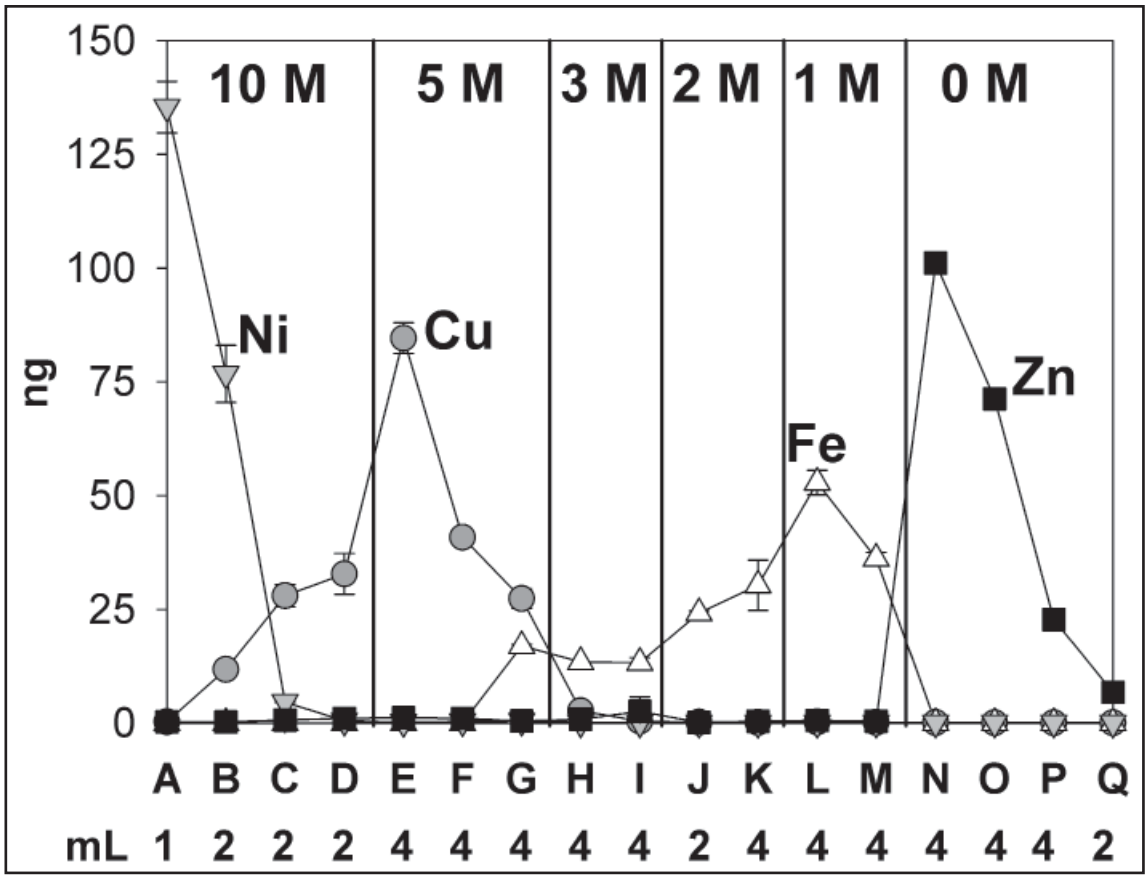

***Figure 1**. Solid – liquid extraction using anion-exchange resin to separate the target element zinc from the sample matrix consisting of copper, iron and nickel with varying amounts and concentrations of hydrochloric acid.*

