EXPLORE

NUMBER 126 JANUARY 2005

Newsletter for the Association of Applied Geochemists

Focus ON Petroleum Geochemistry

Special thanks to Dave Seneshen for assembling focus topics for this issue — Petroleum Geochemistry.

Incorporation of Petroleum Geochemical Explorationists into the Association of Applied Geochemists

By David Seneshen
Direct Geochemical, Golden Colorado

With the dissolution of the Association of Petroleum Geochemical Explorationists (APGE) in 1999, workers in this field are now searching for a new avenue to publish articles related to geochemical exploration for petroleum. Because many aspects of surface geochemical exploration for petroleum are similar to those employed for mineral exploration (see comparison below), the Association of Applied Geochemists (AAG) would be a logical body for previous members of the APGE to publish articles in the internationally-distributed refereed AAG journal ***Geochemistry: Exploration • Environment • Analysis.*** There is certainly room for more papers related to petroleum exploration in the journal considering that only 19 out of 1412 papers over the last 30 years are devoted to this topic.

This issue of **EXPLORE** is therefore devoted to geochemical exploration for petroleum, and copies of the newsletter will also be mailed to members of the now defunct APGE with the hope of enticing petroleum geochemical explorationists to join the AAG, publish in the journal, present papers at our biannual International Geochemical Exploration Symposia, and collaborate with other geochemical explorationists in the AAG.

Background to Geochemical Exploration For Petroleum

The premise behind surface geochemical exploration for petroleum is that light hydrocarbons (i.e. C1-C5) ascend rapidly to the surface from a pressured reservoir as buoyant colloidal-size "microbubbles" along water-filled fractures, joints and bedding planes (Saunders et al., 1999; Price, 1986). Studies over gas-storage reservoirs support the rapid development of soil-gas hydrocarbon anomalies over a charged reservoir, and the rapid depletion of such anomalies once the reservoir has been depleted (Coleman et al., 1977). Partial aerobic and anaerobic bacterial consumption of the ascending hydrocarbons produces carbon dioxide and hydrogen sulphide, which can significantly alter the chemical and mineralogical composition of overlying sediments (Schumacher, 1996). Changes to overlying sediments can include (1) adsorption of light hydrocarbons on clay particles or inclusion of hydrocarbons in secondary carbonate cements,

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AAG Presidential Address


David Kelley

As I begin my second year as President, I'm reminded of the words of Graham Taylor at the Annual General Meeting in Dublin, 2003, while lobbying for the extension of the Presidential term to two years. Graham's primary point was that it takes nearly a year to understand how the organization works, leaving little time to make changes. Having completed my first year, I can certainly attest to this point. Although 2004 was significant in that we changed our name and updated the By-laws, thereby completing the work of many over the last several years, we must now look forward and consider how we can best take advantage of these changes. I will be asking Council to consider ways that we can optimize and strengthen our organization to better serve our members. As always, input from all of our members is welcome and needed.

One new initiative that needs to be addressed this year is the sustainable management and distribution of charitable funds. As our Association matures, charitable contributions will be more frequent, creating new opportunities for the AAG to support research, scholarships or geoscientists from financially constrained parts of the world. We currently have two scholarship funds in honor of our distinguished colleagues, Alan Coope and Steve Cone, and the Developing Countries Fund, yet we have no strategy in place to market and manage these funds. I've asked Mary Doherty to head a new committee to look into these issues. She will be joined by members of the short-lived Benevolent Fund Disbursement Committee - Cliff Stanley, Neil Adshead, and David Seneshen.

A few months ago I sent an email to all members asking them what professional meetings they had attended over the past two years. The purpose was to gain insight into our members interests and areas of specialization and to learn more about the diversity of our Association. The results are impressive: of the 13% of our membership that replied (77 members), 92 different meetings covering a broad range of disciplines were attended (Table 1). Of those meetings, about 33% were related to mining and exploration, 24% to general earth science, and 21% to environmental science. The remaining 22% is divided between energy, biological sciences, geophysics, geochemistry, chemistry and "other." The PDAC meeting in Toronto was attended by the most members, followed closely by our own IGES conference, Roundup in Vancouver, and the recent SEG meeting in Perth.

There are many ways to look at the results of this informal survey. Clearly our members represent a global

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(2) development of soil bacteria anomalies and the development of “paraffin dirt,” (3) precipitation of isotopically light calcite, pyrite, pyrrhotite, uranium, sulfur, and magnetic iron oxides, (4) bleaching of redbeds through the removal of Fe^{3+} by reduced groundwater, (5) conversion of illitic clays and feldspars to kaolinite by acidic, reduced groundwater, and (6) variations in the major and trace element chemistry of soil and vegetation. Chemical reactions that produce the various minerals found in “reduced chimneys” above petroleum reservoirs are shown in Figure 1.

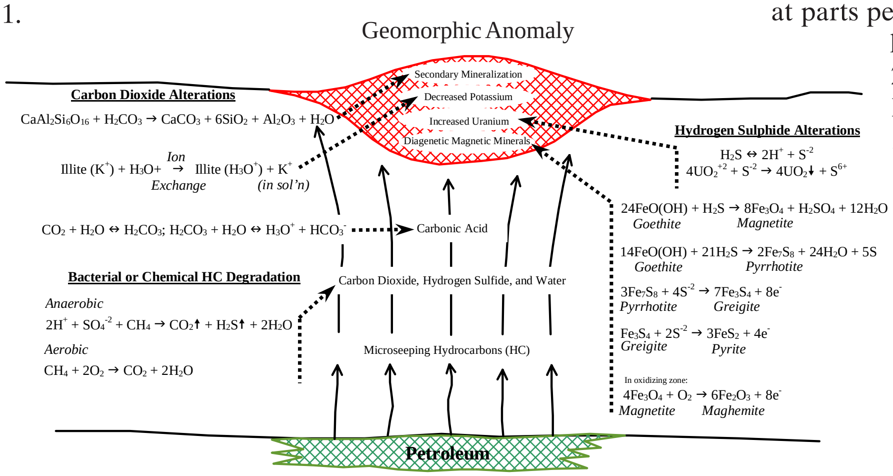

Figure 1. Possible model of hydrocarbon microseepage-related alteration over petroleum deposits (modified after Saunders et al., 1999)

Geochemical exploration for oil and gas reservoirs has been ongoing for over 70 years. The first soil gas survey was conducted in Germany in 1929 (Laubmeyer, 1933). In this study, Laubmeyer observed more total hydrocarbons (methane) in soil air over productive areas than over non-productive areas. The first reported soil gas work in the United States was by Rosaire (1938) and Horvitz (1939). Their research showed that there is a higher concentration of hydrocarbons adsorbed on soil particles than in soil air. Since these pioneering studies, geochemical exploration for petroleum has evolved into a very diversified science.

Direct methods, which involve the determination of hydrocarbon concentrations in near-surface soil and soil-air at parts per million (ppm) to parts per billion (ppb) levels have been used by many workers (Seneshen et al., 2004; Horvitz and Ma, 1988). Several case studies have documented either apical or halo hydrocarbon anomalies over existing oil and gas reservoirs.

Indirect methods involve the use of non-hydrocarbon pathfinders for exploration. There are several empirical studies that document changes in the near-surface environment related to hydrocarbon microseepage:

(1) Variation of major and trace element levels in soil (Duchscherer, 1984),

(2) Isotopically light calcite in rocks overlying petroleum reservoirs that form a shallow resistive zone over the Ashland gas field in southeastern Oklahoma (Oehler and Sternberg, 1984),

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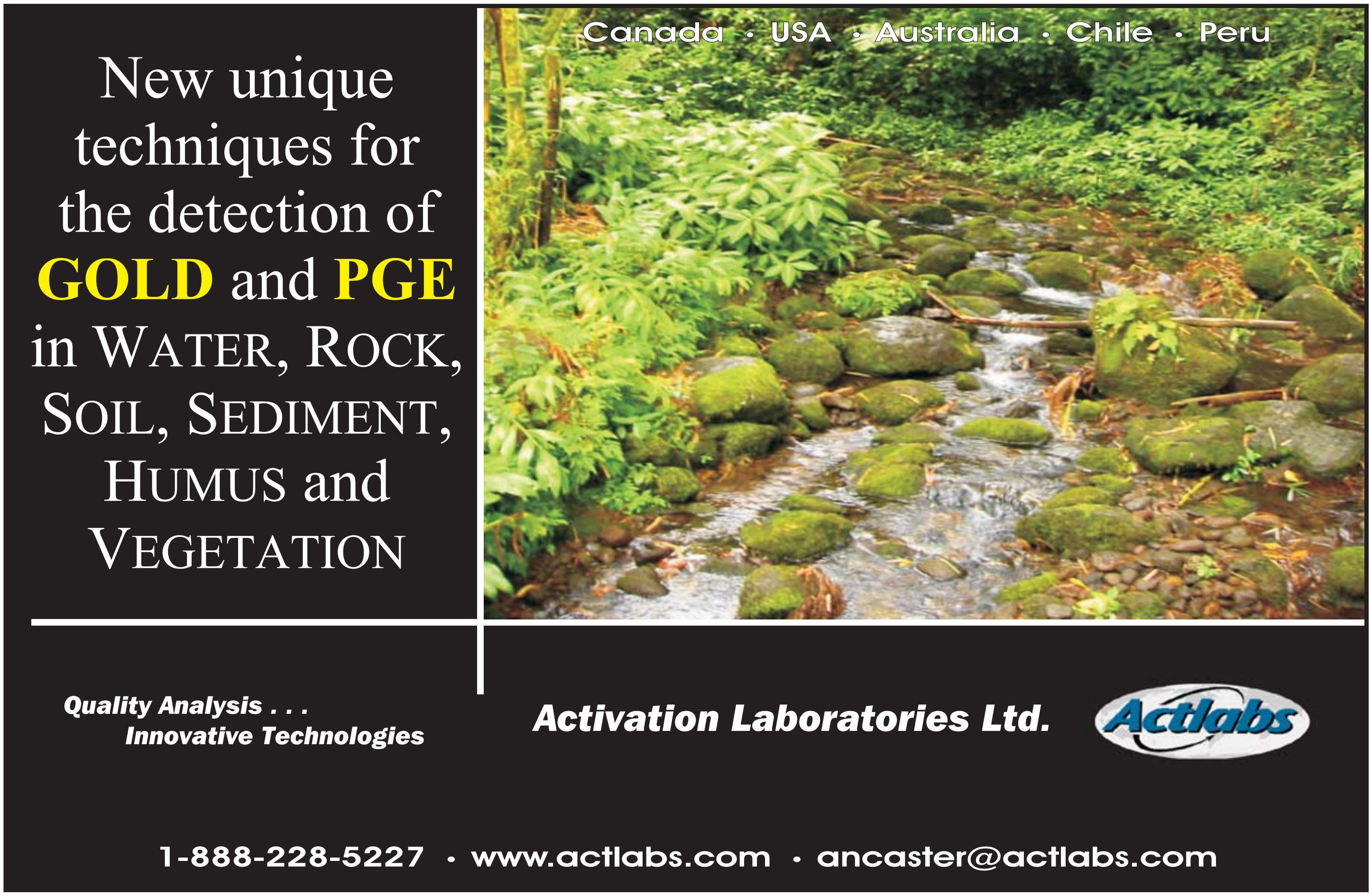

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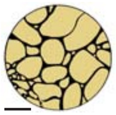

(3) The formation of pyrite and other sulphides that have been observed in drill cuttings and indirectly by Controlled-source Audiofrequency Magnetotellurics and Induced Polarization surveys (Oehler and Sternberg, 1984),
(4) The presence of magnetic iron oxides (high magnetic susceptibility) in rocks and sediments over petroleum reservoirs (McCabe et al., 1987),
(5) Variation of major and trace element levels in vegetation (Klusman et al., 1992),
(6) Soil bacteria anomalies (Riese and Michaels, 1991),
(7) Non-hydrocarbon soil gas anomalies including CO_2, O_2, He and sulphur-species (Barinaga and Farwell, 1988),
(8) Radiometric anomalies (Curry, 1984), and
(9) Spectral anomalies that reflect the hydrocarbon-induced alteration zone (Peters, 1983).

Comparison of Geochemical Exploration Methods for Petroleum and Metallic Mineral Deposits

Geochemical exploration methods for petroleum and metallic mineral deposits under exotic overburden share many of the same attributes. Both methods:

(1) Work best when used in conjunction with geology and geophysics,
(2) Search for reduced bodies in the crust by measuring changes in overburden composition from vertically ascending gases and fluids,
(3) Involve extraction and analysis of compounds and elements at low ppb levels from near-surface media,
(4) Are prone to high site variability because of the irregular distribution of fractures along which gases and fluids ascend.
(5) Show correlation of concentration with organic carbon and clay content of soils.
(6) Involve the use of both direct and indirect indicators of underlying deposits.
(7) Produce apical or halo-like anomalies over and adjacent to petroleum reservoirs and mineral deposits.

Because of the similarities between geochemical exploration methods for petroleum and mineral deposits, there should be considerable synergy between petroleum and mineral geochemical explorationists. Collaboration of geochemists from both fields could be fruitful in terms of solving problems related to sampling, analysis and interpretation. Petroleum exploration geochemists are therefore strongly encouraged to join the AAG to publish in the journal, present papers at meetings and collaborate with other geochemists that share many of the same problems with the application of surface geochemical exploration methods.

The cost to become a member of the AAG is $US70, and benefits of membership include:

(1) Subscription to "***Geochemistry: Exploration . Environment . Analysis***" and "**Explore**".
(2) Discounted registration fees for biannual "International Geochemical Exploration Symposia".
(3) Current publications and bibliography available through the AAG website.
(4) Discounts on various publications by the Association

An application form for membership in the AAG is included in this edition of Explore, and it can also be downloaded from the AAG website (www.aeg.org).

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Regional Geochemical Tool Targets Black River Gas in New York

By David Seneshen, Jim Viellenave and John Fontana
Direct Geochemical, Golden, Colorado

The deep Black River gas play in central New York is fast becoming a significant discovery for this decade, particularly for Fortuna Energy, Inc. which is producing 100 mmcf/d from several new fields. A study of this play, funded by the New York Research and Development Authority (NYSERDA), was undertaken to evaluate the effectiveness of surface geochemical methods over existing Black River gas fields and unexplored areas. A new exploration area, which was being drilled during the study, served as a blind test for the methods. Geochemical methods were chosen to test because they are low cost with a rapid turnaround and are environmentally non-invasive. This last feature is important in light of the high population density and amount of private land access required in this region of central New York.

The results of this study indicate these methods are effective for outlining prospective corridors of the Black River for subsequent leasing, seismic surveys and drilling. In combination with geology and geophysics, surface geochemistry is a complementary tool that can help to reduce risk and exploration costs. In addition to identifying prospects, surface geochemical methods can also identify deep faults that may breach and reduce production from hydrothermal dolomite reservoirs.

