Natural and Experimental Clues to Understand the Transport and Deposition of Supergene Gold in Western Australia

INTRODUCTION

Supergene gold deposits are relatively small (<1.5 Mt) and of low grade (1-5 g/t), but provide easy start up options for early cash-flow generation for small mining operations (Butt 1998), and such operations are abundant in Western Australia. One question asked is “can the information provided by studying the supergene Au be used as a vector to primary systems?” Hough et al. (2007; 2008) have investigated the morphology and geochemistry of Au to unravel some of the mysteries of nugget and single crystal formation that has indicated a need to look closer at both natural and synthetic Au morphologies and environmental constraints that will assist exploration.

Secondary Au deposition occurs through weathering of a primary hypogene Au deposit, dissolution of the Au from the host quartz or sulfide primary minerals, with the Au being mobilized in solution, transported and then deposited via precipitation at a later stage. Gold is inert in many weathering conditions, but can mobilize when complexed to stable ligands that are commonly found in soil and groundwater (Gray et al. 1992). Thiosulfate, organics and halides are believed to be the main ligands that mobilize Au (Butt 1998). In tropical environments cyanide, hydroxide and ammonia may also be functional ligands (Vlassopoulos & Wood 1990; Bowell et al. 1993). Bacteria have been shown to influence Au solubility and precipitation (Reith et al. 2006; Reith & McPhail 2006). A more detailed understanding of the mechanisms of formation of micro- and indeed nano-particulate Au may lead to a better understanding of supergene Au deposits, distance and conditions of mobilized Au, and in turn develop the capability of using morphology of supergene Au in the near surface environment to target larger hypogene Au systems.

A study of saprock fractures at an abandoned open-pit continued on page 2
Natural and Experimental Clues to Understand... continued from page 1

Au deposit was conducted to investigate the morphology of Au in the supergene zone and to search for nanoparticulate components. The pit, south of Southern Cross in Western Australia (Fig. 1), was a small Au deposit where localised primary mineralisation occurs as small, high grade quartz veins, blanketed by 30 m of weathered cover (Fig. 2).

Figure 1. Location of the abandoned open-cut Au pit, approximately 400 km west of Perth, in western Australia.

Figure 2. The regolith profile at the abandoned open cut Au pit near Southern Cross. Regolith depth is approximately 30 m, with significant Fe staining of the upper profile. The approximate location of the saprock sample is shown by the white arrow.

Following the field observations, laboratory experiments were conducted to determine if the morphologies of Au observed in nature could be produced synthetically, and as a result indicate potential mechanisms of formation and deposition, as well as to identify key ligands involved in transportation.

Notes from the Editor

The March issue of EXPLORE (No. 142) includes one scientific article. Ryan Noble, Robert Hough and Elizabeth Grenik describe their study of gold morphology and its contributions to the understanding the transport and deposition of supergene gold in Western Australia. Kiel Arndt reports on the modular exploration geochemistry course recently taught at Laurentian University in Sudbury, Canada. Scientific and technical editing assistance for this EXPLORE issue was provided by Owen Lavin, Newmont Mining Corp., an anonymous reviewer and Roger Paulen, Geological Survey of Canada. Coming in the June issue of EXPLORE will be an article describing Falconbridge’s kimberlite discoveries in Botswana in the late 1970s and early 1980s. The deadline for submitting abstracts for the upcoming IAGS, June 1-4 2009 in Fredericton, Canada has passed, but members should continue to check out the IAGS website for updates on the technical sessions, workshops and field trips.

If you have not already done so, AAG strongly encourages members to renew their membership online to support AAG and help maintain uninterrupted delivery of GEEA and EXPLORE.

Beth McClenaghan
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METHODOLOGY

Saprock materials were collected from the open-pit at approximately 30 m depth, above the primary mineralised zone. The fracture surfaces in the quartz blocks from this zone were covered in finely disseminated Au crystals. Selected pieces with this visible Au were then imaged using optical microscopy and Scanning Electron Microscopy (SEM, Philips XL-40) with an Energy Dispersive X-ray Spectrometer (EDS) used to obtain low magnification images using the backscatter electron (BSE) detector and compositional data (EDS), operating at 30 kV. Field Emission Gun Scanning Electron Microscopy (FEGSEM, Zeiss) images were collected at the Centre for Microscopy at the University of Western Australia. A low accelerating voltage of 3kV was used; with 1 kV used for some images to provide true surface images at high magnifications.

Synthetic Au crystals were manufactured in the CSIRO laboratory (Kensington, WA) by evaporation of 500 ppm chloroauric acid at ambient temperature or on a hot plate at approx. 120°C in a fume hood. In some cases additional ligands such as 0.01 M oxalic acid (C₂H₂O₄·2H₂O) was added to the solution and pH and temperature were adjusted. Characterization of the synthetic Au was conducted in the same manner as with the natural samples.