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President's Message

The 26th International Applied Geochemistry Symposium (IAGS) in Rotorua, New Zealand is fast approaching. Since this is the last opportunity for me to communicate via this newsletter prior to the meeting, I will describe some of the symposium's scheduled activities. The program is being finalized as I write this note and is full of varied and interesting presentations during the meeting (18-21 November), pre-meeting workshops, and pre- and post-meeting fieldtrips. During the meeting, there are multiple-track sessions to whet any applied geochemist's appetite including those on exploration and prospectivity, environmental geochemistry, genetic models in exploration, geochemical mapping, lithogeochemistry, biogeochemistry, applied aqueous geochemistry, urban geochemistry, isotope geochemistry, a session dedicated to rare-earth elements, source-to-sink metal transport, advances in analytical geochemistry, and government-related geochemistry activities. As the meeting incorporates the 35th New Zealand Geothermal Workshop, geothermal-related sessions will include geothermal geochemistry, structural geology, engineering and reservoir modeling, and geothermal geology and geophysics. The Society of Economic Geology is co-sponsoring four sessions, including those on epithermal and orogenic gold deposits. All of the above plus nearly 60 posters and numerous keynote talks over four days are sure to fill our brains to capacity!

Numerous fieldtrips are planned and some are filling up quickly. Planned pre-meeting field trips include a seven-day trip covering active and fossil geothermal and epithermal systems on the North Island (Auckland to Rotorua), a one-day trip visiting the Waitomo Caves and covering coal geochemistry (Auckland to Rotorua), and a one-day helicopter-based trip visiting the active volcanos of White Island and Mt. Tarawera (Rotorua); the latter last erupted in 1886. Post-meeting field trips include a five-day trip to view orogenic gold mines on the South Island (Dunedin to Christchurch), a two-day trip on environmental geochemistry of gold and coal mines (Rotorua to Auckland), a two-day trip on environmental geochemistry of lakes in the Rotorua area, a two-day trip to examine the influence of geology and geochemistry on wine terroir in the Hawkes Bay wine region (Rotorua), a one-day tour of volcanic features around Rotorua, a one-day tour of geothermal resources of the Taupo district (Rotorua), a one-day tour of White Island by boat, and a one-day visit of the Rocklabs factory where sample preparation equipment and international geochemical reference standard materials are produced. Naturally, if minimum numbers are not met, some of the fieldtrips will be cancelled. To ensure your place on a field trip, register early.

One-day workshops held on the 16th or 17th of November include molar element ratio analysis (by Cliff Stanley), exploration for epithermal precious metal deposits (Stuart Simmons), environmental geochemistry of mine drainage (James Pope and Dave Trumm), indicator minerals in exploration (Beth McClenaghan, Alain Plouffe, Dan Layton-Matthews, John Youngson, Paul Spry, Stu Averill, Georges Beaudoin, and Tom Morris), quality assurance in geochemical analyses (Michael Wiedenbeck), use of portable XRF in mineral exploration (Gwendy Hall, Nigel Brand, Paul Morris, Rob Bowell, Ruth Wallender, Margaux Le Valliant, and Dave Lawie), geochemical speciation models in environmental assessments (Jenny Webster-Brown and Anthony Kirk), active seafloor hydrothermal systems (Cornel de Ronde, Christian Timm, Fablo Caratori Tontini, and Heidi Berkenbosch), and a two-hour informal student publishing workshop (Matt Leybourne and Gwendy Hall). One-day geothermal-related workshops include basics of geothermal science (Sadiq Zarrouk and Bridget Lynne) and practical geothermal geochemistry (Ed Mroczek and Bruce Mountain). A two-day workshop on exploration for orogenic gold deposits will be held on 16-17 November (Rich Goldfarb, Dave Groves, and Dave Craw). As with field trips, minimum participant numbers are necessary for workshops, and registering early ensures your spot.

In the tradition of previous IAGS, there is an extensive social programme, including a welcoming function, industry/student evening, official symposium dinner, Maori concert and traditional meal, pub appreciation trek ("pub crawl"), farewell dinner, and a curious hydrothermal fluid society wine tasting event. The partners programme includes tours of Lakes Rotoiti and Rotorua, the Orakei Korako Thermal

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Notes from the Editor

The September 2013 issue of **EXPLORE** features one technical article by Romy Matthies that describes the application of heavy stable isotopes to explain (bio)geochemical processes occurring during the formation, transport and remediation of metalliferous mine waters. **EXPLORE** thanks all contributors and reviewers for this third issue of 2013: Steve Amor, Betty Arsenault, Bob Eppinger, and Matt Leybourne.