The premise behind any surface geochemical method is that light (C_1-C_5) hydrocarbons migrate vertically and rapidly as buoyant microbubbles along water-filled fractures from a pressured reservoir to surface. The result of this microseepage is that hydrocarbons become sorbed to organic and clay particles in overlying soils, and the mineralogy along the hydrocarbon chimney is altered because of reduced conditions brought on by the bacterial oxidation of hydrocarbons. Anomalies at surface degrade once the reservoir pressure has been reduced through production. Anomalies at surface can be apical or halo-like in morphology depending on the plumbing in the reduced chimney. Geochemical anomalies at surface can include soil gas hydrocarbons (free, sorbed and occluded), major and trace elements (e.g. I, Mg, Ni, V, U etc.), and hydrocarbon-consuming bacteria. Surface geochemical methods can help:

Figure 1. Example of soil profile developed on basal till that overlies Upper Devonian shale along a creek bed in the new exploration area.

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President's Message...

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group of geoscientists with interests spanning a broad range of earth science disciplines. Applied geochemistry plays a role in most of these disciplines. Of the meetings attended, only three were devoted exclusively to geochemistry – the IGES, the International Symposium on Environmental Geochemistry, and the Goldschmidt conference, indicating the importance our symposium plays in serving the global geoscience community. This uniquely places the AAG in the driver's seat for training and mentoring future applied geochemists, especially when academic programs continue to diminish. In addition, the wide range of meetings attended shows how broadly our members reach into other societies and areas of science. Attending these meetings provides an excellent opportunity to showcase the AAG, recruit new members, solicit papers for our journal, and ensure that advances in applied geochemistry are brought to the forefront in other disciplines. We should all take advantage of these opportunities as we attend these meetings. We can also use the list in Table 1 to reflect on the AAG and the service we provide to our members. Do we provide the benefits our members want and need to stay current in the field of applied geochemistry? Now that we have broadened the scope of our Association, are there other groups of geochemists that we want to recruit and interact with? Petroleum geochemists certainly come to mind. Please send me your thoughts on these issues.

I'm happy to announce that Stew Hamilton will succeed Cliff Stanley as the AAG Distinguished Lecturer and will serve in this capacity for the next two years. Stew has taken on this new assignment with great enthusiasm; by the time you read this he will have already given talks in Elko, Nevada and Golden, Colorado. Please contact Jeff Jaacks, our Distinguished Lecturer Chairman, if you are able to host Stew in your area. I would like to thank Cliff for his outstanding contribution to the Association and especially for representing the AAG at the recently-held Technical Training Course on Exploration Geochemistry given by the Institute of Geophysical & Geochemical Exploration in Langfang, Hebei, People's Republic of China. Great job Cliff!

In other news, Iftikhar Malik from Pakistan is now our Regional Councilor for Southeast Asia. Councilors for 2005-2006 are Robert Eppinger, David Seneshen, Alan Kelly, Phil Baker, David Cohen, Stephen Cook, Jorge Loredo and Olle Selinus. This is a larger group than normal (in number, not in size) due to the elimination of the Second Vice President position. I look forward to the contribution all of you will make to the AAG. I'd also like to thank Christopher Oates and Cliff Stanley for serving on Council; I hope that you will run for Council again in the future and help with the many other initiatives we have in progress. Ian Robertson has asked to step down as Chair of the Student Paper Competition Committee. Ian, thank you for looking after this for so long and for doing such an excellent job. We need a volunteer to fill this important role for the Association. Rodrigo Vazquez has also retired from the Webmaster position after providing his expertise to the AAG free of charge for the last several years. We will miss Rodrigo's help.

This year will be a busy one for the AAG as we host our **22nd International Geochemical Exploration Symposium** and the **1st International Applied Geochemistry Symposium** in Perth, Australia, September 19-23. I encourage all of you to submit abstracts for talks or posters and to help make this meeting a great success. We are also co-sponsoring the **Geological Society of Nevada's** symposium **"Window to the World,"** May 15 - 18, 2005 in Reno, Nevada and the **15th Annual Goldschmidt Conference: "A voyage of discovery,"** to be held May 20-25 in Moscow, Idaho. We need volunteers to help with both of these meetings so please contact me if you are planning to attend.

At the last Council meeting, we unanimously accepted the bid from Jorge Loredo for the 2007 IGES/IAGS to be held in Oviedo, Spain. Thank you Jorge for the excellent proposal. We also passed a motion to make Student Membership only $10. That is an awesome deal. Please help spread the word to every student and Professor you know.

Finally, the Focus Topic of this issue of **EXPLORE** is a departure from previous ones and is a reflection of the broader range of disciplines that utilize applied geochemistry. For those of you who, like myself, are not involved with petroleum exploration, this is an opportunity to consider how applied geochemistry in petroleum exploration may relate to environmental geochemistry or mineral exploration. Are the dispersion processes similar? Could the methods used by petroleum exploration geologists be used in other areas

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of earth science or could they be modified to be useful? Clearly there is significant overlap in the realm of soil gas and some aspects of soil geochemistry. I suspect that reading this literature and others like it will spark new ideas about how to approach geochemistry in our own fields.

May 2005 be a great year for all of you and I hope to see you at one of the meetings.

Sincerely,

David Kelley
WMC Exploration
8008 E. Arapahoe Ct, #110
Englewood, CO
80112 USA
Tel: 720-554-8318
dave.kelley@wmc.com

Table 1 – Meetings attended by 13% of the AAG membership in 2003-2004.

Mining and Exploration – 33%
Australasian Institute of Mining and Metallurgy New Zealand Branch
Alaska Miners Association
Association of Mineral Exploration of Quebec
Association of Mining and Exploration Companies
American Society for Mining and Reclamation
Controversies in Geodynamics & Ore Genesis
Canadian Institute of Mining, Metallurgy and Petroleum
Mining and Metallurgical Research Center
Center for Ore Deposits Research - 24 ct Au Workshop
CRC LEME/AMEC - Minerals Exploration Seminar
Diggers and Dealers
Explorers Conference, Western Australia
Fennoscandian Exploration & Mining Conference
Gold Conference
Georange
Kimberlite Conference
Mining & Environment III
Mining Conference, Western Australia
Manitoba Mining & Minerals Convention
Northwest Miners Association
PACRIM - Australasian Institute Mining & Metallurgy
Paydirt Conference
Prospectors & Developers Convention
Pit Lakes
ProExplo
Roundup
Society of Economic Geologists
Society of Mining Engineering
Society for Geology Applied to Mineral Deposits Biennial Meeting
Uranium Conference
General Earth Science – 24%
American Association for the Advancement of Science, Pacific Division
American Association of State Geologists Central States Cluster Meeting
Atlantic Geological Society Annual Meeting
Association of Women Geoscientists Conference
Canadian Quaternary Association-Canadian Geomorphology Research Group
CRC LEME - Advances in Regolith Symposium
Canadian Society of Petrology and Geology Workshop
Geological Association of Canada
Geological Association of Canada-Mineralogical Association of Canada
German Mineralogical Society
Geological Society of America
Geological Society of Australia Conference
Geological Society of Nevada (Reno)
International Volcanological Congress
International Geological Congress
Institute on Lake Superior Geology, Iron Mountain, MI
Nordic Geological Winter Meeting
Soil Science Society of America Annual Meeting
Tobacco Root Geological Society Conference
Peruvian Geological Congress
Chilean Geological Congress
Yellowknife Geoscience Forum, Yellowknife, NT
Environmental – 21%
West Virginia Task force on Acid Mine Drainage
Evaluating the Impact of Mining on the Environment
Diffuse Pollution Conference
Environmental Problems of Cities, Serbia
Global Geochemical Baselines for Environmental Management in India
Radioelement Mapping and Status of the Global Radioelement Baseline Maps
International Association of Hydrologist
International Association of Hydrological Sciences/International Commission on Continental Erosion
International Conference on Acid Rock Drainage
International Conference on Radioactive Waste Management and Environmental Remediation
International Conference on Oxidation and Reduction Technologies for In-Situ Treatment of Soil and Groundwater
International Symposium on Environmental Geochemistry
International Symposium on Permeable Reactive Barriers
International Symposium on Water-Rock Interaction
International Symposium on Conditioning of Radioactive Operational and Decommissioning Wastes
National Ground Water Association
Asia Pacific Symposium on Environmental Geochemistry
Wildland Fire Impacts on Watersheds (GSA Special Conference)
Symposium on Water-Rock Interaction
Energy – 4%
American Association of Petroleum Geologists
Coal Combustion Byproduct Symposium
Nevada Petroleum Society
Rocky Mountain Association of Geologists

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Biological Sciences – 4%
Annual Epidemiologic Research Exchange
Geochemical Ecology and Biogeochemical Study of Biosphere Toxins
Medical Geology
Natural Science and Public Health

Geophysics – 3%
American Geophysical Union Annual Meeting
International Union of Geophysics and Geodesy
National Geophysical Research Institute

Geochemistry – 2%
Goldschmidt
International Geochemical Exploration Symposium

Chemistry – 2%
American Chemical Society Annual Meeting
Canadian Chemistry Conference

Other – 7%
Association for the History of Glass
Computer Aided Exploration Techniques
Historical Metallurgical Society
International Association of Mathematical Geology
Investors Conference
Middle Atlantic Archaeological Conference

Queen's
UNIVERSITY

Canada Research Chair Tier 2 — Geochemistry

The Department of Geological Sciences and Geological Engineering, Queen's University, one of Canada's oldest and best-known earth-science departments, seeks exceptional researchers to apply for a Tier 2 Canada Research Chair in the field of Earth System Science, with a focus on the geochemical processes that take place on or within the Earth. Areas of specific interest are: rock-forming processes in the lithosphere, the origin of mineral deposits, biogeochemistry, sedimentary geochemistry, and the origin/diagenesis of bio-chemical sediments. The successful candidate must be within 10 years of receipt of their Ph.D. and have an outstanding research record in order to fulfil the criteria for Tier 2 Canada Research Chairs (see www.chairs.gc.ca/web/program/nominate_e.asp). It is expected that the Chair holder will supervise graduate students at the M.Sc. and Ph.D. levels, contribute actively to undergraduate and graduate teaching, undertake vigorous externally funded research, and collaborate with departmental colleagues. The department has faculty with a wide range of expertise and emphasizes the linkage between field and laboratory-based research and teaching. Its labs include state-of-the-art geochemical facilities. For more information about the Department, visit www.geol.queensu.ca .

The University invites applications from all qualified individuals. Queen's is committed to employment equity and diversity in the workplace and welcomes applications from women, visible minorities, aboriginal people, persons with disabilities, and persons of any sexual orientation or gender identity. All qualified candidates are encouraged to apply; however, Canadian citizens and Permanent Residents will be given priority. The academic staff at Queen's University is governed by a collective agreement, the details of which are posted at http://www.queensu.ca/qufa. In accordance with the Queen's guidelines for the assignment of Canada Research Chairs, applications from qualified women are particularly encouraged for this position.

Applicants should send a current curriculum vitae, a statement of research interests and future plans, a statement of teaching experience and interests, and samples of research writing to the following address. Individuals who intend to apply should provide to the undersigned, as soon as possible, the names and addresses of five persons of international standing who have agreed to provide letters of reference. Doctoral and/or post-doctoral supervisor(s) may be included. Review of complete applications will begin on January 24, 2005.

Robert W. Dalrymple, Head,
Department of Geological Sciences and Geological Engineering,
Queen's University,
Kingston, ON K7L 3N6, Canada
Telephone: 613-533-2598
Fax: 613-533-6592
E-mail: zarichny@geol.queensu.ca

Annual General Meeting of the Association of Applied Geochemists

Minutes of the Annual General Meeting of the Association of Applied Geochemists held on September 29, 2004 in Perth, W.A. during the SEG meeting
Meeting called to order by President David Kelley.
Minutes taken by M. Doherty (for D. Smith).

1. Quorum established with approximately 25 in attendance, 20 fellows.
2. Minutes of the last AGM accepted (N. Radford/W. Coker)
3. Secretary's report presented by G. Hall (for B. Arseneault). Name change for the association to AAG is completed. Email address change to be investigated further.
4. President's report (D. Kelley)
   a. The President's term has changed to 2-years, so D. Kelley will hold office for 2004-2005.
   b. AAG By-Laws were accepted in Canada, concluding the legal process required to change the name from *Association of Exploration Geochemists* (AEG) to *Association of Applied Geochemists* (AAG).
   c. The organization publishing the journal "Applied Geochemistry" has changed their name to "International Association of Geochemistry," with their journal retaining the same name. Some discussions were held concerning a potential merger which was decided against and no further action is planned.
   d. A Geochemistry Course of 3-week duration is being conducted in China with ~15 students. Cliff Stanley was expected to attend and provide some lectures.
   e. It was proposed to conduct a 1-week basic exploration geochemistry course for junior geoscientists around the IGES Perth 2005 meeting. General discussion ensued about the possibility of AAG sponsoring more short courses at various meetings and University sites.
   f. Sponsorship of students at the IGES 2005 and of people from developing nations was discussed.
   g. A recommendation was made to council that the Student Membership fee be lowered to $5 – 10. Motion proposed (Mazzuchelli / Gray) and passed.
   h. Scholarship funds were discussed. The Colorado School of Mines fund (S. Cone Memorial) requires an additional $7000 funding to become a permanent scholarship fund. If this goal is not reached, the funds would be used to fund students over 5 years or until the fund is depleted.
   i. Recommendation was made (M. Doherty, R. Smith) that *easy* guidelines be developed to allow people to leave funds to the Association from their inheritance.
   j. Plans for 2005 include a push for new members, with a goal of expanding from the current 540 to 700-750 total members.
5. Treasurers Report (G. Hall)
   a. Association funds at C$433,000., the same as last year, and down from C$600,000 5 years ago.
   b. There is no longer any royally received from Elsevier.
   c. E. Cameron is meeting with the investment group to evaluate their costs and investment strategy.
6. Journal Report, GEEA (G. Hall)
   a. GEEA production cost the association C$10,000 last year.
   b. 50% of next year issues planned as special issues. In 2005 these will include the conference proceedings from IGES 2003 Dublin, and the conference proceedings from the Edinburough 2003 meeting.
   c. Regular issue papers slow in arriving.
   d. GeoSoc is doing well and expanding their advertising of the Journal. Digital subscriptions are expected to increase.
   e. Library subscriptions still very low (<100)
   f. Still would like to see more publicity for GEEA.
7. **EXPLORE** Newsletter Report, M. Doherty (for Chris Benn)
   a. Chris Benn continues with editorship and will maintain individual theme issues.
   b. Next issue of Explore in progress, focus on Environmental Geochemistry
8. Symposium Update
   a. Second flier for IGES 2005 Perth has been sent out and was included with the conference literature for the SEG2004 meeting.
   b. AAG will be a co-sponsor of the Goldschmidt conference (Idaho)
   c. AAG will also co-sponsor the GSN 2005 meeting (Nevada), exchanging advertisement for the meeting for a free booth.
   d. A proposal for IGES 2007 (May) was received from geoscientists in Spain.
   e. Discussion was held concerning potential activities at the Exploratioon2007 meeting Toronto (September) Ideas included possibility of a short course and/or sponsoring a session within the meeting.
   f. IGES2003 Dublin was a loss of approximately $6000 to AAG.
9. Councilor elections will be approaching and interested parties were asked to submit their names to D. Smith, Secretary.
10. Meeting adjourned.