RESULTS

The use of various microscopy techniques revealed the morphology and chemical composition of the saprock materials. On the surfaces of the fractures, numerous populations of Au crystals were observed with the common euhedral, face centred, cubic, crystal structure. The Au shapes were triangles and hexagons. Other minerals such as halloysite and barite were also detected.

The laboratory work produced Au particles in all experiments. The solutions did not change their absorbance characteristics over time or with the different conditions. Following evaporation, microscopy and EDS analysis showed microparticles and nanoparticles of Au in triangular and hexagonal morphologies. Some variation existed in the number and size of Au particles depending on the treatments of the AuCl solutions.

DISCUSSION

Primary Au typically occurs as a Au-Ag alloy. However, secondary Au is commonly pure, although secondary Au-Ag alloys have also been shown to form in isolated cases (Webster & Mann 1984; Bowell et al. 1993). Supergene deposits are formed via chemical and mechanical weathering. This two-phase weathering results in Au being mobilized in solution and precipitating as pure secondary Au crystals in other areas. The mobilization of Au is probably in the order of a few metres to a few hundred metres in the Yilgarn Craton (Anand et al. 2007; Hough et al. 2008). Weathering fractures above primary mineralisation are the ideal place to observe this secondary deposition of Au. Studying the morphologies coupled with laboratory experiments can also provide clues into the natural conditions, mechanisms and associated ligands that are involved in the transport and deposition of Au.

The hypogene quartz veins at the base of the pit contain visible Au with approximately 10% Ag in an Au-Ag alloy. The surrounding groundwater also contains large concentrations of both Au and Ag, 44 and 293 ppt, respectively (Hough et al. 2008). A study of saprock fractures above this zone shows significant populations of Au crystals. The Au is pure, and exists as euhedral, isometric crystals. These particles vary in diameter from 300 µm to 0.02 µm (Fig. 3). Initial imaging of these samples did not show...
some of the large triangles and hexagons of Au as they are extremely thin (<20 nm; Hough et al. 2008). The SEM images produced at the commonly used voltage of 30 kV were seeing “through” these plates as the atomic number contrast was not great enough in the SEM BSE (Fig. 4).

Imaging of the surfaces of the large Au triangles using FEGSEM and secondary electrons revealed banded patterns that represent the smaller population of Au nanoparticles and halloysite. Hough et al. (2008) states that these phases are not coprecipitated (one forming nucleation sites for the other), but they are randomly coexisting in a drying pattern related to differential precipitation during evaporation and particle deposition. The halloysite is supported by a matrix of Au nanoparticles (Fig. 3D), these nanoparticulate Au crystals may also occur in smaller size fractions (left of centre in Fig 3D). These weathered fractures in the saprock also contain various Fe oxides, clays, sulphates and salts.

The size of these Au populations may be relevant to our understanding of partial extraction results and transport mechanisms. Partial extractions may only dissolve the smaller, nanometre-sized, more labile Au crystals resulting in biased results. Understanding the constraints on Au morphology may reveal more information about the formation of secondary Au deposits and Au fractions in soils, although more work is required. The aim would be to use the chemistry and morphological information of supergene Au to vector in to primary hypogene systems.

Regolith and groundwater chemistry influence the mobility of Au. In the southern areas of Western Australia groundwaters are highly saline, greater than 3x seawater (67,000 mg/L Cl) and acidic (pH down to 3), and soluble Au primarily occurs in solution as the Au-chloride complex (Gray 2001). Evaporation of chloroaauric acid (HAuCl₄) was conducted in the laboratory to observe the morphology that can be expected with Cl as the primary ligand and compared to the natural samples (Figs. 3 & 4). Results show the morphology of Au to be similar to those observed in saprolite from the study site (Fig. 5). Populations of microparticulate and nanoparticulate triangles and hexagons occur on top of Au-chloride salt crystals as determined by SEM EDS analysis. The triangles and hexagons range in size from 100 µm to 0.060 µm.

Figure 4. Naturally occurring hexagons and triangles of Au in the saprock fractures. Some of these plates are very thin and are partially transparent, showing the underlying Fe oxides and silicates (A), where as others are growing into cubic pyramid forms (B).
The Au-chloride solution was not evaporated immediately, and the visible light absorption was measured over time. Previous work in the area of materials science and nanoparticles has shown those Au colloids forming in solution change the solution colour as the reaction progresses, with colour controlled by the size of the colloidal Au. Using evaporation as the mechanism of formation, the absorption did not change during the experiments, indicating the Au is not colloidal during this time and formed after the solution was placed on the slide as a result of evaporation.

Other organic ligands may also be important for particulate Au formation; combining Au-chloride with oxalic acid produced numerous forms of Au (Fig. 6). Not only were the common hexagons and triangles observed, but also larger 3D pyramids and wires of Au. The reduction of the Au-chloride by the oxalic acid rapidly precipitates Au crystals in minutes compared with the hours of formation via evaporation. In natural conditions, a Au-chloride bearing solution would form supergene Au quickly, particularly in the presence of oxalic acid (or other strong reductants). Organic compounds are usually used in the nanotechnology manufacturing as capping agents to control size and shape of Au (Bi et al. 2008; Tan et al. 2003). The common supergene environment (especially in this study region) does not contain a large concentration of organic ligands, and in turn these compounds are unlikely to act as controlling variables, hence the bulk of formation is likely driven by slightly slower, inorganic evaporation.

