

EXPLORE

Newsletter for
the Association
of Exploration
Geochemists



NUMBER 106

JANUARY 2000

PAST PRESIDENT'S MESSAGE

It is hard to believe that 1999 is now history. 1999 was a year of transition for the Association as well as the industry. Papers from the Vancouver meeting will be the last that members will receive published through Elsevier under the Journal of Geochemical Exploration. The new Journal, **Geochemistry: Exploration, Environment, Analysis (GEEA)**, will be published through a cooperative effort with the Geological Society of London.



Erick Weiland

The anticipated lower cost to libraries and electronic publication should result in increased visibility and accessibility, thus helping to sustain the publication well into the future. Please note that although the new Journal will be accepting submissions of papers in January of 2000, the Journal will not be ready for distribution until 2001 due to our now terminated contract with Elsevier. However, Council authorized that all members will receive the book "Drift Exploration in Glaciated Terrain" as a substitute for not receiving a journal during 2000. The book is edited by M.B. McClenaghan, S. Cook, and P.T. Bobrowsky and focuses on till geochemical and indicator mineral methods of exploration in the glaciated terrain of Canada with direct application to glaciated terrains of North America, northern Europe and Asia and mountainous regions of South America.

The Association also moves into the new year with a new Editor for **EXPLORE**, Lloyd James. On behalf of the Association I would like to express our sincere thanks and appreciation to Sherman Marsh and Tom Nash for their outstanding stewardship of **EXPLORE**. Under their direction, many good articles and much needed information has been provided to the membership. I am equally sure that under Lloyd's direction **EXPLORE** will continue to provide timely and effective information to the membership.

The AEG web site has become a true voice for the Association under Beth McClenaghan's direction. It now has a members only area where members can access the current membership directory and other very useful information. The web page is still under revision so keep your browser tuned to watch for exciting new additions.

Gwendy Hall has completed an excellent (and perhaps a little exhausting) year within the Distinguished Lecture Series, "Selective leaching — a tool in identifying an element's provenance" and "Cost effective protocols for the collection, filtration and preservation of water samples collected in hydrogeochemical surveys," on behalf of the Association.

AEG-sponsored Short Courses were presented at the Vancouver IGES Meeting, the Geological Society of Africa conference in Cape Town, and the Northwest Mining Associa-

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PRESIDENT'S MESSAGE

The AEG is now more effective than ever as a professional organization, and I would like to thank the AEG Council and particularly outgoing president Erick Weiland for their leadership and guidance during the past year.

Having enjoyed the benefits of AEG membership now for twenty three years, I am proud to be able to serve this year as AEG president, and am excited about the possibilities the new year brings. I'd like to talk about some of these possibilities here.

Geochemistry resides at the interface between two scientific fields, geology and chemistry, and merges knowledge from both into effective solutions to challenges in our industry. Applied geochemistry has proven especially effective in minerals exploration, and the AEG continues to assemble and communicate the collective hard earned knowledge of past and present members in the resource exploration arena. This position at the interface is ideal for the information age we are now in, and the interface is expanding to include the environmental geochemistry field with our new journal, **Geochemistry: Exploration, Environment, and Analysis**, to begin in January, 2001.

My own career experience has involved working with a range of exploration, development, and production professionals in the mineral resources industry around the world, and I've seen that geochemical knowledge can contribute to problem solving throughout our global industry. Our worldwide membership holds knowledge we all can use and share, and the AEG provides an important "exchange center" for the contributing and sharing of knowledge.

I would ask that all AEG members share the image of the AEG as an information archive and "exchange center", where we all can contribute and receive useful knowledge for our work. On the AEG Council, we have identified three primary



Paul Taufen

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Information for Contributors to EXPLORE

Scope. This newsletter is the prime means of informal communication among members of the Association of Exploration Geochemists, but has limited distribution to non-members. EXPLORE is the chief source of information on current and future activities sponsored by the Association, and also disseminates technical information of interest to exploration and environmental geochemists and analytical chemists. News notes of members are appropriate. We welcome short- to moderate-length technical articles on geochemical tools for exploration, concepts for finding ore, mineral-related environmental geochemistry, new analytical methods, recent deposit discoveries, or case histories. The goal of this newsletter is communication among exploration geochemists, and to that end we encourage papers on new methods and unconventional ideas that are reasonably documented.