Call to Action for Exploration Geochemists

The Society of Economic Geologists recently held its international conference on “Predictive Mineral Discovery Under Cover” in Perth, Western Australia. A very obvious link between several of the keynote addresses on the first day was that, given current understanding, near-surface geochemistry (read soil sampling) has little or nothing to offer mineral explorers in our quest to find new mineral deposits below both pre- and post-mineralisation cover. Happily the AAG was strongly represented in subsequent sessions and excellent papers by Gwendy Hall and Dave Kelley demonstrated that in some circumstances soil sampling can ‘see through cover.’ Paul Agnew’s presentation demonstrated that there is still a lot to find in areas of little or no cover, even from variable quality public domain data sets.

But the perception is clearly widely held that near-surface geochemistry cannot see through even quite thin cover. Some of us are pretty certain that it does, but we know too little of how these signals get to surface to make our science predictive. The next IGES (19 to 23 September 2005) will be held in Perth, Western Australia (see www.promaco.com.au/conference/2005/iges) and a full day session is being devoted to ***“Geochemical Exploration’s Brave New World. Seeing through transported overburden, mechanisms of metal mobility.”*** If we are to dispel the perception that geochemistry has no role to play in predictive exploration through cover, we must use this session to see where we are, and decide where we need to go to, how to get there and how to tell our colleagues what the score is.

Gwendy Hall has already agreed to be Keynote speaker for this session. Gerry Govett has agreed to chair at least part of it. Let’s make it a really defining event and dispel the myth that geochemistry has had its day!

Nigel Radford.
Joint Chair, committee organising the 22nd IGES.

AAG New Distinguished Lecturer

Stew Hamilton will follow in Cliff Stanley’s huge footsteps in becoming the AAG’s next Distinguished Lecturer for 2005-2006. Stew starts his stint of duty in January with a visit to Elko, Nevada and Golden, Colorado.

Change in Student Membership Fees

For persons who are enrolled as full-time students in a pure or applied science program at a recognized University or School of Mining. Membership fee: $10.00 US

Request for Promotional Photos from the New Membership Committee

The New Membership Committee is looking for promotional photographs that can be used to help attract new members and photos that illustrate any aspect of membership benefits or show some of the interesting and fun activities that geochemists are involved in. This could include AAG field trips, meeting venues, social activities, lecturers, sampling, or just about anything else that conjures up the excitement of practising geochemistry and being a part of the AAG.

The photos should be forwarded to Robert Jackson at rgjackson@eastlink.ca with a short description of the photo. They will be used in posters and Powerpoint presentations that describe what the AAG is all about and the benefits derived from membership. The professional activities photos will be used to help attract the interest of students in our discipline.

The AAG is initiating a membership drive for 2005. The organization is looking for any individuals who are willing to make a short presentation to any group in their local area that may be a source of new members. The occasion could be a conference, a geologic discussion group meeting, or a university lecture in geochemistry, or any other gathering you can think of. The slide presentation describes the aims of the association, membership information, structure of the organization, publications, Web site, Distinguished Lecturer series, and past and upcoming symposia. It can be made available on request together with membership applications. Presenters can pick and choose amongst the illustrations to focus on relevant material given the interests of the target group and the time available.

Interested individuals should again contact Robert Jackson. The AAG needs everyone’s help to promote the growth of the organization. Please identify an opportunity to speak proudly of what the AAG means to our profession and the benefits that accrue from membership.

New Members

The following applications were reviewed by the Admissions Committee and approved by Council.

Regular Memberships

Mr. Barrie Bolton, Membership #3819
Ok Tedi Mining Ltd., Environmental Dept.
PO Box 535, Hamilton Central
QLD, Australia 4007

Helen W. Folger, Membership #3821
Research Geologist, US Geological Survey
954 National Center, Reston, VA USA 20192

Mr. Phillip C. Larson, Membership #3822
Consulting Geologist, 9540 Morningside Loop, #103
Anchorage, AK USA 99515

Student Membership:

Mr. Ryan R.P. Noble, Membership #3820
PhD Candidate, Curtin University of Tech.
5 Boundary Rd., St. James, WA AUSTRALIA 6102

CALENDAR OF EVENTS

International, national, and regional meetings of interest to colleagues working in exploration, environmental and other areas of applied geochemistry.

- January 24-27, 2005 BCYCM – Mineral Exploration RoundUp 2005, Vancouver, BC www.chamberofmines.bc.ca/eventcalendar.htm
- February 28-March 2, 2005, 2005 **SME Annual Meeting and Exhibit,** Denver, CO. INFORMATION: Meetings Department at 800-763-3132 or 303-973-9550. http://www.smenet.org/meetings/calendar event_calendar.cfm
- March 6-9 Prospectors and Developers Association of Canada (PDAC) 2005, Toronto, Ontario, Canada. www.cim.org/mce/toronto2005/
- April 11-21, 2005. **Modular Course in Exploration for Hydrothermal Ore Deposits** , Sudbury, Ontario, Canada. Information: contact Harold Gibson, Mineral Exploration Research Centre, Department of Earth Sciences, Laurentian University, Ramsey Lake Road, Sudbury, ON, Canada, P3E 2C6; Ph. +1.705.675.1151 x2364, Fax. +1.705,675.4898, email: hgibson@laurentian.ca, web: http://earthsciences.laurentian.ca.
- April 3rd-7th **8th International Conference on Biogeochemistry of Trace Elements (ICOBTE),** Adelaide
- April 24-29, 2005 **2nd General Assembly of the European Geosciences Union (EGU 2005)** Vienna, Austria http://www.copernicus.org/EGU/ga/egu05/index.htm
- April 24th-27th Canadian Institure of Mining & Metallurgy **CIM-AGM Toronto 2005**. www.cim.org/mce/toronto2005/
- May 15 through May 18, 2005, **Geological Society of Nevada Symposium 2005** Sparks, Nevada USA, INFORMATION: Geological Society of Nevada (gsnsymp@unr.edu)
- May 20-25, 2005 **15th Annual Goldschmidt Conference –** A Voyage of Discovery. University of Idaho, Moscow, Idaho, USA email gold2005@uidaho.edu. http://www.uidaho.edu/gold2005
- August 8-11, 2005 **Earth System** Processes 2, Co-covened by Geological Association of Canada and GSA, Calgary, Alberta, Canada. http://www.geosociety.org/meetings
- August 29-2 September **STOMP 2005 –** International Conference on Structure, Tectonics and Ore Mineralization Processes. Townsville, Australia. Email Stewart.Parker@jcu.edu.au. Website www.es.jcu.edu.au.
- August 30-September 13, 2005. **Modular Course in Structure, Tectonics, and Mineral Exploration** , Sudbury, Ontario, Canada. Information: contact Bruno Lafrance, Mineral Exploration Research Centre, Department of Earth Sciences, Laurentian University, Ramsey Lake Road, Sudbury, ON, Canada, P3E 2C6; Ph. +1.705.675.1151 x2364, Fax. +1.705,675.4898, email: blafrance@laurentian.ca, web: http://earthsciences.laurentian.ca.
- September 5-19 2005 **GEOCHIM 2005**, Prague, Email **pasava@cgu.cz or masek@cgu.cz**
- September 19-23 2005 **22nd IGES** Perth Western Australia – see this EXPLORE . www.aeg.org
- October 25-November 5, 2005, **10th Brazilian Geochemical Congress and 2nd Geochemical Symposium of the Mercosul Countries,** Porto de Galinhas, Recife, Brazil (Dr. Valderez P. Ferreira, President, Dept of Geology, UFPE – Universidade Federal de Pernambuco, POBox 7852 CEP 50670-000, Cidade Universitaria, Recife, PE, Brazil, Phone/Fax (55)-81-2126.8242, Email: valderez@ufpe.br Web: www.ufpe.br/xcbgq).
- December 8-17, 2005. **Modular Course in Exploration Geophysics**, Sudbury, Ontario, Canada. Information: contact Michael Lesher, Mineral Exploration Research Centre, Department of Earth Sciences, Laurentian University, 933 Ramsey Lake Road, Sudbury, ON, Canada, P3E 6B5; Ph. +1.705.675.1151 x2364, Fax. +1.705.675.4898, email: mlesher@laurentian.ca, web: http://earthsciences.laurentian.ca.
- April 5-16, 2006. **Modular Course in Exploration for Magmatic Ore Deposits**, Sudbury, Ontario, Canada. Information: contact Michael Lesher, Mineral Exploration Research Centre, Department of Earth Sciences, Laurentian University, 933 Ramsey Lake Road, Sudbury, ON, Canada, P3E 6B5; Ph. +1.705.675.1151 x2364, Fax. +1.705.675.4898, email: mlesher@laurentian.ca, web: http://earthsciences.laurentian.ca.

Please check this calendar before scheduling a meeting to avoid overlap problems. Let this column know of your events.

Chris Benn
BHP Billiton
2400/1111 West Georgia St
Vancouver V6E 4M3 BC Canada
TEL: 604 632 1493 FAX: 604-683 4125
e-mail: Chris.Benn@bhpbilliton.com

Coming soon in the AAG **EXPLORE** newsletter:

Technical articles and letters to the editor are encouraged as submissions for discussion within the newsletter. Each issue of **EXPLORE** contains a series of short discussion papers which provide either an update on a particular geochemical topic, or present current debates about issues of interest. Suggestions for future "Focus" topics may be forwarded to the editor,

Chris Benn (Email: Chris.Benn@BHPBilliton.com)

Issue:	**Focus topic and Contact:**	
127	Regional Geochemical Surveys	
	Contributor Deadline	February 28, 2005
	Publication Date:	April 2005
128	Geochemical Data Processing	
	Contributor Deadline	June 30, 2005
	Publication Date:	August 2005

Geochim
postgraduate course

Organized by the Czech Geological Survey, Prague
and
Society for Geology Applied to Mineral Deposits (SGA)
with the support of UNESCO
Prague and Dolní Rozínka, Czech Republic
September 5-19, 2005

Aims of the course

Certificated postgraduate course aims at providing knowledge of important geochemical methods widely used in the prospecting for ore deposits and at showing their applications in the solution of environmental problems. Individual lectures covering various geochemical methods will be accompanied by practical field and also computer training. The course will be followed by a 3 day field trip visiting ongoing open and underground mining operations and processing plants as well as abandoned mining sites with the aim to demonstrate possible ways of effective usage of geochemical methods in both exploration and environmental issues.

Contents of the course

Principles of exploration and environmental geochemistry, exploration and environmental applications of soil geochemistry, stream sediments, heavy minerals, biogeochemical, lithogeochemical, hydrogeochemical, geophysical and radiometric studies with practical field and computer training.

Language of the course

The official language of the course will be English.

Other information considered relevant to the course

For technical reasons, the number of participants has to be restricted to 15 persons. Tuition fees including the cost of printed handouts is USD 100 for university postgraduate students, USD 200 for personnel from state agencies such as geological surveys and USD 400 for staff members of private companies. The organizers will cover accommodation, travelling and meals during the course so that no per diems are provided. International travelling to Prague is not included. A diploma will be awarded to each successful participant.

Insurance

No travel insurance will be organized for any of the course participants. All participants are reminded that they should organize their own personal insurance for all aspects of the course and field excursions. The organizers shall accept no responsibility whatsoever for any damage, loss, personal injury or death suffered by any participant during the course and associated field excursions.

Place

Prague (2 days), Dolní Ro•ínka - Hotel Duo (40 km North of Brno).

Duration 5 - 19. September 2005

Application procedure

Applicants must have a good knowledge of English and the fundamentals of geochemistry. A BSc degree or equivalent is the minimum requirement.

The application form together with a short CV should be sent to organizers not later than March 15, 2005.

Letter of acceptance with detailed programme, travel and payment instructions will be sent to selected applicants during May 2005.

Deadline for application: March 15, 2005

Contact address:
GEOCHIM 2005
Dr. Jan Pašava
Czech Geological Survey, Geologická 6
152 00 Prague 5 - Barrandov
phone: +420-2-51085506; fax:+420-2-51818748
e-mail: pasava@cgu.cz or masek@cgu.cz

GEOCHIM 2005
Training Course in Geochemical Exploration Methods and their Environmental Applications
Prague and Dolní Ro•ínka, Czech Republic
September 5-19, 2005

APPLICATION FORM

Name: ____________________

Surname: ____________________

Date of birth: ____________________

Passport number: ____________________

Obtained degree(s): ____________________

Present position: ____________________

Institution: ____________________

Contact Address: ____________________

____

Phone: ____________________

Fax: ____________________

E-Mail: ____________________

Home address: ____________________

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Male/Female (please tick): Male ☐ Female ☐

Date: Signature:

Return by March 15, 2005

RECENT PAPERS

This list comprises titles that have appeared in major publications since the compilation in **EXPLORE** Number 125. Journals routinely covered and abbreviations used are as follows: Economic Geology (EG); Geochimica 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.): Applied Earth Sciences (formerly 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, not to **EXPLORE**.

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Anon., 2004. The Gondwana Metal-Potential GIS: A Georama Interactive CD-ROM of Geology and Mineral Deposits of Gondwana. BRGM (France) and CIGCES - University of Capetown (South Africa). CD-ROM.

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Armienta, M.A., et al., 2003. Environmental behavior of metals from tailings in shallow rivers: Taxco, central Mexico. Applied Earth Sci. 113(1): 76-82.

Bao, Z., Zhao, Z., Guha, J., and Williams-Jones, A.E., 2004. HFSE, REE, and PGE geochemistry of three sedimentary rock-hosted disseminated gold deposits in southwestern Guizhou Province, China. Geochem. J. 38(4): 363-372.

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Corbett, G., 2004. Epithermal and Porphyry Gold – Geological Models. AusIMM Bull. Nov./Dec.: 33-44.

Cossio, S., Noyoba, J.L., Gonzalez, P., and Espinosa, R., 2004. Sampling and assaying of coarse gold at La Herradura-Minera Penmont S. de R.L. de C.V. Mexico (Abst.). CIM Bull. 97(1084): 72.

Craw, D., Wilson, N., and Ashley, P.M., 2003. Geochemical controls on the environmental mobility of Sb and As at mesothermal antimony and gold deposits. Applied Earth Sci. 113(1): 3-10.

Dove, P.M., De Yoreo, J.J., and Weiner, S., 2003. Biomineralization. Rev. Min. and Geochem. V. 54. 381 p.

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Focus on: Regional Geochemical Tool Targets ... *continued from page 4*

- ☐ Differentiate between oil and gas
- ☐ Define areas for leasing and seismic surveys
- ☐ High grade seismic anomalies
- ☐ Find traps invisible to seismic surveys
- ☐ Identify by-passed pay
- ☐ Define structural trends

The methods cannot, however, provide information about reservoir depth or quality. In addition, interpretation is made difficult in under-pressured basins with stacked pays. These are by no means “stand alone” techniques, but they can help reduce risk when used properly in conjunction with geology and geophysical methods. A multi-component approach to geochemical exploration is therefore preferred to reduce risk and maximize rewards. Orientation surveys should be performed prior to any regional survey to select optimum sample media and analytical methods for a particular play or basin. In other words, one might consider testing the effectiveness of several sample media, sample spacings and analytical methods over existing production to select optimum methods for the larger survey.