Beth McClenaghan
Editor

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ference of two isotopes of heavier, non-traditional, elements (HSI = heavy stable isotopes) commonly leads to much lower isotopic fractionation. We therefore require analytical techniques with improved precision than those applied for LSI. A number of methods are now available for the analysis of these non-traditional stable isotopes. However, the development of Multi-Collector Inductively-Coupled Plasma Mass Spectrometry (MC-ICP-MS) in the early 1990s (Walder & Freedman 1992) has been a breakthrough for HSI research because of the higher precision compared to other ICP-MS instruments and improved ionization compared to Thermal Ionization Mass Spectrometry (Albarede & Beard 2004; Walczyk 2004). The multi-collectors consist of four main components (Albarede & Beard 2004): i) the sample introduction system ; ii) the inductively-coupled argon plasma to ionize the sample; iii) the mass spectrometer interface to establish high vacuum; and iv) the mass analyser that separates the ions by their kinetic energy. MC-ICP-MS requires the sample to be in a dissolved state unless coupled to a laser ablation system (e.g. Standish *et al.* 2012). For this purpose, most samples have first to be digested. The target element can then be separated by solid - liquid extraction (Fig. 1). Trace contaminants remaining in the sample may cause interferences that can bias the isotope results. As with LSI, heavy stable isotopes are commonly reported in delta notation (e.g. Cu in eq. 1) where the ratio of the heavy over the light isotope of an element in a sample is compared to the same isotope couple in an international standard.

$$1)\ \delta^{65}Cu = \left(\left({}^{65/63}R\right)_{sample}\left({}^{65/63}R\right)_{standard}^{-1}\right) - 1$$

APPLICATION OF HSI IN MINE WATER RESEARCH

Traditional stable isotopes have found wide application in mine water research. They have been used to trace pollution sources (Frandsen *et al.* 2009;

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Herbert & Björnström 2009), identify the origin and infiltration behaviour of water (Gammons *et al.* 2010; Wisskirchen *et al.* 2010), assess transportation processes and residence times in underground mines and passive treatment systems (Wolkersdorfer 2006) and clarify a variety of (bio)geochemical processes such as mineral sulfide oxidation and bacterial sulfate reduction taking place in waste rock damps and passive treatment systems (Tröger *et al.* 2005; Fonyuy & Atekwana 2008; Guo & Blowes 2009; Knöller *et al.* 2011). Since the development of MC-ICP-MS, we have seen an exponential increase in studies using HSI in diverse fields of the natural sciences (Douthitt 2008). Studies on heavy stable isotopes in AMD research are still scarce, but have already led to an enhanced understanding of mine water related processes as the following examples show.