Additional evaporite minerals are also evident in the study area and indicate that the evaporation mechanism of Au deposition is plausible. Gold microparticles are clearly visible in barite crystals (Fig. 7). Once bound in the barite, this Au is much less easily mobilized, which again indicates the importance of understanding the morphology as well as the host minerals of secondary Au in the near surface and deeper environments. This understanding may have significant implications for i) the formation and deposition of supergene Au, ii) secondary mineral fractions removed from soils in partial extractions with relation to Au, and iii) the ability to develop methods of using partial extractions and secondary mineral fractions to vector to mineralisation.

**CONCLUSIONS**

Studying the natural Au crystal morphologies, coupled with laboratory experiments has provided insight into the environmental conditions, mechanisms and associated ligands that may be involved in the transport and deposition of supergene gold in Western Australia. In the southern Yilgarn Craton supergene gold deposits are most likely formed through the evaporation of AuCl complexes in a relatively short time. Whether the use of the secondary Au crystal characteristics and associated minerals can be linked
Natural and Experimental Clues to Understand... continued from page 6

Figure 6. Particulate Au triangles and hexagons formed from the reduction reaction with oxalic acid. continued on page 8
to primary hypogene systems is unclear, but it provides an ultimate goal and direction for future research.

ACKNOWLEDGEMENTS

Peta Clode (UWA), Michael Verrall (CSIRO) and Greg Hitchen (CSIRO) assisted in SEM work. The National Measurement Institute allowed use of the absorbance spectrophotometer. Funding for this work was provided by CRC LEME and CSIRO Minerals Down Under Flagship program. Owen Lavin, Beth McClennaghan, David Gray, Nathan Reid, Ravi Anand and an anonymous reviewer are thanked for reviewing this manuscript.

REFERENCES


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Modular Course in Exploration Geochemistry (GEOL 5806)
Laurentian University, Sudbury, Ontario, Canada

Laurentian University, located in Sudbury, Ontario, presented the Modular Course in Exploration Geochemistry from December 3 – 12, 2008. This course was offered by the University’s Department of Earth Sciences and Mineral Exploration Research Centre (MERC) as one module of an Applied M.Sc. Program at Laurentian (http://www.earthsciences.laurentian.ca). A total of 16 people attended the course this year: 11 students, 2 industry geologists, and 3 industry geologists that will commence the Applied M.Sc. Program through taking this course. Some of the students came straight from undergraduate studies, whereas others had varying levels of industry experience. Industry professionals were welcome to attend as a one-time enrollment for continuing education. Unfortunately, industry enrollment was down from past years.

Geochemistry, as it relates to mineral exploration, was presented in ten days of intensive lectures and laboratory

**Topic**
- Hydrothermal Sediments and Applications in Exploration
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- Overview of Surficial Geochemistry: Soil Development and Processes, Sample Media and Methodology, and Designing Sampling Programs
- Drift Prospecting: Till Sampling, Ice Flow Indicators and Dispersal Trains, Indicator Minerals
- The Use of Lake Sediment Geochemistry for Mineral Exploration
- Soil Geochemistry in Areas of Thick Cover
- Forest Rings and Their Implications to Geochemical Exploration for Oil, Gas, and Mineral Deposits

practicals. The organizer and head lecturer of the course was Dr. Stephen Piercey, PGeo (SJPGeoConsulting/Memorial University of Newfoundland/MERC). Other presenters for the course came from the mineral exploration industry as well as academia and government.

The first day of the course provided an introduction to geochemistry with topics of sampling, sample preparation, and different analytical techniques. In the afternoon session, QAQC methods and best practices were covered. Following the lecture, data sets were provided for hands-on use of several of the methods. The next four days were spent on theoretical geochemistry. Topics covered were lithogeochemistry, radiogenic isotopes, stable isotopes, and hydrothermal alteration geochemistry, which included mass balance methods, element mobility, and how to set up alteration indices to a specific style of mineralization. In the afternoons, laboratory practicals were assigned with sample datasets. The next three days consisted of presentations from guest lecturers covering the geochemistry of different styles of mineralization and associated case studies. The final two days covered surficial exploration geochemistry presentation topics including soil, till, and take sediment geochemistry.