Geology and Gas Production in the Study Area

Black River hydrothermal dolomite reservoirs in the study area range in depth from 9,000 to 10,000 feet. These narrow, east-northeast trending reservoirs reflect the channeling of hydrothermal fluids along zones of extension in Late Paleozoic time. Extension and dolomitization could have occurred along pre-existing faults during early Paleozoic rifting. The hydrocarbons were probably derived from interbedded Ordovician source rocks.

The reservoirs in the study area produce significant amounts of gas on an annual basis and production rates for individual wells vary from 0.4 to 19 mmcf/d (Figs. 2 and 3). As of 2002, the most productive fields were Wilson Hollow, Quackenbush Hill, Terry Hill South and Cutler Creek (Fig. 2). Recent production data are unavailable, but presumably Quackenbush Hill is now outperforming the older Wilson Hollow and Terry Hill South Fields. The dry gas produced is uniform in composition between fields, and it consists mainly of methane with minor C_2-C_5 hydrocarbons, CO_2 and N_2 (Table 1).

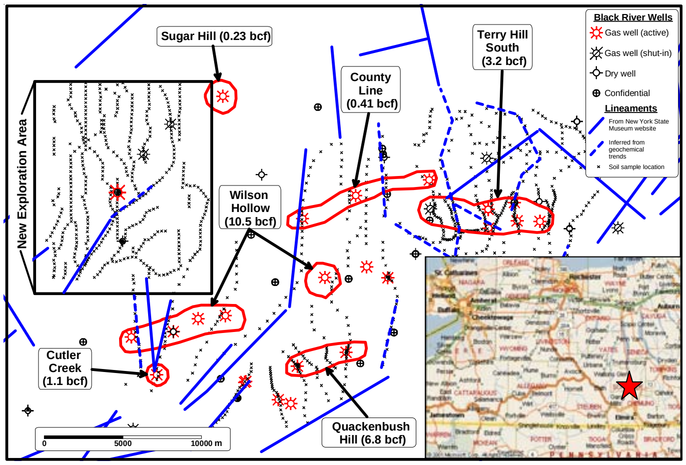

Figure 2. Map which shows location of the study area and distribution of gas fields, wells, lineaments and soil sample locations. Production data for each field represents annual production for the year 2002. These data were obtained from the New York State Museum website.

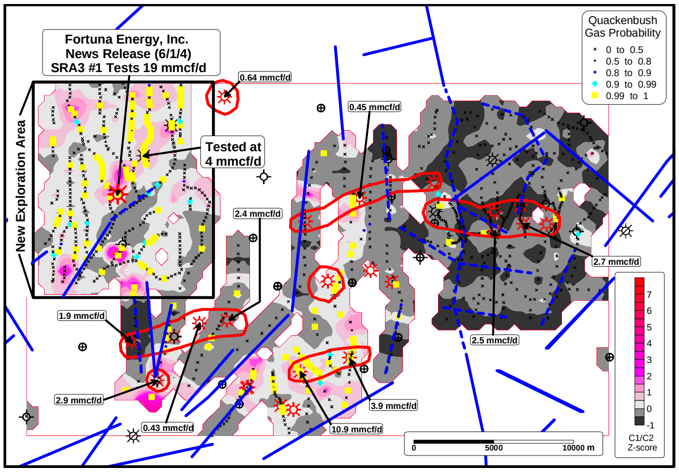

Figure 3. Quackenbush gas probability superimposed on the C1/C2 ratio Z-score. The gas probability was derived through discriminant analysis of C1-C6 hydrocarbon data using the samples collected around Quackenbush gas wells and dry wells. Note that the well drilled by Fortuna Energy, Inc. in the new exploration area is correctly predicted by the discriminant probabilities and anomalous C1/C2 ratio. Production rates for wells outside of the new exploration area are for the year 2002, and these were obtained from the New York State Museum website.

Component	Mol%
Methane	97.97
Ethane	0.45
Propane	0.05
I-Butane	0.15
N-Butane	0.13
I-Pentane	0.02
N-Pentane	< 0.01
Hexanes+	< 0.02
Nitrogen	1.07
CO_2	0.16

Table 1. Produced gas composition from the Rice 1301 well in the Wilson Hollow Field (Courtesy of Fortuna Energy, Inc.)

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Focus on: Regional Geochemical Tool Targets ...

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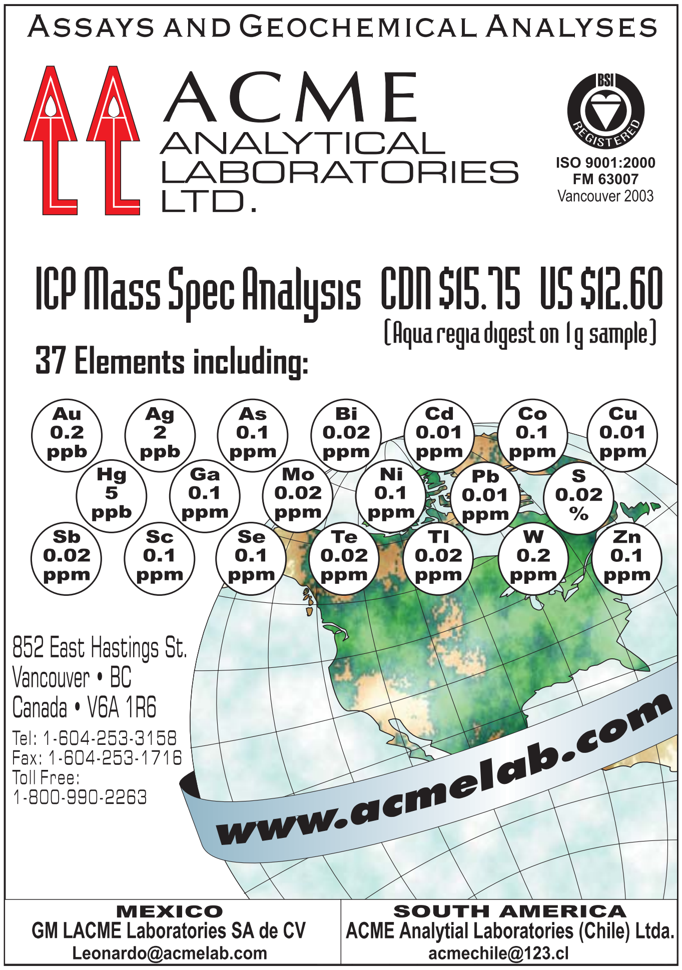
Sample Collection

Soils were chosen as the preferred sample medium in the NYSERDA study because of uniform parent material in the area (99% basal till), ease of collection, ability to evaluate both alteration and hydrocarbon sorption in soils over Black River gas fields, and minimal impact on landowners (Fig. 1, see page 4). The field geologists were careful to collect soils that are consistent in terms of horizon, color and texture. Care is taken when collecting samples to avoid contaminating the soils with hydrocarbons or metals. The soils were collected from 8 to 12"-depth with a tree-planting shovel and stored in teflon-sealed glass jars for transport to the laboratory. Sample site locations were recorded using Global Positioning System (GPS) satellites and field notes were taken at each site.

One of the difficulties commonly encountered in geochemical surveys is that sample intervals are inadequate to resolve anomalies. The sample interval chosen is based on the size of the target such that two consecutive anomalies can be realized over the area of interest. For this study, a total of 1265 soils were collected over an area of approximately 500 km^2 at intervals of 100 to 500 m (Figure 2). Of the 1265 samples collected, 669 (53%) were along public roads that cross gas fields, 394 (31%) were from the new exploration area (blind test), 130 (10%) were samples around productive gas wells, and 72 (6%) were samples around dry wells.



Sample Preparation and Analysis

Soils were dried at low temperature in a temperature-controlled oven to avoid altering mineralogy, which can increase variability in hydrocarbon and elemental concentrations. The samples were sieved to a fine-grain size fraction through stainless steel screens and aliquots of sample were then weighed out for hydrocarbon, elemental, pH and conductivity analyses.

For hydrocarbon data, soils are thermally desorbed using a proprietary technique developed by Direct Geochemical. The desorbed gases are injected into a gas chromatograph with a flame ionization detector (GC-FID) for analysis of C_1-C_6 hydrocarbons. Detection limits are at low parts per billion levels.

For the elemental analysis, the sieved soil is digested in concentrated nitric acid and the supernatant is then filtered and analyzed for 26 major and trace elements by Inductively Coupled Plasma Emission Spectroscopy (ICP-ES). The pH and conductivity of a 1:1 soil slurry was estimated with probes and pH and conductivity meters. Internal standards, duplicates and blanks are analyzed within batches as quality control checks. The precision of the hydrocarbon, elemental, pH and conductivity analyses is better than ±10% at the 95% confidence level.

Interpretation and Mapping

Multivariate statistical techniques were applied to attempt to discriminate between productive and non-productive areas using samples collected around gas and dry wells as a training set. These techniques measure the covariance of several variables in multidimensional space simultaneously. For example, several hydrocarbons may correlate over productive areas as opposed to dry areas allowing for the distinction between favorable and unfavorable exploration targets. Development of a discriminant model allows the classification of samples from an unknown area into "productive or non-productive" categories based on the probability of a sample belonging to either category. In addition to multivariate analysis, several hydrocarbon ratios were examined to evaluate the "dryness and wetness" of the seeping gases. Both the hydrocarbon and elemental data were converted to "Z-scores" so as to better assess anomaly contrast. These scores are calculated by subtraction of the sample mean from individual values and division by the sample standard deviation. The data are then reduced to a mean of zero, and anomalies are represented as standard deviations (1, 2, …etc.) above the mean. The hydrocarbon, elemental, pH and conductivity data are displayed using unbiased computer contour and proportional symbol mapping techniques.

Results of the Geochemical Survey

The results of the study are very encouraging in that the shallow surface geochemical methods tested are capable of:

(1) Outlining areas with high Black River gas potential.

(2) Mapping faults that intersect and possibly breach gas reservoirs.

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Focus on: Regional Geochemical Tool Targets ...

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Four anomaly types have been recognized in the study area (Table 2). In general, there is more methane relative to ethane (C1/C2 ratio is a measure of gas dryness) in soils over Quackenbush Hill, Cutler Creek, and sporadic parts of Wilson Hollow, County Line, and Terry Hill South (Fig. 3). When Quackenbush gas probabilities are superimposed on the C1/C2 ratio there is significant correspondence (Fig. 3). A post-survey well (SRA3 #1) intersected significant gas production (19 mmcf/d) where anomalous gas probabilities are correlated with the dry gas ratio in the new exploration area (Fig. 3). In addition to the dryness ratio, other variables that contribute to the discrimination of gas and dry reservoirs are ethene, isobutane, isopentane and, to a lesser degree, propane. Factor scores show the spatial distribution of samples with a strong correlation between ethene, isobutane and isopentane in the study area. This hydrocarbon association is anomalous over all or parts of all gas fields in the study area (Fig. 4). Propane is particularly anomalous over the highly charged Quackenbush Field and around the new SRA3 #1 discovery well (Fig. 5). Anomalously low dryness ratios are evident over mapped and inferred

Table 2. Hydrocarbon and Elemental Anomalies Identified in the Study Area

	2002 Production (bcf)	Ethene-iC4-iC5 factor scores	Dryness Ratio (C1/C2)	% Propane	Ethane/ ethene, Ca, Mg, Sr, Pb, Zn, Tl
Quackenbush Hill	6.8	✓	✓	✓	None
New Discovery (SRA3 #1)	Not producing yet	✓	✓	✓	None
Cutler Creek	1.1	✓	✓	✓	None
Wilson Hollow	10.5	✓	Sporadic	None	✓
Terry Hill South	3.2	✓	Sporadic	Sporadic	✓
County Line	0.4	✓	Sporadic	Sporadic	✓

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News of Members

Mary Doherty has accepted a position as U.S. Manager for ALS Chemex based in Reno Nevada. She will be managing the ALS Chemex labs in Elko, Reno and Winnemucca, Nevada as well as Fairbanks Alaska. As a geochemist and former exploration and mine geologist she will be providing geochemistry and sample advice to ALS Chemex clients. She can be reached at Mary.Doherty @alschemex.com, Mobile (775) 830-7943.

Focus on: Regional Geochemical Tool Targets ...

continued from page 15

lineaments, particularly in the eastern half of the study area (Fig. 3).

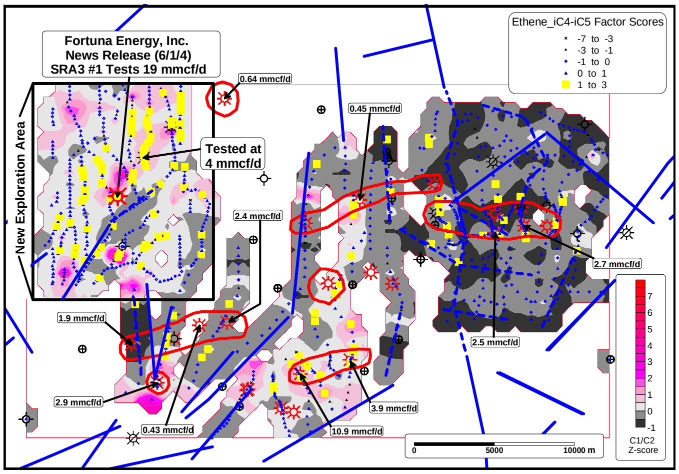

Figure 4. Ethene_iC4-iC5 factor scores superimposed on the C1/C2 ratio Z-score.

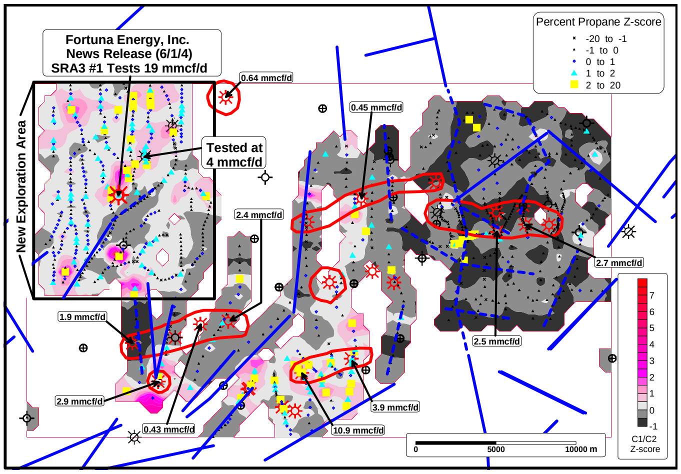

Figure 5. Percent propane Z-score superimposed on the C1/C2 ratio Z-score

Lead in soils, which can be an indicator of Mississippi Valley Type (MVT) mineralization, is antithetic with the C1/C2 ratio, but sympathetic with the ethane/ethene ratio (cf Figs. 5 and 6). Calcium and magnesium show similar anomaly patterns to that of lead, but they are not as widely dispersed (Figs. 7 and 8). Other variables that correlate with the Pb, Ca, Mg association are Sr, Zn, and Tl. This element association shows linear anomaly trends which, in some cases, are aligned with mapped lineaments.