REDOX PROCESSES

Chromium, uranium, iron and copper are redox sensitive elements. It has been observed that during oxidation, reduction, or both, a significant isotopic fractionation occurs that could be used to track redox processes during metal (im)mobilization. Jamieson-Hanes et al. (2012) studied the reduction and immobilization of Cr (VI) to Cr (III) in batch and column experiments using organic carbon as a reducing agent. Whereas the batch experiments showed that the isotope fractionation followed the general Rayleigh-type of closed systems, the column experiments were much less conclusive, suggesting that the flow patterns within the columns as well as other chromium removal mechanisms, such as sorption, had a significant influence on the isotope fractionation. Similarly, the reduction of uranium from U (VI) to U (IV) leads to a decrease in mobility. Shiel *et al.* (2013) investigated uranium immobilization and its isotope fractionation during *in situ* experiments at an uranium mine in Colorado. Bacterial iron and sulfate reduction led to significant isotope fractionation ($\Delta^{238}U_{max}$ = -1.3 ‰) and an enrichment of light isotopes in the non-reduced phase. The study by Egal *et al.* (2008) on iron isotope fractionation in the Iberian Pyrite Belt was somewhat less conclusive because of a multitude of overlying processes such as mineral sulfide oxidation, the speciation of mobilized iron and the type of secondary hydroxide precipitate. The primary sulfide minerals showed a rather homogeneous isotopic fingerprint (Tharsis: $\delta^{56}Fe$ = -0.56 ± 0.08 ‰; Rio Tinto: $\delta^{56}Fe$ = 0.25 ± 0.1 ‰). However, the isotope ratios of the iron hydroxides precipitated in surface water streams downstream of the deposits (-1.98 – 1.57 ‰) and the mine waters (-1.76 – 0.43 ‰) showed a wider scatter with significant variations in separation factors (Δ = -0.98 – 2.25 ‰) between the iron isotopes in the water and those of the secondary hydroxide precipitates. Kimball *et al.* (2009) investigated the fractionation of copper during (a)biotic oxidation of enargite and chalcopyrite and compared the isotope fractionation factors with those of a watershed affected by mine drainage. The authors found, that because of the preferential oxidation of ^{65}Cu, abiotic oxidation caused a fractionation of up to 1.37 ‰ ($\Delta^{65}Cu$) whereby the mobilized copper in the leachate was more isotopically heavy than the copper in the source minerals. If the leaching was promoted by microorganisms (e.g. *Acidithiobacillus ferrooxidans*), minimal fractionation was observed for enargite ($\Delta^{65}Cu_{aq\text{-}min}$ = 0.14 ‰) whereas for chalcopyrite the leachate was enriched in light copper isotopes ($\Delta^{65}Cu_{aq\text{-}min}$ = -0.57 ‰). Observations of copper isotopes from the field suggested that the dominant process connected to copper mobilization was likely of abiotic nature, which may be interesting from an AMD prevention perspective.

ANTHROPOGENIC PROCESSES

The identification of (bio)geochemical processes of non-redox sensitive HSI can be more difficult because the isotopic fractionation is smaller and a primary process causing enhanced fractionation is lacking as observed by Cloquet *et al.* (2008) for zinc. This makes the interpretation of the isotope data obtained in natural settings — with multiple processes occurring in parallel — challenging. It has, however, been shown that a number of anthropogenic processes may cause a significant isotope fractionation, which may be used to trace these pollution sources and differentiate them from other sources. Sivry *et al.* (2008) and Juillot *et al.* (2011), suggested that mineral processing and the efficiency of zinc extraction may lead to a distinct fractionation of zinc isotopes in the tailings material as compared to the unprocessed ore, permitting discrimination of Zn derived from tailings from other natural and anthropogenic sources. It is currently under investigation whether similar fractionation may occur for the nickel isotope system (Quantin *et al.* 2012). Despite several recent studies on iron (Herbert & Schippers 2008; Pérez Rodríguez *et al.* 2013), zinc (Sonke *et al.* 2007; Aranda *et al.* 2012), copper (Balistrieri *et al.* 2008; Borrok et al. 2008) and lead isotopes (Choi *et al.* 2013), more research is needed to better understand

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the underlying isotope fractionation mechanisms. In addition, effective element-matrix separation methods as well as analytical methods on the multi-collector are still needed for a number of HSI. Further, for many of these elements no certified international isotope standards exist, which makes it difficult to compare isotopic data obtained by different laboratories. The presented studies, however, have shown that HSI provide a tool for improved understanding of many biogeochemical and anthropogenic processes during AMD formation and metal transport and may also be valuable to improve our understanding of many passive mine water treatment systems that otherwise may not have been achieved.

At the University of Waterloo's *Hydrogeology, Geochemistry and Remediation* research group, we have started to apply a number of HSI (e.g., Cu, Cr, Hg, Ni, Se, Zn) to investigate in lab and field-scale experiments the fractionation behaviour of these elements during their mobilization from sulfidic mine wastes from various North American massive sulfide and kimberlite deposits and their attenuation through interaction with organic and inorganic substances. In a study investigating the potential to prevent AMD generation from mine waste by the amendment of organic substrates, we assess the potential of HSI to trace microbial induced reduction processes. We also apply HSI to discriminate anthropogenic, mine derived one-point pollution sources and investigate diffuse pollution and related isotope fractionation on a catchment scale.