Format. Manuscripts and short communications should be submitted in electronic form to minimize errors and speed production. Files can be transmitted on IBM-compatible 3.5 inch diskettes or attached to email. Most popular text and graphics files can be accommodated. Figures and photos can be transmitted in hard copy (which we will scan) or as high quality digital files. Some issues are published with color pages for special maps and figures which should be planned by early communication with the editors.

Length: Technical communications can be up to approximately 1000 words, but special arrangements may be made for longer papers of special interest. High quality figures, photos, and maps are welcome if they present information effectively.

Quality: Submittals are reviewed and edited for content and style through peer reviews. The intent is to improve clarity, not suppress unconventional ideas. If time permits, the author will be shown changes to material, by FAX or email. Time constraints do not allow author review of galley proof from the printer.

All contributions should be submitted to Lloyd James by email (l-njames@central.com) or J.T. Nash (tnash@usgs.gov) or by mail (EXPLORE, c/o J.T. Nash, U.S. Geological Survey, Box 25046 MS 973, Denver, CO 80225 USA). Only in rare situations should FAX be sent (303-236-3200).

Information for Advertisers

EXPLORE is the newsletter of the Association of Exploration Geochemists (AEG). Distribution is quarterly to the membership consisting of 1200 geologists, geophysicists, and geochemists. Additionally, 100 copies are sent to geoscience libraries. Complimentary copies are often mailed to selected addresses from the rosters of other geoscience organizations, and additional copies are distributed at key geoscience symposia. Approximately 20% of each issue is sent overseas.

EXPLORE is the most widely read newsletter in the world pertaining to exploration geochemistry. Geochemical laboratories, drilling, survey and sample collection, specialty geochemical services, consultants, environmental, field supply, and computer and geoscience data services are just a few of the areas available for advertisers. International as well as North American vendors will find markets through EXPLORE.

The EXPLORE newsletter is produced on a volunteer basis by the AEG membership and is a non-profit newsletter. The advertising rates are the lowest feasible with a break-even objective. Color is charged on a cost plus 10% basis. A discount of 15% is given to advertisers for an annual commitment (four issues). All advertising must be camera-ready PMT, negative or file on disk. Business card advertising is available for consultants only*. Color separation and typesetting services are available through our publisher, Vivian Heggie, Heggie Enterprises.

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Past President's Message

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tion meeting in Spokane. Our sincere thanks and appreciation to the many members who provided their time and efforts to make these a success.

In April we were able to honor two of our own members, Harry Warren and Robert Boyle, at a very successful annual general meeting and symposium. These are both very deserving individuals. Additionally, the student paper prize for 1998 was awarded to Matthew Leybourne for his paper entitled "Hydrogeochemical, isotopic, and rare earth element evidence for contrasting water-rock interactions at two undisturbed Zn-Pb massive sulphide deposits, Bathurst Mining Camp, N.B., Canada".

One of the major items which was on the agenda for 1999, but has not been completed, was the revision of the By-Laws. Several major discussions have been aired within Council to complete this effort and at last check, it should be ready for the membership in the near future.

I would like to express my appreciation and thanks to all who have served the Association (Councilors, Regional Councilors, Executive, Committee Chairs & Participants) this last year. It has been a pleasure working with you and the Association is much better for this investment of time and energy. THANK YOU!

I look forward to the year to come as many of the projects that were started before or during my tenure as President will be completed and provide the members of the Association with useful and relevant information. I leave my tenure knowing that the Association is in very good hands for the future. I especially want to thank Paul Taufen for his support and advice as First Vice President and wish him the very best for a successful year as President of the AEG in 2000.