**Lecturer**
- Jan Peter (Geological Survey of Canada/MERC)
- Jan Peter (Geological Survey of Canada/MERC)
- Eric Grunsky (Geological Survey of Canada/MERC)
- Wayne Goodfellow (Geological Survey of Canada/MERC)
- Stephen Piercey
- Michael Lesher (Dept. Earth Sciences/MERC)
- Michael Lesher (Dept. Earth Sciences/MERC)
- David Crabtree (Ontario Geoscience Labs)
- Stephen Piercey
- Bill Coker (BHP-Billiton)
- Beth McCleneghan (Geological Survey of Canada)
- Richard Dyer (Ontario Geological Survey)
- Stewart Hamilton (Ontario Geological Survey)
- Stewart Hamilton (Ontario Geological Survey)

Speakers for the final days of the modular course: (left to right) Stew Hamilton, Beth McClenaghan, Steve Piercey, Richard Dyer, Bill Coker.

continued on page 11
Modular Course... continued from page 10

The Ontario Geoscience Laboratories (OGL), which is part of the Ontario Ministry of Northern Development and Mines, invited the course participants to tour the labs for an afternoon. During the tour, the participants were shown sample storage, sample preparation, nickel fire assay, partial digestions by acid, ICP-MS, preparation of glass bead and pressed pellet for XRF, loss on ignition analysis, particle size analysis, and electron microprobe analysis and images. During the course, an Innov-X portable XRF analyzer was provided by Jan Peter (Geological Survey of Canada) for hands on use. A suite of massive sulfide hand samples were also available for closer inspection. Microscopes were set up for a laboratory exercise in grain picking of kimberlite indicator minerals as well.

Glenn House of Vale Inco Ltd. looking at indicator minerals in the lab session of the drift prospecting module.

This course provided the participants with a broad spectrum on the background and recent advances of geochemistry and its application to mineral exploration. The first five days provided a great introduction to theoretical geochemistry as well as comprehensive laboratory practicals that ensured an understanding of the material presented, whereas the final five days provided a wealth of knowledge from the geochemistry of different styles of mineralization to surficial geochemistry presented by highly respected individuals in the field of geochemistry. The training of geologists in exploration geochemistry is essential to the maintenance and growth of this field. It is important that universities, such as Laurentian, continue to offer courses in exploration geochemistry.

A special thank you to Dr. Steve Piercey for organizing this course and passing on your expertise. Many thanks to the guest lecturers for taking the time to travel to Sudbury to ensure the advancement of geochemistry. Also, a thank you to the Mineral Exploration Research Centre, Department of Earth Sciences at Laurentian University.

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AAG Newsletters on the Web

All issues of the Association’s newsletters are now available as pdf files on the AAG website, starting with issue No. 1 published in February, 1971. While scanning these valuable archives you will notice that in October 1987 (issue No. 61), the newsletter adopted a new format and the official title of EXPLORE. These old issues of the newsletter are a great source of AEG/AAG history and scientific communications some of which are still relevant today. Thanks to Bob Garrett, Chris Benn, Bill Coker, Andrew Ransom, Bob Eppinger, Sherman Marsh and Geological Survey of Canada staff for their help in making the complete set available in digital format to all AAG members.

AAG Member News

Gwendy Hall, AAG’s Treasurer, Editor of Geochemistry: Exploration, Environment, Analysis, and emeritus research scientist in exploration geochemistry at the Geological Survey of Canada was named Honorary Fellow of the Geological Society in 2008. The Geological Society of London was founded in 1807. It is the United Kingdom’s national society for geoscience, and the oldest geological society in the world.

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Minutes of the 2008 Annual General Meeting of the Association of Applied Geochemists held by telephone conference on November 5, 2008

I. Call to Order – Establishment of Quorum
President D. Cohen called the Annual General Meeting (AGM) to order at 3:05 PM MST and determined that 16 Fellows were present for the meeting. This number represented one more than the required 15 for a quorum.

II. Discussion and approval of 2007 AGM minutes
The minutes for the 2007 AGM had been distributed previously to all AAG members. One typographical error had been noted.

It was moved (D. Cohen) and seconded (D. Lentz) that the minutes of the 2007 AAG Annual General Meeting be accepted. The motion was passed unanimously.

III. Business manager’s report (B. Arseneault)
We have 505 paid AAG members for 2008 compared to 550 members for 2007 (20 Students, 289 Members, 196 Fellows). Eleven of these members have a senior membership and 16 have opted for the EXPLORE and ELEMENTS only option. Seventeen of these are new memberships (3 Students, 14 members). There has been one member upgraded to Fellow status in 2008. At the present time, our Developing Country membership fund has a balance of $10,800 US. The Distinguished Applied Geochemists Scholarship Fund contains $18,300 US. The Association sponsors two members, one from Pakistan and one from Iran.

AAG continues to pursue the establishment of the Distinguished Applied Geochemists Fund. We are currently waiting final approval of charitable status from Canadian authorities.

IV. President’s Report (D. Cohen)
In 2007, the following Fellows were elected to Council to serve a 2-year term (2008 and 2009): Mark Arundell, Rio Tinto Exploration, David Garnett, Cooperative Research Centre for Tropical Savannas Management, David Lentz, University of New Brunswick, Ray Lett, British Columbia Geological Survey, Cliff Stanley, Acadia University

The Association is stable in terms of its structure, membership and finances and is conducting activities as expected. These include the production of the journal Geochemistry: Exploration, Environment, Analysis, the publication of AAG’s quarterly newsletter EXPLORE, the hosting of the biennial International Applied Geochemistry Symposium, the sponsoring of workshops focusing on various topics in Applied Geochemistry, and providing support for students to attend the symposium and workshops.