ACKNOWLEDGEMENTS

Matt Leybourne is thanked for reviewing and improving this manuscript.

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AAG Website Update

The AAG website now includes the symposium abstract volume as well as pdf versions of powerpoint presentations for the 21st International Geochemical Exploration Symposium (IGES) held in Dublin, Ireland between August 28-September 3, 2003. Gerry Stanley of the Geological Survey of Ireland is thanked for providing the digital files to the AAG. These files can be accessed in the Events/Past Events webpages of the AAG website. Abstract volumes from older IGES symposia will be added to the AAG website as they become available.

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Park and Cave, Mokoia Island, a Huka Falls River cruise, and visits to art studios, galleries, cafés, and museums. Finally, the official symposium dinner will include presentation of the award for best student paper, AAG Gold Medals to Clemens Reimann and Eric Hoffman, and a Silver Medal to Gwendy Hall.

This is certain to be a memorable IAGS, thanks to Tony Christie and his local organizing committee members. Numerous corporate, university, and society sponsors and a promising trade exhibition are also helping to ensure the meeting's success. I encourage you to attend and look forward to meeting up with you over a beer or glass of wine. Current information is available from the symposium website, http://www.gns.cri.nz/iags/ and you can also get to this via a link on the AAG website's home page. Support for students includes very low registration and conference dinner fees, prizes for best student oral and poster presentations, and limited student travel grants (contact David Cohen, d.cohen@unsw.edu.au).

Once again I encourage you to become more active in AAG by serving on Council, on a committee, or by simply contributing to our website or **EXPLORE** newsletter. The web sites's What's News page is always looking for new content. The 2013 election for 2014-2015 AAG Councillors is fast approaching. Please consider running for Councillor to bring new ideas to the table. If not yet an AAG Fellow, then apply for Fellowship using the online application form. Through your help, AAG continues to thrive and evolve.

See you all in Rotorua!

Bob Eppinger
President

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

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

28-29 October 2013. 2nd Annual International Conference on Geological & Earth Sciences (GEOS 2013). Phuket Thailand. Website: www.geoearth.org

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

15-16 November 2013. 11th Swiss Geoscience Meeting. Lausanne Switzerland. Website: http://tinyurl.com/orv8fzl

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

2-6 December 2013. Northwest Mining Association: 118th Annual Meeting, Exposition & Short Courses. Sparks/Reno NV USA. Website: www.nwma.org/pdf/2013_regbrochMay.pdf

6-11 January 2014. 2014 Winter Conference on Plasma Spectrochemistry. Amelia Island FL USA. Website: http://tinyurl.com/ck2s5eu

27- 30 January 2014. Mineral Exploration Roundup 2014. Vancouver BC Canada. Website: www.amebc.ca/roundup/overview-2014.aspx

2-5 March 2014. Prospectors and Developers Association of Canada Annual Convention. Toronto ON Canada. Website: www.pdac.ca/pdac/conv/index.aspx

27 April – 2 May 2014. European Geosciences Union General Assembly 2014. Vienna, Austria. Website: www.egu2014.eu

11-16 May 2014. 5th International Congress on Arsenic in the Environment. Buenos Aires Argentina. Website: www.as2014.com.ar

21-23 May 2014. GAC/MAC Annual Meeting. Fredericton NB Canada. Website: www.unb.ca/conferences/gacmac2014

9-13 June 2014. Goldschmidt 2014. Sacramento CA USA. Website: http://goldschmidt.info/2014

17-20 June 2014. 38th International Symposium on Environmental Analytical Chemistry. Lausanne Switzerland. Website: http://tinyurl.com/p4q2qgd