Discussion of Results

Any discussion of the results of this study must take into account:

(1) The linear heavier hydrocarbon/metal anomalies, which are aligned with known lineaments in places.

(2) The variable hydrocarbon signature over fields that produce dry gas of identical composition.

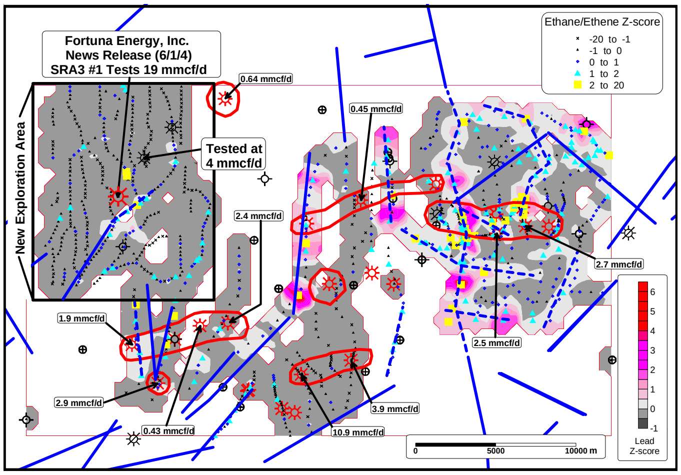

Figure 6. Ethane/ethene ratio Z-score superimposed on the lead Z-score. High ethane/ethene ratios are thought to be indicative of faults because rapid ascent of ethane does not allow adequate time for oxidation to ethene. The correlation of ethane/ethene ratios with lead could reflect the presence of Mississippi Valley Type mineralization along the faults.

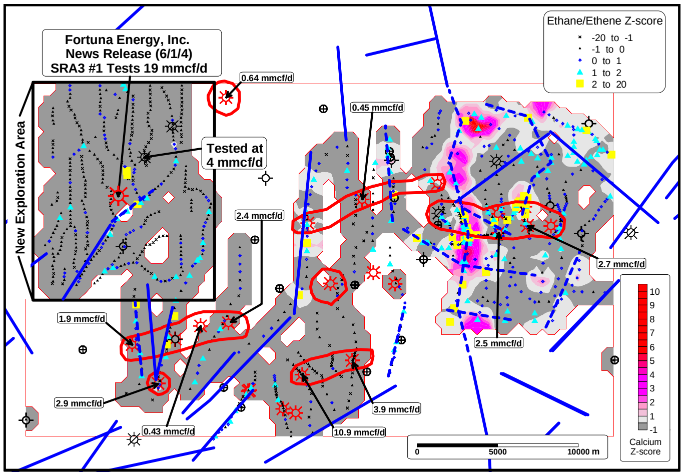

Figure 7. Ethane/ethene ratio Z-score superimposed on the calcium Z-score.

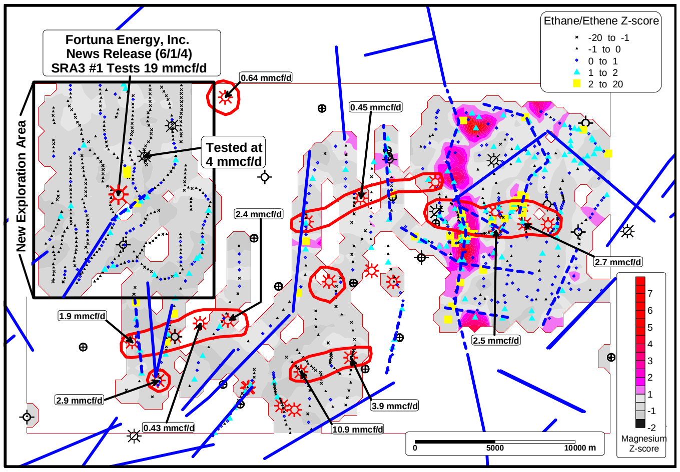

Figure 8. Ethane/ethene ratio Z-score superimposed on the magnesium Z-score.

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Focus on: Regional Geochemical Tool Targets ...

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The linear metal-hydrocarbon anomalies could be explained by deep faults that intersect Black River reservoirs. Evidence that supports the occurrence of these anomalies along deep faults is:

(1) Anomalous ethane/ethene ratios relative to methane suggests rapid ascent of a heavier hydrocarbon to surface along faults such that there is insufficient time for oxidation to ethene. In unfaulted areas, where microseepage of ethane is slower, there is abundant ethene in the soils (i.e. over Quackenbush).

(2) The MVT element association (Ca, Mg, Sr, Pb, Zn, Tl) suggests that the Black River hydrothermal dolomite reservoir has been tapped by a deep fault. There are no dolomites at the surface or in the overlying stratigraphic section to derive such a mineral assemblage.

An interesting observation to note is that the most productive fields in the area (i.e. Quackenbush) do not appear (based on surface lineaments) to be dissected by these types of deep faults, possibly implying that the best reservoirs have not been breached by leaky faults.

All of the hydrocarbons present in the soils over Black River gas reservoirs are also in the produced gas (Table 1). The ethane-iC4-iC5 association is noted in soils above all gas fields, but the dryness ratio (C1/C2) and percent propane are more anomalous over Quackenbush, Cutler Creek and the new SRA3 #1 discovery (Figs. 4 and 5).

Ethene can be produced through biological or chemical oxidation of ethane and other hydrocarbons as it gradually ascends to surface. Isobutane and isopentane, which are present in the produced gas, are also part of this “slow” microseepage association. The dryness ratio (C1/C2) and percent propane anomalies over Quackenbush, Cutler Creek and new gas discovery (SRA3 #1) relative to Wilson Hollow, Terry Hill South and County Line is puzzling, considering that produced gas composition from all fields is nearly identical. Possible reasons for the different hydrocarbon signatures observed in soils over the fields are:

(1) Wilson Hollow, Terry Hill South, and County Line have been breached by deep faults along which heavier hydrocarbons can ascend rapidly. This would explain the heavier hydrocarbons and metals over these fields as opposed to Quackenbush, Cutler Creek and the new discovery that have not been breached by deep faults.

(2) Pressure in the older Wilson Hollow, Terry Hill South and County Line reservoirs may have declined more than Quackenbush, Cutler Creek, and the new discovery because of more production and/or breaching by deep faults. The drop in reservoir pressure may have slowed or curtailed microseepage to the surface such that the dryness ratio and percent propane anomalies have disappeared. The ethane-iC4-iC5 association in soils over all gas fields suggests that this assemblage of hydrocarbons is more stable in soils and can exist for some time after microseepage ceases because of pressure drops related to production and/or breaching by faults.

The explanation for the change in the hydrocarbon signature in soils over compositionally identical reservoirs can be further refined once current production pressures for all gas fields are obtained.

Conclusions

The following conclusions are drawn from this test of surface geochemical methods over deep Black River gas targets in central New York:

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The surface geochemical methods tested are effective in terms of:

(i) Detection of unique microseepage from commercial Black River reservoirs, which will help to pre-screen large areas to focus leasing, seismic and drilling activities. Variables that distinguish gas and dry reservoirs are ethene, isobutane, isopentane, methane and propane. The lack of dryness ratio (C1/C2) and %propane anomalies in soils over some fields might reflect the presence of deep faults that carry heavier hydrocarbons and metals to surface and/or drops in reservoir pressure related to production and breaching by deep faults.

(ii) Mapping of faults that intersect and possibly hinder production from dolomite reservoirs. Indications of these faults are anomalous ethane/ethene ratios relative to methane, Ca, Mg, Sr, Pb, Zn and Tl in soils.

(iii) Minimal impact to landowners because of the rapid, non-invasive nature of the sample collection method.

Soil Geochemistry and Seismic in Southeast Colorado

By Chuck K. Goudge
GrayStone Exploration Labs, Inc, Golden Colorado

Introduction

For more than 70 years geochemists have documented the leakage of low molecular weight hydrocarbons to the surface from underlying accumulations. However, many geologists exploring for oil and gas "traps" still have not been convinced. Even with 3-D seismic surveys documenting gas plumes extending from an accumulation to the surface, geochemical techniques still only attract a small fraction of total exploration dollars.

Soil Surveys

Collecting and measuring the leaking gaseous compounds directly has been the most popular method applied to hydrocarbon exploration geochemistry, and in some environments it is the only possible approach. Exploration techniques exploiting the effects of hydrocarbons on soils, however, are numerous. The quantity of hydrocarbons delivered to a soil over time is substantial and the chemical changes produced in the soil are not minor. Not all prospective oil and gas areas have appropriate soils to utilize these techniques, but if they do, soil changes are an effective way to map hydrocarbon leakage.

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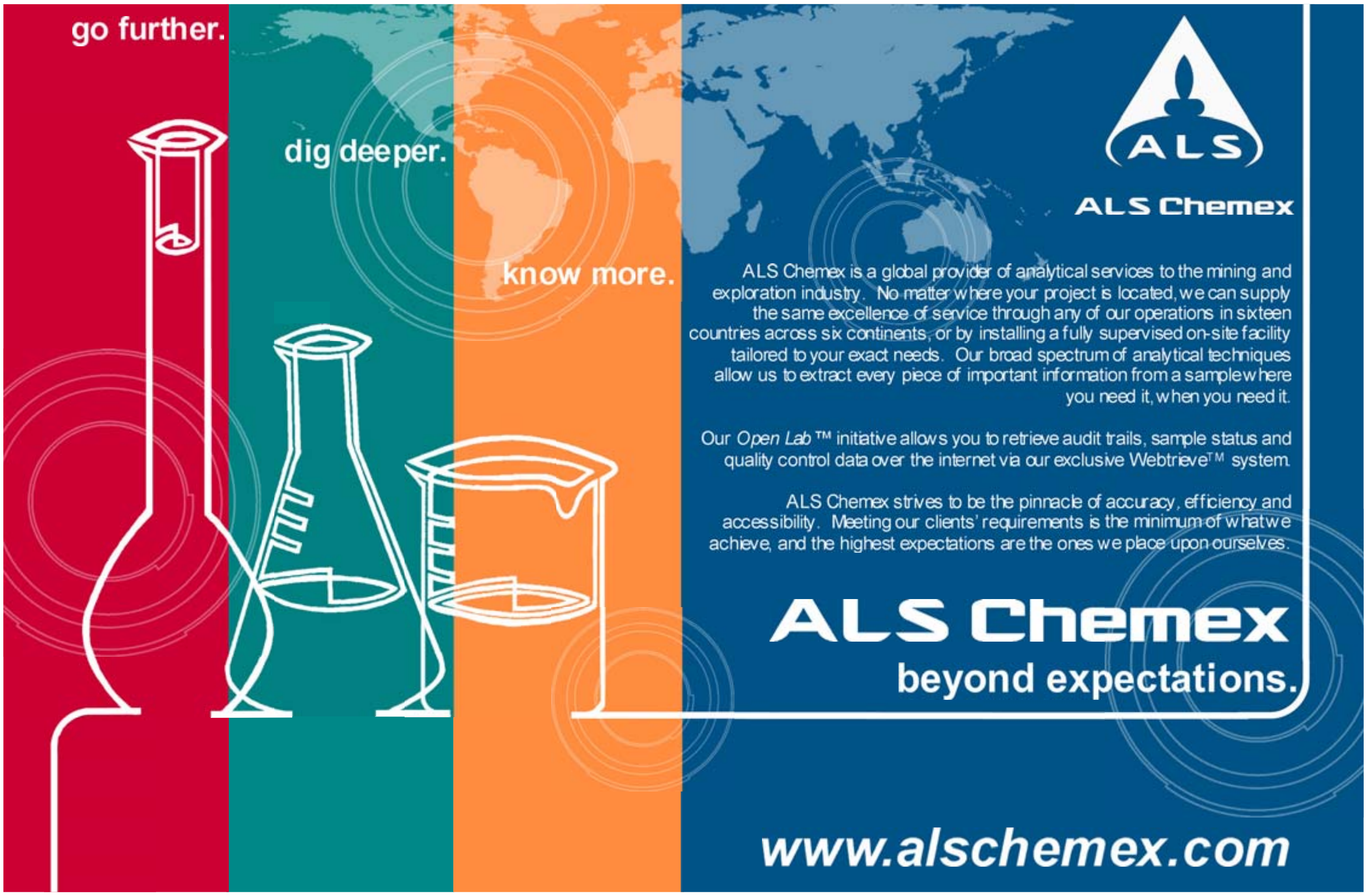

Focus on: Soil Geochemistry and Seismic ... *continued from page 18*

Soil geochemistry spans a large range of techniques, including changes in bulk soil properties, the accumulation of epigenetic compounds, the depletion or accumulation of elements and even the measurement of hydrocarbon-consuming bacteria. Detecting these changes is not an issue, as we are rarely, if ever, stretching the limits of analytical chemistry. Additionally, the hydrocarbons moving as gases extend their effects all the way to the surface.

The surface (0 to 2-inches) is the best place to consistently sample the same location in the soil profile, and it also allows for rapid integration of multiple soil aliquots into composite samples. Hydrocarbons follow preferred pathways through the overburden, the regolith, and the soil, producing widely divergent flux rates at any given point. Multi-point composite soil collection methods help to mitigate this problem. Hydrocarbon flux rates are also variable over time. The flux responds to changes in barometric pressure as well as daily, monthly and yearly cycles. The soil acts as a natural integrator of this variable flux, making it easier to combine data from sequential surveys.

Soil Chemistry

Hydrocarbons retrieved from the soil as free gases are often measured in concentrations of more than 50 ppm. This is not a trivial amount and the power of these reactive compounds, as mentioned above, produce significant changes in the soil.

One of the geochemical tools used to track hydrocarbon microseepage is the iodine concentration of surface soils. Iodine occurs in the atmosphere as a diatomic molecule, and like all oxidizers, it is continually seeking electrons. Iodine free radicals, produced by relatively low energy photons, can abstract and replace a hydrogen atom, covalently bonding to the carbon in the organic molecule. These replacement products are far less volatile than the original organic gas and accumulate in anomalous amounts in areas of hydrocarbon seepage.

The Study

Each of the four wells presented were seismic prospects generated by Anschutz Exploration Corp. The primary target of the exploration program was the Morrow formation in southeastern Colorado on the northwest flank of the Los Animas Arch. The Morrow channel sands are difficult to locate but can be prolific reservoirs. Additional zones in the Pennsylvanian Marmaton above the Morrow and the Mississippian below can also be productive.

Geochemical surveys were completed in four areas prior to the report of the drilling results. Surface soil samples (2-inch depth) were collected along the seismic lines to generate drilling prospects and also along public access roads.

All four surveys (see page 20) were collected while the drilling rig was on site. Dry wells were correctly predicted in three of the four survey areas on the basis of low soil iodine concentrations. A post-survey hydrocarbon-show well drilled at the Plum Creek prospect was correctly predicted by anomalous iodine concentrations in surface soils.