AAG must look at future growth of the Association and ways that we can develop closer ties with kindred societies to better serve our membership. The Association must play an increased role in the education of future applied geochemists as we are seeing fewer and fewer universities teaching applied geochemistry.

President Cohen thanked all the Members of Council and other members of AAG who have been involved Association activities and committee work over the past year. The Association is looking forward to a successful IAGS in Fredericton in 2009.

V. Treasurer’s Report (G. Hall)
Auditor’s report for 2007 (previously distributed to Council by email): Our auditor continues to be McCay, Duff and Co. Our current assets as of 31 December 2007 stand at $483,878 (US), up by ~ $60K from the previous year. Against these are liabilities, such as accounts payable and scholarship funds, that total $58,244, slightly higher than those for 2006 ($52,622). Our investments for 2007 did well in the hands of our manager, Eion Cameron, bringing in an income of $44,067, up substantially from 2006 ($24,022). The other major source of revenue explaining the increase over 2006 is that gained from the two workshops presented at Exploration ’07, in excess of $20,000. For this we thank not only the presenters, but the organisers, especially Beth McClenaghan. A small net surplus was recorded for the publication of Geochemistry: Exploration, Environment, Analysis (GEEA), as was the case in 2006. We appear to have spent considerably more in 2007 for the Explore Newsletter which should be examined if it continues into 2008.

It was moved (G. Hall) and seconded (D. Smith) that AAG accept the 2007 auditor’s report by McCay, Duff and Co. and that this firm be retained for preparing the 2008 report. President Cohen asked for a vote on this motion and it passed unanimously.

Investments: Eion Cameron had been warning us, for many months, of the impending financial crisis and was sending reports to the AAG Executive more frequently than the usual monthly rate. On 24 September 2008, he sold most of our securities, converting 76% of the $415K into cash and money market funds; he retained gold-weighted holdings. This action saved the AAG a lot of money and we are
Minutes of the 2008 Annual General Meeting... continued from page 12

extremely grateful to Eion for his foresight, knowledge and stewardship. In these highly volatile times, Eion feels slightly uncomfortable as the person responsible for our investments; however, we have assured him that he has our complete confidence and gratitude.

One outstanding financial report is that from the 23rd IAGS which was held in Oviedo, Spain in June 2007. This conference may not have garnered any major revenue for the AAG; seed money was not requested.

VI. GEEA (G. Hall)
There have been two special collections of papers in the 2008 issues of the AAG journal, Geochemistry: Exploration, Environment, Analysis (GEEA). The first issue of 2008 led off with selected papers originating from the ‘Workshop on Environmental Geochemistry’ held in Naples. We thank Benedetto de Vivo, Jane Plant and Annamaria Lima for organising this excellent contribution demonstrating multidisciplinary methods of characterising contaminated sites using geochemistry. Parts 3 and 4 of 2008 GEEA comprise a superb compilation of papers in honour of Arthur G. Darnley for his leadership in international- and global-scale geochemical mapping. The twelve papers describe the various methods used in, and highlight the multi-faceted applications of, geochemical mapping around the world. We are indebted to Clemens Reimann and Dave Smith for all their hard work in creating this valuable special double issue which should serve as a reference in the field of geochemical mapping for years to come.

The Geological Society of London (GSL), our partners in publishing GEEA, launched the Lyell Collection (www.lyellcollection.org) in 2007; GEEA has now been added to this fully searchable online collection of most of GSL’s books and journals (go to www.geea.lyellcollection.org). Members of the AAG are entitled to access all online content for the journal free of charge. Amongst the features of the Lyell collection, there is full-text linking to other key earth science journals, including those of GeoScienceWorld (www.geoscienceworld.org; 45 journals, GEEA being one).

Full online electronic submission to GEEA will take place in 2009; we are in the process of defining the protocols currently. By 2011, as with other GSL journals, GEEA will be available online only but those who cling to the printed copy can still receive this for an additional price.

A special thank you is given by Council to Marcia Scrimgeour, the Editorial Office Manager for GEEA, for her contributions that make the journal possible.

VII. EXPLORE (B. McClenaghan)
Explore 141 (December issue) is in press and will be mailed out at the end of November. It includes technical articles on the Canadian portion of the North American Soil Geochemical Landscapes Project by I. Kettles et al. and on the national-scale geoscience initiatives that are under way in Australia, by Patrice de Caritat et al.

Regional Councilors were asked by President Cohen after the March 2008 AAG Council meeting to submit short reports, new items or photos of activities in their region that would be suitable for publication in EXPLORE. One excellent contribution from Boudewijn de Smeth was received so far.