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President's Message

Continued from Page 1

avenues to assemble and communicate knowledge useful to our membership: the **AEG Journal**, the **EXPLORE Newsletter**, and the **AEG Internet Web Page**. The AEG Council and other AEG volunteers are working toward strengthening each of these three "communication avenues" of our association. We ask for your support in contributing to each of these centers, and in communicating to me and to council what knowledge you would like to see available through these "communication avenues".

Erick Weiland has mentioned the progress with the new AEG journal. I'll mention some developments with the **EXPLORE** newsletter and **AEG Web Page**.

After having served as co-editors of **EXPLORE** for several years, Tom Nash and Sherman Marsh will be handing over the editing of **EXPLORE**. I'd like to thank Tom and Sherman for their tireless efforts and significant contributions to the success of both **EXPLORE** and the AEG. I'm delighted to report that long serving member (since 1970!) and AEG fellow Lloyd James has agreed to serve as **EXPLORE** editor, and ask membership to welcome Lloyd as editor and contact him (email: l-james@ecentral.com) with contributions to **EXPLORE**.

Our **AEG Web Page** (www.aeg.org) provides an instant opportunity to share knowledge useful for our work. We are continually assembling ideas to improve the **AEG Web Page**, and would like to receive new ideas from membership regarding what you would like to see available at the website. Send your suggestions to webmaster Beth McClenaghan (bmcclena@nrca.gc.ca), and check the web page to see how it is evolving.

I'm sure you can see as I do that the year 2000 brings exciting new possibilities for the AEG to more effectively serve membership as a knowledge and information "exchange center." As we refocus attention on the **AEG Journal**, the **EXPLORE Newsletter**, and the **AEG Internet Web Page**, we will all more fully realize the benefits of AEG membership. Your feedback, knowledge, contributions, and support are requested. Let's make 2000 a great year for the AEG!

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TECHNICAL NOTE

Geochemical News from Western Australia

It has been 36°C today in Perth, capital of Western Australia, and that means the summer is well and truly upon us. For some, in Canada for example, summer is the geochemist's field season, but for those of us with projects in WA's north, it's now too hot to do much serious field work. A couple of years ago, a field assistant actually died of heat exhaustion! So as the daytime temperatures rise above 40°C every day, most geologists and their field crews move back to Perth to "write up" and plan next year's programme, assuming there will be a budget for next year, and these days that's not a foregone conclusion!!

So this is the time of year for conferences. The Association of Exploration Geochemists has recently co-sponsored a conference entitled "Exploration Geochemistry for the New Millennium." Co-sponsors were the Australian Institute of Geoscientists and the Specialist Group in Applied Geochemistry of the Geological Society of Australia. It's appropriate that AEG sponsors such meetings in Australia since over 200 of AEG's 1000 plus members are Australian, and more than 80 of them live in Western Australia. Nevertheless, the organising committee was desperate when, with only 2 weeks to go, we had less than 30 registrants, but finally 110 of us turned up and made an excellent forum for reviewing the latest ideas in exploration geochemistry. We need not have worried, a date of 5 November (Guy Fawkes Day in UK) would ensure that there were plenty of fireworks!

Twelve presentations ranged across the full scope of geochemists' interests. The AEG can be proud that 7 of the 12 speakers are members of the Association. Leigh Bettenay provided an imaginative review of future possibilities, featuring amongst other things, a "wire-line" burrowing mobile laboratory which transmits its data back to the office, or was that a joke? There were papers on regolith mapping and regolith-based data interpretation (Simon Bolster and Ravi Anand). Three papers covered partial extraction geochemistry. Case histories from Craig Rugless and John Karajas covered diverse environments such as Western Australia and Sweden. David Gray provided a summary of recent work by CSIRO, and considered possible mechanisms without the understanding of which partial extractions are unlikely to be predictive. Bob Gilkes from the Soil Science Department of the University of Western Australia, presented a fascinating review of the role of biota in the metal balance in soils. This is surely an area that most geochemists (me for sure!) dramatically underestimate, probably because most of us are scared of or ignorant of organic chemistry. Papers by Dennis Arne and Susan Vernacombe reviewed litho-geochemistry studies associated with respectively slate belt Au and VHMS deposits. John Watling from Curtin University gave an informed view of new developments in ICP mass spectrometry. Mark Noppe demonstrated the application of neural processing to multi component data sets, and finally Paul Agnew presented state of the art visualisation of surface sampling data from the Sepon deposit in Laos.