Seismic was used in each case to locate the channel cut containing the Morrowan sands. In all three dry wells the well did encounter the ancient Morrow channel but failed to locate the porous sands necessary for production. At Plum Creek, oil was intersected in the Marmaton and the Morrow and again the Morrow channel was successfully located. The Mamaton had “fair to good productive potential” with “live oil” in the side wall cores. The Morrow had “18 feet” of sand also with “live oil” in the side wall cores. Production casing was set, but the well was not produced.

Conclusions

Both the geochemical and seismic methods were successful at locating Morrow Channels. The seismic was searching for the channel and found it four times. The iodine geochemical method tested for hydrocarbon microseepage and correctly predicted three dry wells and a show well with “live oil” in two underlying formations. Ironically, with all this success no hydrocarbons were produced.

Clearly in this Morrow exploration play, finding the channel is not enough. Including geochemical soil iodine data, in the well selection process, could have avoided the drilling of three dry wells. The iodine anomaly at Plum Creek correctly predicted hydrocarbon microseepage from an underlying reservoir, but the intensity and spatial distribution of the anomaly could not resolve the commercial producibility of the reservoir.

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Morrow Seismic Prospects

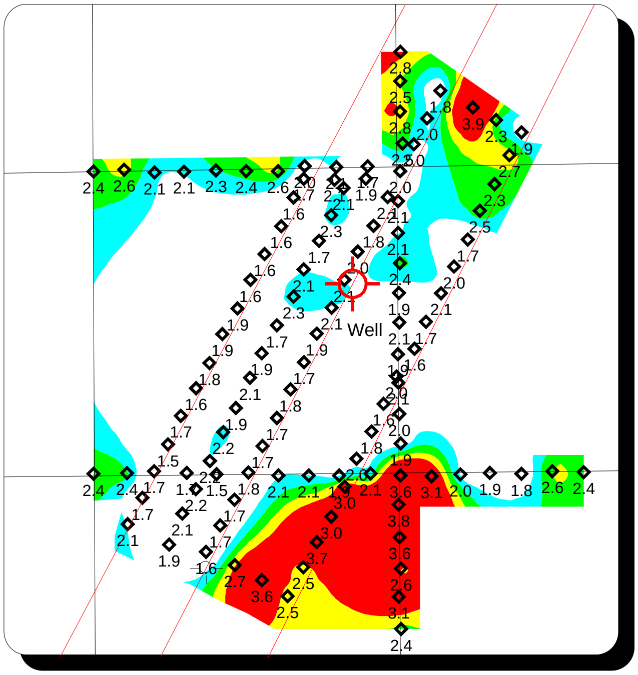
Kit Carson County, Colorado

1 mile

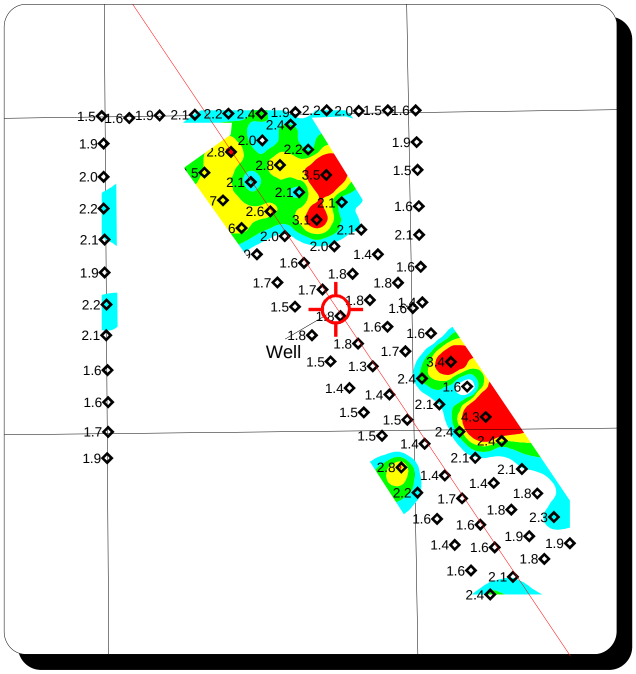
Seismic Lines

Iodine Intervals
ppm I_2

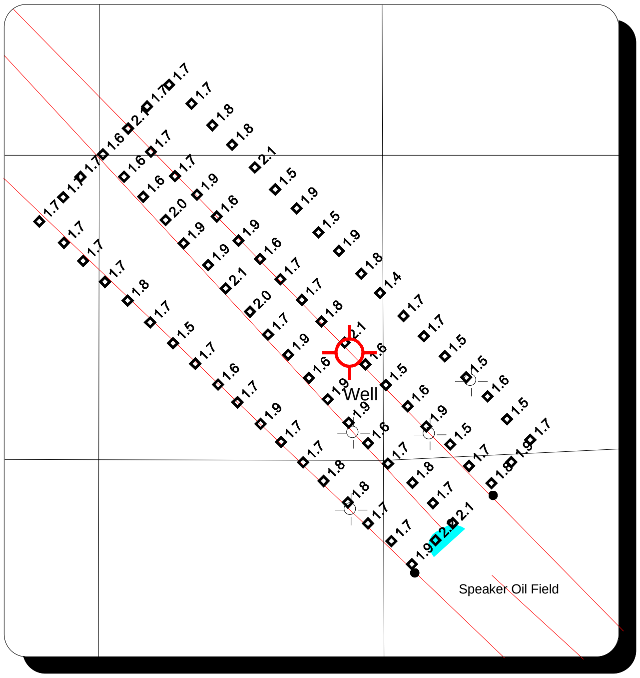
☐ 0 - 2.0
🟦 2.1 - 2.2
🟩 2.3 - 2.4
🟨 2.5 - 2.6
🟥 2.7 -



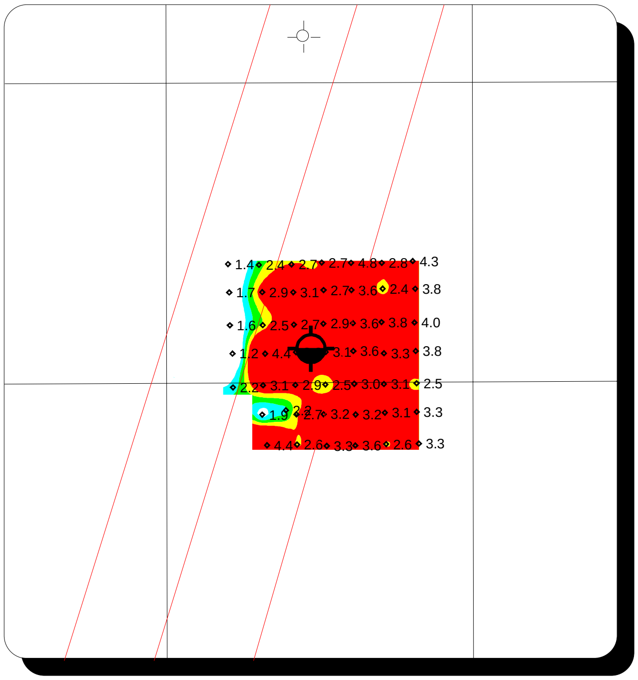
East Bledsoe
(Wildhorse 8-21)
T12S R50W Sec. 21



Windmill
(Vassios 9-2)
T11S R50W Sec. 2



Speaker West
(Dairy 9-2)
T12S R51W Sec. 2



Plum Creek
(Adobe 14-14)
T13S R51W Sec. 14

Technical Note: Sample Preparation of 'Nuggety' Samples: Dispelling Some Myths about Sample Size and Sampling Errors

by: Barry W. Smee
Smee and Associates Consulting Ltd.
1011 Seaside Dr., Sooke, BC V0S 1N0, Canada
VOX (250) 646-2298, FAX (250) 646-2398
bwsmee@geochemist.com

and: Clifford R. Stanley
Department of Geology, Acadia University
Wolfville, Nova Scotia B4P 2R6, Canada
VOX (902) 585-1344, FAX (902) 585-1816
cliff.stanley@acadiau.ca

Introduction

During recent audits of numerous commercial laboratories, the first author has noticed that many laboratories prepare pulp samples from rock, drill core and drill cuttings of approximately 3 kg mass using large, fixed-bowl, shatter box-type, vibratory pulverizers. This preparation method is referred to by the laboratories as "total preparation", because the complete 3 kg sample submitted by the geologists is pulverized before sub-sampling. During these laboratory audits, each laboratory manager was asked if this 3 kg pulverizing equipment produced a pulp equal to or better in quality than the smaller 1 kg shatter box pulverizers also in common use by commercial laboratories. Each of the laboratory managers indicated that the large pulverizer actually produced a pulp product that was ***inferior*** in grain size specifications to the 1 kg shatter box pulverizers. The laboratory managers furthermore admitted that the larger pulverizers were used solely because the clients requested the 3 kg pulp in the belief that it results in significantly better sub-sampling (preparation) precision than a 1 kg pulp. This purportedly improved precision was thought to be especially important for samples containing a significant "rare grain" or nugget effect.

Actual sampling, preparation and analytical quality control data gathered over the past 12 years by both authors from a wide variety of mineral deposit types, many of which contain a significant nugget effect, have shown this belief to be misguided. This brief communication presents the actual precision levels measured from two representative types of gold deposits using duplicate samples collected at each step of sample treatment (field sampling, preparation and analysis). In all cases, sample preparation involved the submission of samples larger than 3 kg, homogenization of the large sample before final pulverization, and the use of a 1 kg pulverizer. The overall precision levels observed in these case histories are then compared with the overall precision levels predicted (by Poisson statistics) to occur if a 3 kg pulverizer were used to prepare corresponding 3 kg samples of the same material. Results indicate that no substantial advantage is offered by preparation of a 3 kg pulp because the field sampling error represents the vast majority of the non-geological variations observed in the samples.

Sample Preparation Scheme Observed

During auditing of the laboratories, several procedural problems were identified that could affect the quality of subsequent analytical results. The laboratories typically receive rock, drill core, or drill cutting samples in calico bags that are, in turn, shipped from the field in woven polypropylene bags. Unfortunately, calico bags containing dry drill cuttings sometimes exhibit contamination and sample loss problems, due to sample leakage via pores in the cloth, as well as splits in the bags (Figure 1). Consequently, it is recommended that sturdy plastic bags should be used for samples and sample shipment.

Figure 1- Dry samples received by the laboratory in calico bags may split and leak drill cuttings from one sample to the next during shipment. Spilled material is evident by the footprints on the floor.

In addition, the audited laboratories treat wet or damp samples in significantly different ways than dry samples, and this difference can produce additional errors during preparation. Some laboratories dry every sample in its calico bag before beginning sample preparation. Other laboratories remove the samples from their calico bags and place them in drying pans for drying, Other laboratories do not dry samples at all before beginning the preparation process. The amount of moisture in the samples will influence the efficiency of the sample preparation process, in particular pulverization, and this could cause significant errors and biases in the subsequent geochemical analyses.

The clients of the audited laboratories have been instructed to send no more than 3 kg of sample so that it fits directly into the pulverizer bowl. However, many samples received by the laboratories exceed 3 kg. This is particularly true for samples obtained from reverse circulation or blast hole drilling projects, as more than 3 kg of material is generally available. When samples exceed 3 kg, the laboratory should pass the entire sample through a jaw crusher to reduce its mean grain size, homogenize the sample using appropriate homogenization equipment, split off the excess reject, and then pulverize the 3 kg sample. However, several laboratories simply split off the excess sample without any pre-treatment (grain size reduction or homogenization) and discard it (Figure 2). This clearly imposes representativity problems that can severely affect overall measurement precision.

Under the 'total preparation' protocol, the 3 kg sample is pulverized so that nominally 95 % of the material is less than 105 microns (-150 mesh) or similar size. Then, a 250 g

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Technical Note: Dispelling Some Myths...

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Figure 2 – Splitter used to reduce oversized samples to 3 kg before pulverizing. Samples are typically split without pre-treatment by crushing and homogenization. The excess sample is discarded.

scoop is taken from the top of the fixed pulverizer bowl and placed in a pulp bag for analysis. As the 250 g scoop cannot be collected in a geometrically representative manner because the large pulverizer bowl cannot be moved, further potential for sample bias is introduced. The excess pulp is placed either in the original calico bag or in a new plastic bag and stored for future reference.

Although all audited laboratories collect a pulp duplicate in each batch for analysis at some stage of the preparation process, only one laboratory actually routinely examines the long-term duplicate data to assess pulverized sample precision. Unfortunately, because of the presence of nuggets, the pulp from which these duplicates are derived may not be homogeneous, so these pulp replicates are affected by pulp and analytical error. As a result, an estimate of sample preparation precision is not typically possible using the 'total preparation' procedure. Nevertheless, geologists or geochemists who evaluate the pulp duplicate data can obtain an idea of the magnitude of pulp plus analytical error in their samples by using precision measurement techniques described below.

Sample Preparation Scheme Employed

An alternative sample preparation scheme for the resource delineation projects used as examples in this paper permits the step-wise calculation of precision at each stage of sample size reduction (sampling, pulverizing, and analysis).

The initial field sample size is not critical to this protocol. A 10 kg split from a reverse circulation drilling program can be handled in the same manner as a 4 kg sample of 1 m of half BQ core that is split or cut in the field. Nevertheless, a duplicate sample must be obtained at each stage of the sample size reduction process, from the field sample to the final, weighed analytical pulp, in order to allow estimation of the actual sampling/sub-sampling error introduced at each sample size reduction stage. This preparation scheme is as follows:

1. Field samples are collected from splits of drill core, reverse-circulation (RC) or blast hole (BH) cuttings or outcrop. Ideally, RC and BH samples should be obtained directly from the drill discharge as drilling progresses. Drill core samples should be obtained by cutting, as this prevents biases associated with 'hand cobbing' from taking place.
2. A '*field*' or '*sampling*' duplicate is collected from the same sampling interval as the original sample at a frequency commensurate with the size of the exploration program. In RC or BH drilling programs, two representative splits of mass equal to normal samples represent adequate duplicate samples. These splits are best obtained by passing the material from the entire sampling interval through a riffle splitter of Jones or Gilson design. Opposite halves of the same core comprise ideal sampling duplicates from drill core; however, quarters or thirds of core sampling duplicates have been collected by some companies and suffice as long as their weaknesses are appreciated. Because of the different sample masses of these smaller duplicates, calculated precision levels overestimate sampling errors in larger half core samples. Fortunately, these biases imposed by different sample supports can be corrected using ideal theoretical (Poisson statistical) models. Duplicate samples are selected according to a random-stratified regimen to ensure that one duplicate sample occurs in each analytical batch. Each sampling duplicate is given a separate number so that it is blind to the laboratory.
3. Once received by the laboratory, the entire sample is removed from the bag and placed in a drying pan of sufficient size and robustness to handle the larger sample. The entire sample is then dried.
4. After drying, the sample is removed from the drying pan and jaw crushed to reduce its fragment size so that 95 % of the sample is less than 2 mm in size (monitored by subsequent screen tests).
5. This crushed 2 mm material is then passed through an appropriately sized riffle splitter several times to homogenize it before a final split of 1 kg is collected. The residual material is stored as a coarse reject, lest sample miss-ordering or other mishaps to the pulp occur (in one case, a fire) during analysis.
6. As above, a 1 kg duplicate of the coarse reject is again collected randomly for each analytical batch. This '*preparation*' duplicate is subsequently given a distinguishing sample number and treated like a normal sample.
7. The one kilogram sample is then pulverized using a one kilogram shatter box bowl such that at least 95 % of the material is less than 105 microns (-150 mesh) in size (again, monitored by screen tests).