Payments from advertisers/sponsors for 2008 are slowly coming in. Five of the 13 advertisers/sponsors have paid to date. All of the CIBC banking issues have now (finally!) been resolved. Account statements are now being sent directly to the EXPLORE office rather than to the AAG office in Ottawa. Online banking for the Explore account was activated on October 10.

VIII. ELEMENTS (D. Lentz)
The December 2008 issue of ELEMENTS will contain a profile of AAG President D. Cohen as well as a call for papers for the International Applied Geochemistry Symposium. Upcoming themes for ELEMENTS include bentonite, scientific exploration of the moon, mineral magnetism, gold, and nontraditional stable isotopes.

IX. Symposia (P. Morris, D. Lentz)
Fredericton 2009
Local Organizing Committee Chairman Dave Lentz has an active website for the 2009 AAG Symposium (www.unb.ca/conferences/IAGS2009), and is actively pursuing sponsorship, and taking out advertising.

AAG 2011
Following the Oviedo meeting and the acceptance of Fredericton as the venue for the 2009 meeting, expressions of interest were shown by potential organisers in South Africa, China, Portugal and Finland to host the 2011 meeting. To date, the only proposal received has been from Finland. This was circulated to the AAG Symposium Committee and AAG Council. It is customary to announce the location of the...
Minutes of the 2008 Annual General Meeting...

continued from page 13.

subsequent AAG Symposium at each meeting, so a decision about the 2011 location needs to be made, for announcement at Fredericton. An early decision also gives the 2011 LOC more time for preparation.

Future Symposia
In the course of circulating the Finland proposal, a few Council members suggested that the USA should consider hosting an upcoming symposium given that a Symposium has not been held there for a while, and a good part of the membership is domiciled in North America.

Symposium Questionnaire
In order to assess AAG members' impressions of its Symposia, a questionnaire was published in EXPLORE v136, with a request for responses from those who had attended at least one of the last three AAG Symposia (Dublin, Perth, or Oviedo). A rather disappointing 41 responses were received. A few things came out of the responses: most showed an interest in exploration (compared to environment, data handling, analysis), with academics showing the greatest interest in exploration and environment; 61% of respondents preferred a single-sessional with only academics preferring parallel sessions in terms of venue; although most preferred to present orally, posters were seen as important; industry and privately-employed members preferred an upmarket location, whereas government and academia members preferred lower-cost venues; 73% of those who responded thought associated field excursions were an important part of the meetings, and the vast majority wanted workshops, and subsidies for students.

Revision to Symposia Guidelines
A revised set of Symposia guidelines were circulated to AAG Council and the AAG Symposium Committee earlier in 2008. There was general agreement with the content of the revised guidelines, with the main areas of debate over the level of control that AAG has over the format and content of the Symposium, and the agreement of the LOC to adopt both profit and loss sharing arrangements. A recurring comment in discussions about organizing Symposia and formulating guidelines is the diminishing amount of time that potential LOC members have to devote to conference organisation. One solution to this is to involve other societies in conference organisation, but this has implications in terms of profit (and loss) sharing, and whether it is still an ‘AAG Symposium’. To date, the revised guidelines have not been posted on the website - in order to let potential organisers know what AAG expects, perhaps they should be posted in the near future.

X. Web Site (B. Eppinger)
AAG’s webmaster, A. Ransom, took a new job with Rio Tinto and has had a lot of associated travel. These factors have impinged on his ability to make timely updates to the website and he apologizes for this. The pace is slowing down for him, so he should be able to devote more time to the website work. Because of his irregular updates, he has not submitted to the AAG Business Office any bills yet for his services. B. Eppinger has encouraged him to do so for this latest batch of updates.

Updates to the Website
- All issues of Explore should now be available from the website, thanks to A. Ransom, B. McClenaghan, and S. Marsh, who rummaged around his attic to find and scan the two final issues.
- ThermoScientific logo added to the Explore webpage
- 24th IAGS link moved to the top of the homepage; red lettering added to highlight it
- Graphic for 24th IAGS added to the homepage
- Immediately below the 24th IAGS link is a link to the symposium guidelines for submitting papers and posters
- EXPLORE publication dates added to the EXPLORE/Contributions webpage
- Upcoming Events on homepage updated
- D. Cohen’s report from EXPLORE #139 added to Latest News on homepage
- New entries for What’s News added
- Memorial for David McConchie added (bottom of the homepage/Memorials)

Needed
- What’s News contributions
- Committee heads to look at the website and ensure that the committee membership and contact info is up to date

XI. Other Business

Student Chapters (D. Lentz)
To grow the Association, we must aggressively go after new members. Establishing Student Chapters is one way of doing this. Our chapters at the University of Nevada (Reno) and in Chile are currently inactive. In an effort to revitalize these chapters and add new chapters, D. Lentz has been in discussions with C. Stanley and B. Townley about making a group to look after Student Chapters and expedite the process to bring in student members. Contacts have been made with universities in Iran, South Korea, Argentina, and India. D. Lentz has volunteered to build and host an AAG Student Chapter web site for each chapter that is formed. Advice from Council is needed regarding possible financial support for Student Chapters to make them more viable for various universities throughout the world.