29 June - 2 July 2014. 2nd International Conference on 3D Materials Science. Annecy France. Website: www.tms.org/Meetings/2014/3DMS2014

7-10 July 2014. Australian Earth Sciences Convention, Newcastle NSW Australia Website: www.aesc2014.gsa.org.au

14-19 July 2014. Earth Sciences and Climate Change: Challenges to Development in Africa. Nairobi Kenya. Website: www.aawg.org

29-30 July 2014. Sampling 2014 (AusIMM). Perth WA Australia. Website: www.ausimm.com.au/sampling2014

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3-7 August 2014. Microscopy & Microanalysis 2014. Hartford CT USA. Website: http://tinyurl.com/mrtf48v

11-14 August 2014. XII International Platinum Symposium Yekaterinburg Russia Website: http://tinyurl.com/qyle4lp

19-22 August 2014. 14th Quadrennial IAGOD Symposium Urumqi China. Website: www.14iagod.org/en/

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

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

21-26 September 2014. IWA World Water Congress and Exhibition. Lisbon Portugal. Website: www.iwa2014lisbon.org

24-27 August 2014. 7th International Conference on Environmental Catalysis. Asheville NC USA. Website: www.efrc.lsu.edu/ICEC

1-5 September 2014. 21st General Meeting of the International Mineralogical Association (IMA2014). Johannesburg South Africa. Website: www.ima2014.co.za

19-22 October 2014. GSA 2014 Annual Meeting. Vancouver BC Canada. Website: www.geosociety.org/meetings/2014

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

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

Please let **EXPLORE** know of your events by sending details to:

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New Member Applications

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New Member Applications

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26TH INTERNATIONAL APPLIED GEOCHEMISTRY SYMPOSIUM
INCORPORATING THE 35TH NEW ZEALAND GEOTHERMAL WORKSHOP

NZGW

April 2013

THIRD CIRCULAR

Lake Rotorua and Rotorua city in the foreground

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)

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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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 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

AAG Regional Councillor's Report: Chile

Applied geochemistry in Chile has slowly been growing, as geochemistry is being used in ever broader applications, such as geothermal energy exploration and evaluation, environmental base line and impact studies, and in mining, geo-mineral metallurgy characterization as well as in exploration. Human resources trained in geochemistry are still limited, but young Chilean geologists returning from overseas graduate programs and an increasing number of our own graduates are showing increasingly more interest in applied geochemistry.

Recent applied research projects include study of rutile and tourmaline chemistry in porphyry copper environments (AMIRA project, Universidad de Concepcion); study of geochemistry in geothermal environments (Center of Excellence in Andean Geothermalism - CEGA, Universidad de Chile); Geochemistry applied to geo-mineral metallurgical characterization (Department of Geology, University of Chile and recently the Advanced Mining Technology Center - AMTC, at University of Chile); Exploration Geochemistry (Department of Geology, University of Chile), including geochemistry applied to exploration in areas of transported overburden, and caliche geochemistry, including isotopic geochemistry; various projects in Environmental Geochemistry (Universidad de Concepcion, Universidad de Chile and Universidad Catolica del Norte), and soon to begin, Geochemistry, Mineralogy and Geology applied to characterization of terroir in the wine industry (Department of Geology, University of Chile together with the Chilean Wine Consortium).

Upcoming environmental legislation will finally include baseline geochemical requirements as well as geochemical environmental impacts, likely to become mandatory as of 2013-14. The definition of environmental baseline studies was developed by a multidisciplinary group of the Departments of Geology, Geophysics and Civil Engineering of the University of Chile.

On a more local scale, since October, 2012 an increasing number of Geologists/ Geochemists have been gathering for social meetings once every two months. This is an initiative that has allowed closer networking of the few applied geochemists in Chile, which numbers maybe a little over 20.

The AAG Distinguished Lecturer Ravi Anand, CSIRO, Australia visited Chile the first week of March 2013. He presented two talks, on March 6th and 7th, at the Central Codelco Auditorium in Santiago, Huerfanos.

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