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8. When pulverized, the removable shatter box bowl is turned upside down on a clean mat so that the entire pulverized pulp forms a conical pile. A representative split of the pulp, usually 250 g, is then taken from the pile on the mat for analysis. The remaining pulp reject (approximately 750 g) is stored for future reference or for screen metallics analysis if a severe nugget effect is suspected. Note that a second 250 gram pulp duplicate sample does not routinely need to be collected, because laboratories routinely collect and analyze '*pulp*' duplicates as part of their analytical quality control measures.
9. Finally, for gold, a 50 gram sub-sample from each 250 g sample is weighed out and analyzed by fire assay techniques. Note that because no grain size reduction actually takes place after collection of the 250 grams of pulp, this sub-sampling stage is actually 1 kg to 50 g, instead of 1 kg to 250 g, or 250 g to 50 g.

Calculation of Step-Wise Measurement Precision

Actual precision estimates for the case histories presented in this paper have been made using duplicate samples from all stages of the sample size reduction process (initial sampling in the field, sub-sampling to a 1 kg sub-sample after jaw crushing, and further sub-sampling to 50 g analyte after pulverization; Figure 3, Path A). In this instance, three stages of duplicates are required for the sample preparation scheme described above.

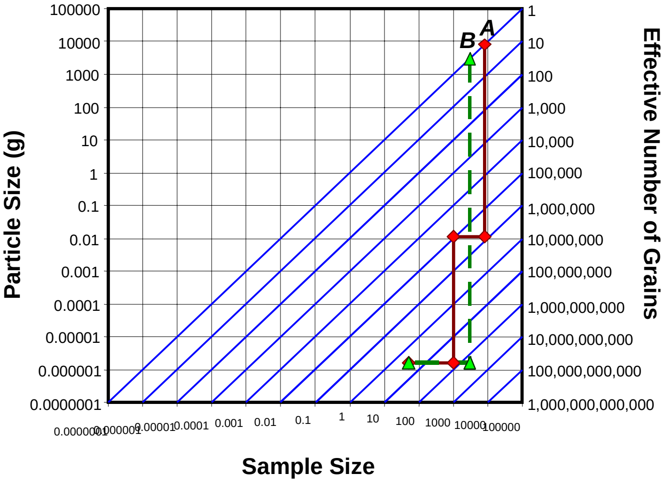

Figure 3 – Sample preparation diagram illustrating the particle and sample size reduction path followed by the initial 8 kg samples from the intrusion-hosted Au deposit example presented (A), and a hypothetical path followed by 3 kg samples that undergo 'total preparation' (B), as defined by the audited laboratories. In both cases, a 50 gram sub-sample is ultimately used in analysis. Diagonal lines and the axis on right describe the number of equant grains that would occur in the samples/sub-samples.

'*Sampling duplicates*' are collected by the geologist, and record the cumulative uncertainties associated with the entire sampling and analytical process. That is: (i) the error introduced through the collection of only part of the core, RC or BH cutting, or rock mass for assay; (ii) the error in sub-sampling a jaw crushed sample for pulverizing; and (iii) the error in sub-sampling the pulverized sub-sample for assay analysis, plus analytical error. '*Preparation duplicates*' are collected by the laboratory, and report the errors due to sample size reduction after crushing, and the errors associated with weighing and analysis of the pulp. '*Pulp duplicates*' are also collected by the laboratory, most of the time routinely, and report the magnitude of sub-sampling error associated with taking 50 grams from a 1 kg pulp, and any subsequent weighing and analytical error.

All duplicates were obtained at random, without regard for mineralization type, grade, or lithology. Any bias in the duplicate sampling program will negate the validity of subsequent precision calculations, so all duplicate pairs were analyzed with the original samples in the same sample analytical batch. Duplicates that were analyzed by a different laboratory, or at a later time, (such as in check assays) can introduce variance artefacts that are not related to sampling precision, and so were not included in these data evaluations.

The statistical technique used to estimate the actual precision levels at each stage of sample treatment was the modified Thompson-Howarth method (Stanley 2003). It, or Thompson and Howarth's original method (Thompson and Howarth 1973, 1976a, 1978; Thompson 1973, 1982; Fletcher 1981; Stanley and Sinclair 1986), represents the preferred precision estimation procedure. In all cases, the regression employed initially fits a line through the data using both slope and intercept. However, in all cases, the magnitude of the intercept was so small that the error was virtually always proportional in character. As a result, a second 'proportional' model was subsequently regressed (involving fitting only a slope, or relative error term), as a simple proportional error model significantly simplifies the subsequent error calculations in this paper.

By assembling and evaluating the field sampling, preparation, and pulp duplicate results, the errors associated with each step of sample treatment can be estimated by subtracting 'downstream error' from each composite error estimate. The source of the greatest uncertainty in the sampling and analytical program can thus be quantified and targeted for reduction through procedural modifications, if necessary.

Examples of Sampling and Analytical Precision

Two representative case history examples of sampling precision estimation programs are presented from different types of gold mineralization. Both mineralization types exhibit significant 'nugget effects' in the gold analyses. The deposit names and locations remain confidential.

Intrusion-Related Gold Deposit

The hosts to gold and copper mineralization at this deposit include altered quartz diorite and granodiorite, and breccias that cross both the intrusive and surrounding andesitic volcanic rocks. Gold mineralization occurs as inclusions in disseminated sulphides and as free gold or electrum on fracture surfaces or in breccia matrices. The gold inclusions appear to be well distributed and do not present a significant sampling problem. Gold within the volcanic rocks and enclosed breccias typically has a larger grain size that contributes to a significant amount of sampling

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Technical Note: Dispelling Some Myths...

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and sub-sampling variability at all stages of sample treatment. The average weight of the two meter long, half core samples was 8 kg.

The three types of duplicate pairs: 'sampling' (n = 3488), 'preparation' (n = 1573) and 'pulp' (n = 1410), were collected during a major drilling project. Relationships between sampling errors and concentrations were determined using the modified Thompson-Howarth technique (Stanley 2003). In all cases, a proportional model was fitted to the duplicate data. One standard deviation relative errors for sample, preparation and pulp duplicates are 17.1 %, 9.0 % and 4.6 %, respectively. By converting these to relative variances via squaring the relative one standard deviation errors, subtracting the relative pulp variance from the relative preparation variance, subtracting the relative preparation variance from the relative sampling variance, and re-expressing the results as relative errors by taking their square roots, the actual relative sampling, preparation and pulp errors can be determined. Total relative error, measured by the sample duplicates, is thus 17.1 %, and all component errors (14.5 %, 7.7 % and 4.6 %, respectively) are presented in Figure 4 to illustrate the relative magnitudes of each error component.

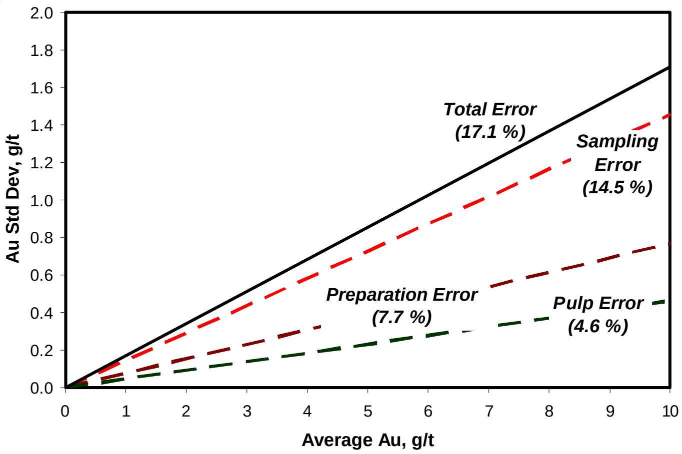

Figure 4 – Modified Thompson-Howarth-type plot illustrating the magnitude of total, sampling (8 kg), preparation (1 kg) and pulp (50 g) error, as determined by duplicate quality control monitoring for preparation protocol (A) on Figure 3, from an anonymous intrusion-related gold deposit.

Note that, based on the associated relative variances, more than 72 % of the total variation created by the entire sampling and analytical process is introduced during cutting (sampling) of the drill core. Only 20 % of the total variation is attributed to splitting the crushed core to 1 kg, and 7 % of the variation is attributed to the splitting and weighing of 50 g of pulp and analysis.

Given the above sampling, preparation and analytical errors, hypothetical errors can be deduced for alternative sampling, preparation and analysis protocols using Poisson statistics. The variance of the number of rare events (a Poisson variable, such as nuggets) is known to be:

$$\sigma_x^2 = x$$

(Speigel 1975), where x is the number of 'equant' nuggets in the sample (Clifton *et al*. 1969; Stanley 1998). Rearranging this equation by inverting it and distributing the variance into standard deviations, we obtain:

$$\frac{\sigma_x}{x} = \frac{1}{\sigma_x} = \frac{1}{\sqrt{x}}$$

Because the relative error on the effective number of nuggets in a sample ($ó_x/x$) must equal the relative error on the element concentration ($ó_c/c$) in the sample, the relative sampling error on the concentration is related to the number of equant nuggets in a sample. Equation 2 thus allows one to deduce the change in relative error that will occur as a result of a change in sample size.

For example, if 3 kg samples from this intrusion-related gold deposit were collected (instead of 8 kg) and prepared using the 'total preparation' method described above (Figure 3, Path B), one can estimate the new sampling error that would result using Equation 2. The original sampling error of 14.5 % allows one to determine that, on average, 47 equant grain nuggets would be present in an 8 kg sample (Clifton et al. 1969; Stanley 1998). As a result, if 47 equant grain nuggets were contained in 8 kg, 3/8 × 47 (= 18) nuggets should, on average, be contained in a 3 kg sample. Using Equation 2, again, the relative sampling error associated with collection of 3 kg samples containing 18 nuggets should be 23.8 %. This is obviously larger than the 14.5 % sampling error for the 8 kg samples because the 3 kg samples are smaller.

Given the above, the total sampling error associated with the 'total preparation' protocol, had it been applied to samples from the intrusion-related gold deposit, can be deduced. Sampling error, pulp error, and total error are presented in Figure 5. Note that no preparation error is included, because no sample size reduction occurs during preparation, as the entire 3 kg sample is pulverized. Furthermore, because the pulp in both cases is 50 g in mass, the pulp error observed in the original sample preparation protocol can be used for the 'total preparation' protocol.

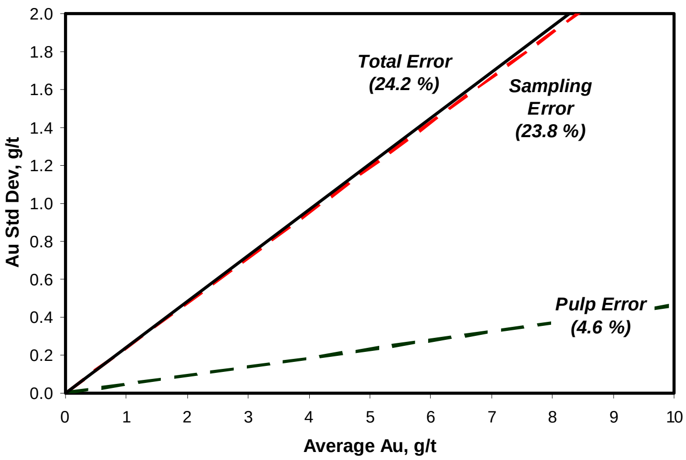

Figure 5 – Modified Thompson-Howarth-type plot illustrating the Poisson-predicted magnitudes of total, sampling (3 kg), and pulp (50 g) error if the 'total preparation' protocol (B) on Figure 3 were used to process the samples from the intrusion-related gold deposit.

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Technical Note: Dispelling Some Myths...

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Comparing the results in Figures 4 and 5, we see that the 'total preparation' protocol (Figure 3, Path B) actually introduces 24.2 % relative error, and thus creates 62 % more error than the original 8 kg => 1 kg => 50 gram sample preparation protocol (Figure 3, Path A). Although the 'total preparation' protocol does not introduce the 7.7% preparation error that the original protocol did, the larger sampling error caused by a smaller initial sample overwhelms this preparation error reduction, primarily because sampling error is the largest component of error. Although the 'total preparation' protocol appears superior at first, the limited sample size required by this approach actually makes it significantly inferior!

Epithermal Low Sulphidation Gold Deposit

This gold deposit is hosted by structurally controlled quartz silica breccia and banded quartz veins. Some gold mineralization exhibits high to very high grades (3 to 1000 g/t) and significant visible gold occurs in the core. Consequently, a very high nugget effect can occur in these samples. During core cutting, the core was orientated so that the veins, if present, were cut as evenly as possible.

A similar sample preparation protocol was followed at this deposit. Because core sample masses range from 3 to 6 kg depending on the core length, an average core mass of 4.5 kg has been used. Sample preparation also involved jaw crushing to 95 % less than 2 mm, homogenization and splitting of 1 kg of material for pulverization to 95 % less than 105 μm, and then splitting of 50 grams for analysis (Figure 3, Path A). A similar duplicate sampling procedure was also followed to determine the magnitude of sampling, preparation and analytical errors associated with assaying.

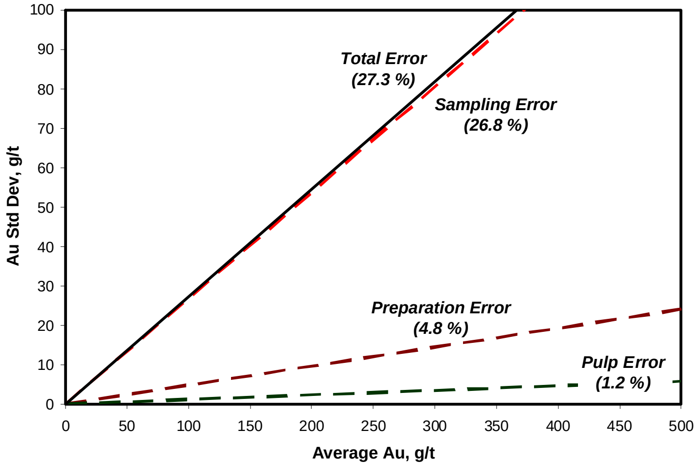

Figure 6 – Modified Thompson-Howarth-type plot illustrating the magnitude of total, sampling (4.5 kg), preparation (1 kg) and pulp (50 g) error, as determined by duplicate quality control monitoring for a preparation protocol similar to that of Path A on Figure 3, from an anonymous low sulphidation epithermal gold deposit.