An array of companies manned booths to demonstrate their wares, and Drillcorp Western Deep Holes supplied the liquid refreshment to close off a stimulating day, giving us all some ideas for our summer's interpretation and some new ideas for next year's programmes, budget willing!

The Australian Mineral Foundation and Keith Yates and

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Geochemical News from Western Australia *continued from Page 3*

Associates jointly sponsored the "New Generation Gold Mines '99" held in Perth on 22 and 23 November. Sixteen papers described new gold discoveries world-wide, and geochemistry loomed large in most of the case histories. Two discoveries were presented from each of Ghana and Greece, and one from Thailand. The remaining 11 are from Australia, showing how vibrant the gold exploration industry still is in Australia.

Prior to the conference two workshops were held involving 4 presenters, 3 of whom are members of the AEG. Simon Bolster presented a hands-on workshop on regolith mapping, with Paul Agnew and Nigel Radford providing some case histories and data interpretations. Simon's audience learnt much about the need for regolith mapping as well as lots of nuts and bolts about how to do it. Nick Merry, from Auspec International, presented a workshop on the PIMA (portable infrared mineral analyser). Nick is one of the world leaders in PIMA spectral interpretations. The instrument is capable of adding new mineralogical dimensions to deeply weathered profiles by identifying many of the clay minerals, an otherwise very haphazard task.

Both workshops were well attended, and the facilities provided by AMF made presentation easy. These conferences provide a valuable forum for exchanging technical information, and very importantly, a forum for "networking": meeting old mates, making new friends, and doing the odd deal or two as well!

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SOUTHERN AFRICA REPORT

New geochemists in the southern African region have continued to join AEG in the past year, and active membership has remained steady. Communication with members in the southern African has greatly improved over the last year. Members were well informed about AEG activities in the region. A major objective for the coming year is to improve on the present level of interaction between members, perhaps by introducing a discussion forum on the internet/e-mail? Could a page be devoted to regional councilors reports on the AEG website?

In June 1999, AEG sponsored a three days short courses preceding and in conjunction with the Geological Society of Africa Conference in Cape Town University of Cape Town. Course presentations were in two modules as follows:

- Dr. Colin E. Dunn and Dr. Gwendy E.M. Hall, Geological Survey of Canada, on Biogeochemistry Applied to Exploration and Environmental Studies, and Recent Developments in the Analysis of Organic and Other Surficial Materials
- Mr. Melvyn Lintern and Dr. Matthias Cornelius, Cooperative Research Centre for Landscape Evolution and Mineral Exploration, Australia on the use of calcrete and laterite as exploration sample media for gold and other commodities.

In April, 1999 AEG supported a workshop on MMI, which was organized by the Geological Society of South Africa. The workshop took place at the University of Witwatersrand, Johannesburg and was led by Dr. Alan Mann of the Geochemistry Research Centre, Bentley, Western Australia.

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TECHNICAL NOTE

Fiddling With Numbers...

by Don Berkman

Most exploration geologists enjoy tinkering with geochemical survey data, to obtain extra information. It is often a challenging process, and many further clues can often be found, in addition to thresholds and elemental correlations.

The procurement cost of a geochemical sample is surprisingly high, if all of the program costs are divided by the number of samples collected. We guess the average cost of collection of each sample is at least \$100, and can reach \$1000 for very remote sites. However, the sample can provide little benefit until it is analysed — the principal value of a geochemical sample is its chemical composition. Thus we suggest that it makes good commercial sense to 'squeeze' every piece of useful information from each sample, by determining all the useful elements in the first pass analyses. The extra cost incurred in analysing for a broad suite of elements is usually only a few dollars per sample, and the benefit far outweighs the small additional charge.