XII. Adjournment
President Cohen thanked all attendees for their participation and declared the 2008 Annual General Meeting adjourned at approximately 3:50 PM MST.
AAG Councillors for 2009-2010

Elizabeth Bailey
Elizabeth received her degree from the Pennsylvania State University in 1980 and completed graduate coursework at the University of Alaska Anchorage. She joined the U.S. Geological Survey in 1982 and has worked in a variety of positions starting as laboratory/field assistant and now as a research chemist. Her primary areas of research include regional-scale stream sediment geochemistry and biogeochemical cycling of mercury near mines. She has contributed to the mineral resource assessment of several areas in Alaska, has been part of a team that developed an on-line digital database for USGS geochemical data from Alaska, and has conducted research on the microbial transformations of Hg near abandoned Hg mines in Alaska. Elizabeth has been a member of AAG since 1993 and a fellow since 2001. She has served as an assistant editor for Explore and is currently on the editorial review board of GEEA. Elizabeth also served as a Councillor for the 2007-2009 term.

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Robert Eppinger
Bob Eppinger is a Fellow and past Councilor in AAG, joining the organization in 1984. He is presently the Chair of the AAG Website Committee, and previously was an assistant editor for AAG’s EXPLORE newsletter from 1997

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GEOCHEMICAL ANOMALY AND MINERAL PROSPECTIVITY MAPPING IN GIS, 11

By E.J.M. Carranza

Included in series:
Handbook of Exploration and Environmental Geochemistry

Description: The book documents and explains, in three parts, geochemical anomaly and mineral prospectivity mapping by using a geographic information system (GIS). Part I reviews and couples the concepts of (a) mapping geochemical anomalies and mineral prospectivity and (b) spatial data models, management and operations in a GIS. Part II demonstrates GIS-aided and GIS-based techniques for analysis of robust thresholds in mapping of geochemical anomalies. Part III explains GIS-aided and GIS-based techniques for spatial data analysis and geo-information synthesis for conceptual and predictive modeling of mineral prospectivity. Because methods of geochemical anomaly mapping and mineral potential mapping are highly specialized yet diverse, the book explains only methods in which GIS plays an important role. The book avoids using language and functional organization of particular commercial GIS software, but explains, where necessary, GIS functionality and spatial data structures appropriate to problems in geochemical anomaly mapping and mineral potential mapping. Because GIS-based methods of spatial data analysis and spatial data integration are quantitative, which can be complicated to non-numerate readers, the book simplifies explanations of mathematical concepts and their applications so that the methods demonstrated would be useful to professional geoscientists, to mineral explorationists and to research students in fields that involve analysis and integration of maps or spatial datasets. The book provides adequate illustrations for more thorough explanation of the various concepts.

Audience: Professional geochemists, geologists, geoscientists, mineral explorationists and researchers and graduate students in fields that involve analysis and integration of maps or spatial datasets.

Bibliographic details:
Hardbound, 368 pages, publication date: NOV-2008
ISBN-10: 0-444-51325-6
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Price: USD 165, EUR 135, GBP 83

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continued on page 16

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Chris joined Anglo American plc as Vice President - PGE's and Proterozoic Cu-Zn and Au deposits. In 1998, sulphides, Archaean VMS deposits, Archaean Au deposits, throughout Western Australia for Ni and Co Laterites, Ni
Senior Exploration Geochemist for exploration programs 1989), he was Exploration Geochemist and subsequently
Australia. During his time with WMC in Kalgoorlie (1981-
Chris Oates began his career as an exploration geochemist with WMC, January 1981 based in Kalgoorlie, Western
Australia. During his time with WMC in Kalgoorlie (1981-
Erick Weiland
An internationally respected geochemist with over thirty years of professional experience and technical knowledge across multiple disciplines, Mr. Weiland has successfully completed projects throughout many countries. Expertise includes: mining/mineral geochemistry, rock/waste characterization, environmental impact assessments, water quality and soil remediation investigations, material characterization, geochemical evaluation of surface water, groundwater, and mineral interactions, and assessing the acid generation potential (acid rock drainage) with associated leaching of hazardous constituents from natural materials. He is an expert in the application of geochemistry supporting engineering/environmental projects including site characterization, feasibility studies, permitting, remediation, water quality, soil remediation, evaluation of acid mine drainage, waste rock dumps and tailings dam engineering/design, and mine closure activities. Mr. Weiland joined the association in 1978 and has been an active member ever since. He has participated as Councilor, President, Database Chairman, Editorial board, Canadian and Australian Geosciences Council representative, and other miscellaneous duties for mineral resource management, (b) teaching at post-graduate level and (c) supervising MSc and PhD students. Since 2003 to the present, he has been Assistant Professor in the ESA department of ITC with more-or-less similar teaching and research tasks as his Researcher appointment. He has supervised and led to graduation 4 PhD students and at least 20 MSc students.