Modified Thompson-Howarth analysis of 637 field sampling duplicates, 501 preparation duplicates, and 501 pulp duplicates was undertaken to determine the various component errors. Results from analysis of sample, preparation and pulp duplicates indicate that these relative errors are 27.3 %, 4.9 % and 1.2 %, respectively. Converting these to variances (as above), subtracting pulp error from preparation error, and subtracting preparation error from sampling error, to isolate the individual errors, results in 26.8 %, 4.8 % and 1.2 % errors for sampling, preparation and pulp procedures. Because of the larger nugget effect in this deposit, this sampling error constitutes 96.7 % of the variance, whereas preparation and pulp errors constitute only 3.1 and 0.2 % of the variance, respectively.

As above, Equation 2 can be used to determine the total error that would occur if the 'total preparation' sampling, preparation and analysis protocol were employed for samples from this low sulphidation epithermal gold deposit (Figure 3, Path B). Results are presented in Figure 7, and indicate that the smaller 3 kg initial sample creates virtually all of the error observed. This error (32.9 %) is again substantially larger than the error produced using the original sampling protocol involving a 4.5 kg sample (26.8 %). Thus using a 3 kg pulverizer does not guarantee the geologist or geochemist that they are using the ideal sample preparation protocol!

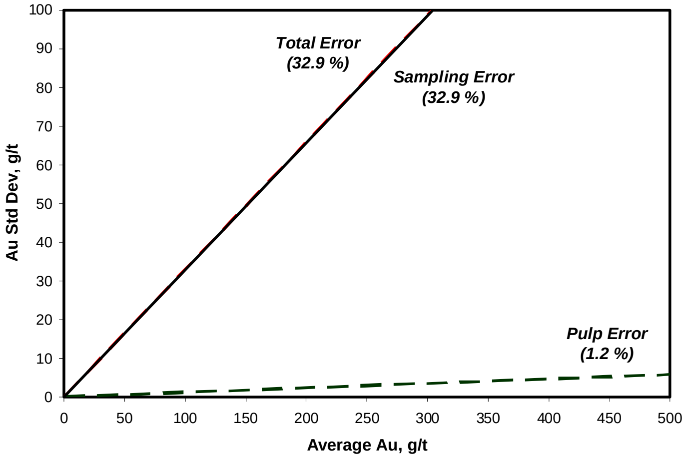

Figure 7 – Modified Thompson-Howarth-type plot illustrating the Poisson-predicted magnitudes of total, sampling (3 kg), and pulp (50 g) error if the 'total preparation' protocol (B) on Figure 3 were used to process the samples from the low sulphidation epithermal gold deposit.

Conclusions

Experience by the authors has shown that the two gold deposit case histories presented involve sampling, preparation and pulp error magnitudes that are representative of many mineral deposits exhibiting nugget effects. At these deposits, geologists should expect the largest component of measurement error to be introduced during the initial field sampling stage. As a result, significant efforts to reduce overall measurement error should focus on this initial stage of the sample treatment procedure, as this is the place where the most benefit can be achieved with the least amount of effort (and cost). Field samples that are as large as is economically possible to handle should be submitted to the laboratory for crushing, homogenization, splitting and pulverization.

Efforts to reduce measurement error by pulverizing large sample masses are shown to be mis-guided, as the initial limitation on sample size (3 kg) typically imposes far more error than is eliminated through the subsequent pulverization

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Technical Note: Dispelling Some Myths...

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of large sample masses. Furthermore, problems associated with pulverization of large sample masses (cross-contamination due to incomplete cleaning of unwieldy equipment, lack of representativity due to arbitrary reduction of sample masses to fit the pulverizing equipment by the laboratory, etc.) can be easily avoided using smaller volume pulverizing equipment and a two-stage sample reduction protocol, without imposing un-acceptable measurement errors. Use of the 'total preparation' sample reduction protocol can actually increase measurement error, resulting eventually in higher capital costs to the future mining venture because the larger errors result in more uncertainty and higher risk.

In summary, geologists and geochemists undertaking drilling programs and assaying samples on exploration projects should familiarize themselves with the sampling theory necessary to understand the limitations of the techniques they employ, so that they can effectively produce quality assay information with acceptable errors for use in subsequent mineral resource evaluations.

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22nd IGES 2005
from Tropics to Tundra

THE ASSOCIATION OF APPLIED GEOCHEMISTS presents the 22ND INTERNATIONAL GEOCHEMICAL EXPLORATION SYMPOSIUM
incorporating the 1ST INTERNATIONAL APPLIED GEOCHEMISTRY SYMPOSIUM

Important Dates: Submission of Abstracts: Friday 4 February 2005
Notification of Acceptance: Friday 25 March 2005

Introduction

On behalf of the IGES Committee we would like to invite you to participate in the 2005 Symposium and consider submitting an abstract on one of the aspects below.

The Symposium theme reflects the diverse environments in which exploration geochemistry is applied, many of which are found in Western Australia.

The keynote speakers will set the scene for the Symposium and your contribution will be greatly appreciated in making a program that will be relevant and attractive to members and others.

We urge you to submit an abstract for a paper as soon as possible for this exciting event.

Nigel Radford, Paul Morris CO-CHAIRS

Note to Authors

As a commitment to attend and support the Symposium, accepted presenters are expected to pay and register for the full-time program on the day of their presentation.

All costs to attend the Symposium, including the registration fee, must be met by presenters.

Call for Abstracts

The organisers of 2005 IGES (the 1st IAGS) are calling for abstracts of papers covering all aspects of the geochemistry of mineral deposits: their genesis, exploration, exploitation and remediation.

Sessions at the Symposium will be organised along the following lines:

- Regolith — the continuum; from tropics to tundra.
- Discovery case histories and geochemical exploration in tropical, temperate and glacial terrains.
- Geochemical exploration's brave new world. Seeing through transported overburdened, mechanisms of metal mobility.
- Environmental Geochemistry: its interaction with exploration.
- Geochemistry of mineral deposits: isotope and hydrothermal geochemistry.
- Data, our raw materials: analysis, QAQC, data management, data processing.

A series of pre-conference Workshops and Short Courses will be offered.

Detailed instructions for authors can be found at:

www.promaco.com.au/conference/2005/iges

Short Courses

The Short Courses, of half or full day duration, will be presented by an individual or group of presenters. Each will follow a set theme, and include course notes.

At present, the following **Short Courses** are planned — more suggestions are welcome:

- Regolith processes in WA. Useful for participants in the WA Regolith field trip, though attendance is not essential. Presenters CSIRO/CRC LEME.
- Geochemical data interpretation in a regolith context. Presenters Simon Bolster (Regolex) and David Lawie (io Geochemistry).
- Spectroscopy in geology: from remote sensing to grade control. Presenter Bob Agar (Australian Geological and Remote Sensing Services).

Field Excursions

Proposed field trips are as follows:

- Regolith and Mineralisation in the Eastern Goldfields.
- Mines and Wines in the South West of Western Australia.
- Pilbara Mineralisation.
- Mineralisation in New South Wales.
- Epithermal Gold Mineralisation in New Zealand.

Workshops

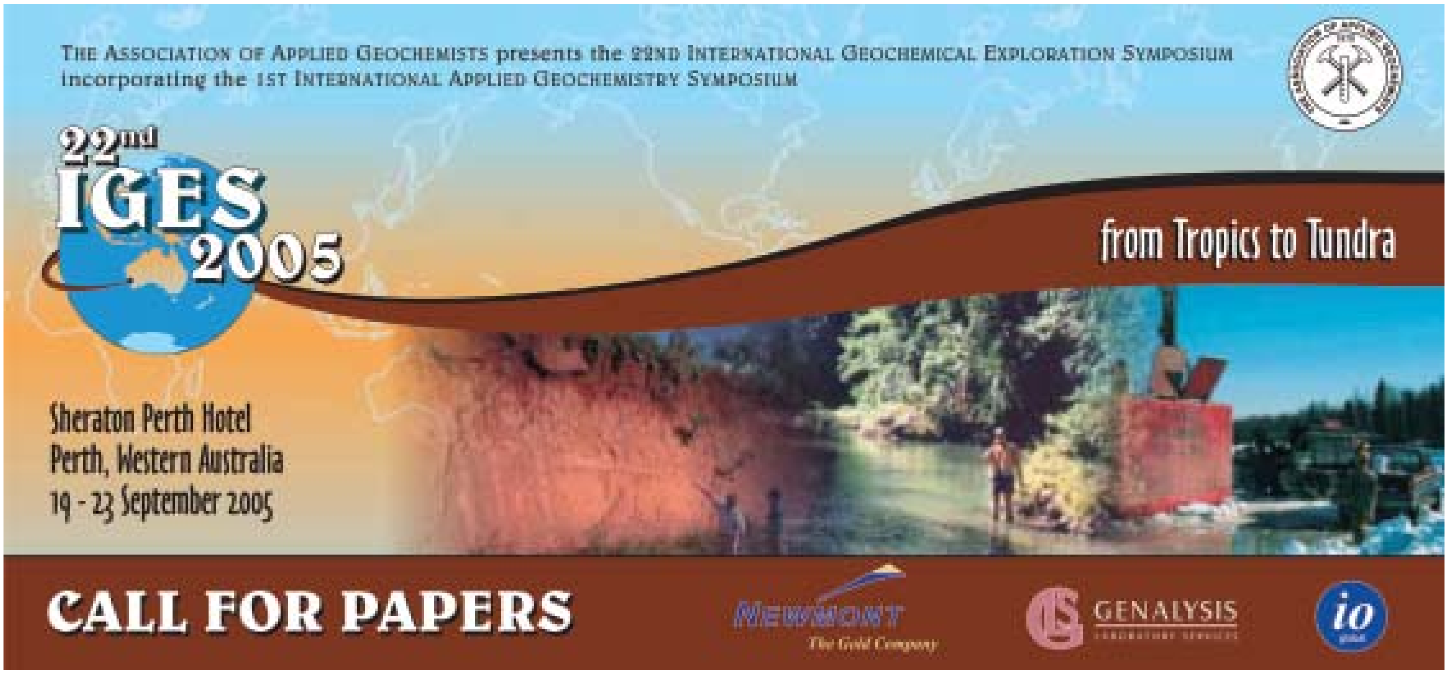
Workshops will be less formal. Each will be coordinated by a facilitator, and various presenters will contribute on a less formal level than would apply to the main Symposium sessions. Discussions between the participants will be an integral part of each workshop. Wherever possible, informal abstracts of presentations will be available to participants..

Workshops are planned for the following topics:

- Deep penetrating geochemistry mechanisms: cations, currents, critters.
- Laboratory methods, new developments, new applications.
- QAQC: being sure you get it right.
- Data management: databases, novel processing, statistics, presentation.
- Environmental geochemistry: what geochemistry does for the rest of society.
- Forensic geochemistry.

Other ideas for workshops are welcome, as are expressions of interest from contributors.

Contributors to the Symposium may wish to expand on their themes via workshops.



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Abstract Format

Abstract submissions are invited for consideration by the Symposium Technical Committee. Accepted papers will be published in the Symposium Proceedings.

It is expected that presenters will have 20 minute timeslots, plus 10 minutes for discussion. Each paper should support one of the six sessions listed.

Abstract Preparation

The purpose of the abstract to define the precise subject of the presentation. The abstract should not contain acknowledgements, figures or references.

Include the names of all co-authors plus affiliations and addresses for general correspondence (including email address).

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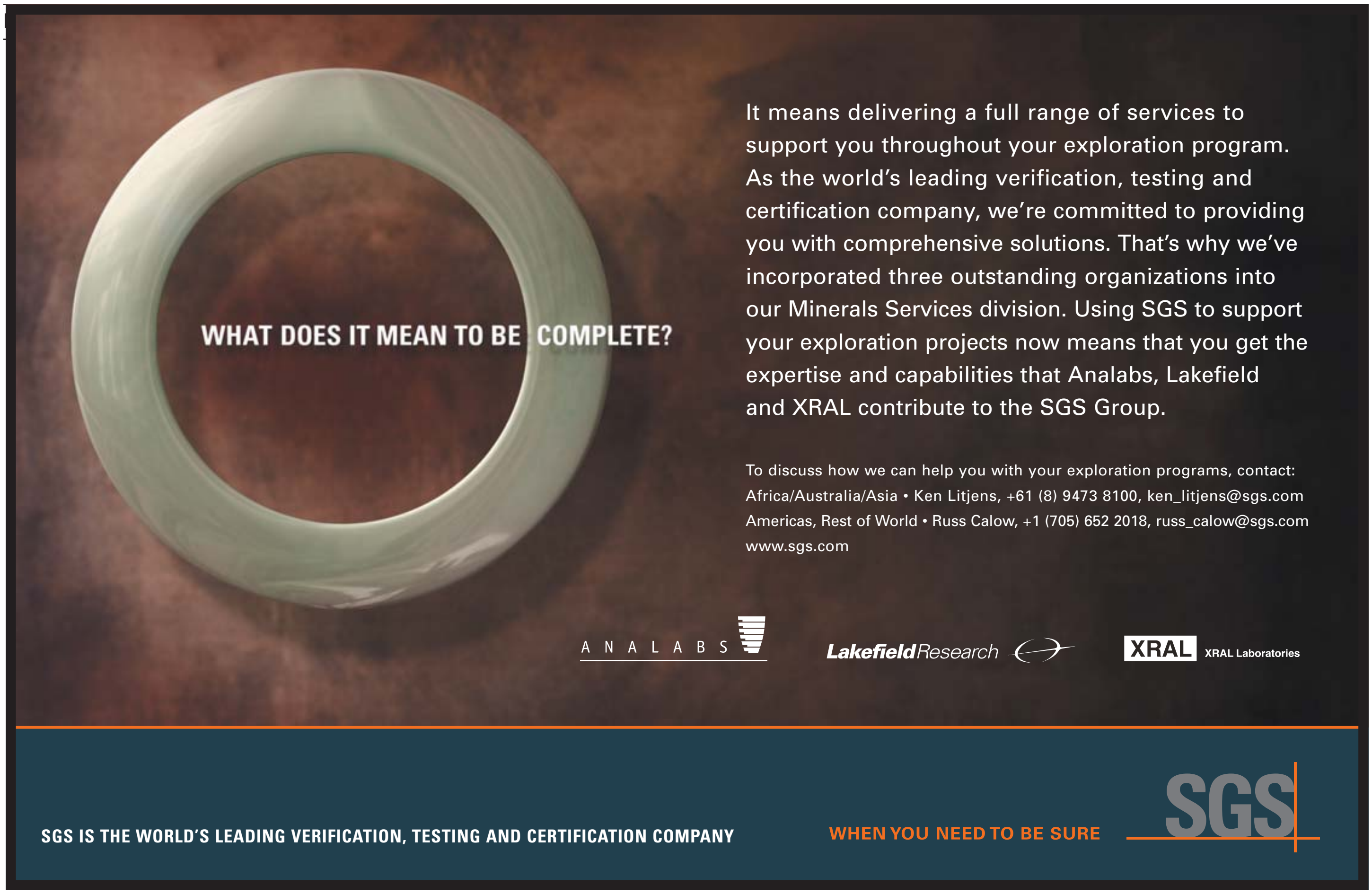

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