Analyses by Inductively Coupled Plasma (ICP) methods allow the determination of about 75 elements, including nearly all of the major rock-forming elements, and all of the commercial metals and their pathfinders. A careful selection from the long list of elements available can provide the explorer with a powerful database, from which the rock type, alteration style and mineralisation class can be indicated, and often precisely defined. In these times of tight budgets but continuing competition, an explorer needs to maximise the return from every exploration sample.

Determination of most of the major rock forming elements is available at modest cost and to geochemical accuracy (about $\pm 10\%$) by the common digestions and ICP methods. Only silicon is unavailable by ICP, and aluminium may not be determined to this level of accuracy. Determination of all rock forming elements, to an accuracy of $\pm 1\%$ is available at higher cost by a combination of instrumental and classical procedures.

This newsletter looks at selection of a suite of elements to be determined in several classes of geochemical samples, so that the maximum information is provided for minimum cost. It describes methods of identifying fresh and weathered rocks by their chemical composition, of discriminating between weathering and ore-associated alteration, and of identifying ore deposit types by their chemical signature. It does not describe changes to the mineral components of rocks which arise from diagenesis or regional metamorphism, on the basis that the change mud-shale-schist-gneiss does not, *sensu stricto*, involve a change in chemical composition.

Readers should be aware that many of the indices and guides presented herein are based on assumptions about the mineral composition of a sample, and in some situations these assumptions may be oversimplified. Nothing written here should be taken as a recommendation that orientation sampling and analyses are not necessary, or that we suggest use of a single alteration index.

Each section ends with a guideline, which summarises the information provided.

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Fiddling with Numbers...

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INDICATION OF ROCK TYPE

Rocks are classified by their texture into igneous, metamorphic and sedimentary groups, and by their mineral assemblage into individual types. Thus geological mapping by rock type is reasonably simple in areas with ample outcrops of fresh or slightly weathered rock — but difficult in regions of pervasive deep weathering, where the rock-forming minerals have been altered to clays and iron oxides. Most of Australia falls in this second class, and many of our geological maps can only show different classes of Recent cover.

The position is not entirely hopeless, as the chemical composition of residual soil, vegetation type and airmagnetic patterns can provide definitive clues to the underlying rock type. These indicators can be tied, by stratigraphic drill holes, to a rock type. The major element composition of a soil or saprolite, determined by chemical analysis, is often a reliable indication of rock type. With a modest investment in a few deeper exploration drill holes, carried down to recognisable basement, a rock name can be applied to most near surface and featureless materials. Comparison of the sample composition with a standard sequence can also define its position in the weathering profile.

Most geoscientists can crudely classify igneous rocks into classes by their trace and major element abundance. We conclude that rocks with a high iron, nickel and chromium content are probably of mafic or ultramafic types, and those with high uranium, vanadium and zinc content are probably of black shale. More complex indices have been invented, which involve some manipulation of the data. A simple example of this method of classification uses the level of major and common trace elements in igneous rocks as shown in Table 1 below.

The procedure is not limited to igneous rocks, and can be applied to weathered materials overlying any rock type.



Figure 1. The Colossi of Memnon, from Fagan (1977).

However, it may not provide useful information in interbedded sediments of widely different composition, such as sandstone and shale. A simple geochemical procedure for identifying igneous rock type in deeply weathered areas was established by Hallberg (1984), using the Ti:Zr ratio. The ratio is little affected by primary alteration or weathering, but is less reliable in the ferruginous and mottled zones of a laterite profile. For volcanic rocks the boundary values are rhyolite $< 4 <$ dacite $< 12 <$ andesite < 60 basalt. Ultramafic rocks cannot be discriminated from mafic rocks using the ratio, but are generally identified by their high Cr content.

This index is widely known and used. A current example is the identification of a single parent for the rhyolitic footwall rocks to the Thalanga massive sulphide deposit. These have been strongly altered to produce a variety of mineral assemblages showing sericite-chlorite-biotite-pyrite alteration, silicification, carbonate-calcsilicate alteration and pyritisation. Although the whole rock composition varies significantly,

the Ti:Zr ratios for all of these rocks is between 3 and 5 (Large, 1998).