Arsenic in Groundwater: A World Problem
© 2008 Netherlands National Committee of the IAH
Editor: T. Appelo

Contents:
1. Introduction
2. Sources and distribution of arsenic in groundwater and aquifers
3. Geochemical experimentation and modelling are tools for understanding the origin of arsenic in groundwater in Bangladesh and elsewhere
4. Review of arsenic behaviour from groundwater and soil to crops and potential impacts on agriculture and food supply
5. Health effects in inorganic arsenic
6. Mapping of hazardous substances in groundwater on a global scale
7. Arsenic in the Dutch coastal provinces
8. Regional occurrence with relation to drinking water production in the Netherlands

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2009


- June 1-4, 2009. 24th International Applied Geochemistry Symposium, Fredericton, New Brunswick, Canada Website: http://www.unb.ca/conferences/IAGS2009

- June 21-23, 2009. Xi’an Ni-Cu Symposium, Xi’an, China. Website: http://2009xani.chd.edu.cn/home1.htm


- June 23-26, 2009. 8th International Conference on Acid Rock Drainage, Skelleftea, Sweden. Website: www.securing.skelleftea.se


- October 18 to 23, 2009. VIII International Symposium on Environmental Geochemistry, Ouro Preto/MG, Brasil. Website: http://www.12cbgq.ufop.br/12cbgq/principaleng.htm


2010


continued on page 18
CALENDAR OF EVENTS
continued from page 17

• June 21-24, 2010. 11th International Platinum Symposium Sudbury, Canada. Website: http://11ips.laurentian.ca


2011

2012

• 2012. Geoanalysis 2012. Brazil

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RECENT PAPERS

This list comprises titles that have appeared in major publications since the compilation in EXPLORE Number 141. Journals routinely covered and abbreviations used are as follows: Economic Geology (EG); Geochemistry et Cosmochimica Acta (GCA); the USGS Circular (USGS Cir); and Open File Report (USGS OFR); Geological Survey of Canada papers (GSC paper) and Open File Report (GSC OFR); Bulletin of the Canadian Institute of Mining and Metallurgy (CIM Bull.): Transactions of Institute of Mining and Metallurgy, Section B: Applied Earth Sciences (Trans. IMM). Publications less frequently cited are identified in full. Compiled by L. Graham Closs, Department of Geology and Geological Engineering, Colorado School of Mines, Golden, CO  80401-1887, Chairman AEG Bibliography Committee. Please send new references to Dr. Closs at chezctc@comcast.net, not to EXPLORE.


continues on page 19


Garcia de Madinabeitia, S., Sanchezhorda, M.E., and Ibarguchi, J.I.G., 2008. Simultaneous determination of major to ultratrace elements in geological samples by fusion-dissolution and inductively coupled mass spectrometry techniques. Analytica Chemica Acta. 625(3): 117-


Neculita, C-M., Zagury, G.J and Bussiere, B., 2008. Effectiveness of sulfate-reducing passive bioreactors for...
RECENT PAPERS
continued from Page 19


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
ASSOCIATION OF APPLIED GEOCHEMISTS

APPLICATION FOR MEMBERSHIP*

Please complete only the relevant section for membership. See below for mailing instructions.

I, ______________________________________________, wish to apply for election as a ___Member / ___Student Member of the Association of Applied Geochemists. I have read the Code of Ethics of the Association and in the event of being elected a Member/Student Member agree to honour and abide by them.

MEMBER: State Employer and Employee title
I am actively engaged in scientific or technological work related to applied geochemistry exploration and have been so for the past two years.
__________________________ as a ___________________________________________.
(employer)                    (employment title)

STUDENT MEMBER: Student status must be verified by a Professor of your institution or a Fellow of the AAG
I certify that the applicant is a full-time student at ____________________________________________ in pure or applied science.
(institution)

__________________________                       _________________________________
(Professor/ AAG Fellow Signature )                                          (Printed Name and Title)

Witness my hand this ______ day of____________, 20______.

____________________________
(Signature of applicant)

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*Application for voting membership (Fellow) requires the sponsorship of three voting members. Request a voting member application from the Association office.

Please note: Your application form will be acknowledged upon receipt. The Admissions Committee reviews all applications and submits recommendations to Council, who will review these recommendations at the next Council Meeting or by correspondence. If no objection is raised the names, addresses and positions of candidates will be listed in the next issue of the AAG Newsletter. If after a minimum of 60 days have elapsed following submission of candidate information to the membership no signed letters objecting to candidates admission are received by the Secretary of the Association from any Member, the Candidate shall be deemed elected, subject to the receipt by the Association of payment of required dues. Send completed application, together with annual dues to:

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P.O. Box 26099, 72 Robertson Road, Ottawa, Ontario, CANADA K2H 9R0
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September newsletter: July 15
December newsletter: October 15

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