Elemental ratios were recently used to solve an archaeological enigma, the origin of the 'quartzite' used for the Colossi of Memnon, in upper Egypt. The two colossi (Figure 1) are each about 20 metres high, and were placed side by side about 18 metres apart about 20 kilometres north of Luxor (Thebes). Each colossus was carved from a single 700 tonne block of silicified sandstone (locally known as quartzite), to produce massive seated figures of the Pharaoh Amenhotep III, who reigned in the 14th century BC. The colossi have had a difficult life, including attempts to destroy them and damage by an earthquake in 27 BC, which toppled the upper head of one. The Roman Emperor Septimus

AVERAGE COMPOSITION OF COMMON IGNEOUS ROCKS

	GRANITE	GRANODIORITE	SYENITE	DIORITE	GABBRO	PERIDOTITE
SiO ₂	72.1	66.9	59.4	51.9	48.4	43.5
TiO ₂	0.4	0.6	0.8	1.5	1.3	0.8
Al ₂ O ₃	13.9	15.7	17.1	16.4	16.8	4.0
Fe ₂ O ₃	0.9	1.3	2.2	2.7	2.5	2.5
FeO	1.7	2.6	2.8	7.0	7.9	9.8
MnO	0.1	0.1	0.1	0.2	0.2	0.2
MgO	0.5	1.6	2.0	6.1	8.1	34.0
CaO	1.3	3.6	4.1	8.4	11.1	3.5
Na ₂ O	3.1	3.8	3.9	3.4	2.3	0.6
K ₂ O	5.5	3.1	6.5	1.3	0.6	0.2
H ₂ O+	0.5	0.6	0.6	0.8	0.6	0.8
P ₂ O ₅	0.2	0.2	0.4	0.4	0.2	0.1

Table 1. Average composition of common igneous rocks, from Tables 7.2, 7.3 and 7.4 in Wedepohl (1969)

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Fiddling with Numbers... *Continued from Page 6*

Severus ordered the renovation of the colossi at the end of the 2nd century AD, after visiting the site. The repairers apparently found identical quartzite blocks, including a piece of about 50 tonnes used to repair the damaged head.

An American team identified the source of the original and replacement quartzite using geochemical analyses in the 1970s. After examining all known ancient quarries with access to the Nile, they were able to narrow the source to two areas, based on the calcium, magnesium and sodium content of the quartzite. The two possibilities were a Cretaceous sandstone near Cairo and an Oligocene sandstone near Aswan, about 900 kilometres apart.

The final solution was based on the Co and Eu content, expressed as Eu:Fe and Co:Fe ratios, which showed that the Cairo quarries were the source of the original colossi. Thus the ancient Egyptian masons had somehow (the mind boggles!) brought the two 700 tonne blocks upstream, for a distance of about 680 kilometres. The Roman renovators used the Aswan source, and only needed to bring their smaller blocks about 220 kilometres downstream (Glover, 1997).

GUIDELINE 1

Elements useful in defining rock type are Si, Al, Fe, Mn, Mg, Ca, Na, K, Ni, Cr, Ti and Zr. All except Si can be determined at low cost by a 'total' digestion of the sample using hydrofluoric, nitric and perchloric acids and a hydrochloric acid leach, followed by an ICP-AES analysis. Discrimination between rocks of apparently similar composition may need analyses for rare earth elements, available on the same solution by ICP-MS.

WEATHERING

Most exploration geologists have a par knowledge of alteration at atmospheric temperature and pressure, the pervasive and universal process commonly dismissed in our academic years as weathering. The efforts of the Cooperative Research Centre for Landscape Evolution and Mineral Exploration (CRC LEME) of the CSIRO Division of Exploration and Mining are beginning to fill this gap, but there is a long way to go. The critical ability we lack is a means of discriminating between 'ordinary' weathered rock, and mineralised altered rock, in which the changes due to hydrothermal ore emplacement processes are obscured by weathering effects. The discrimination is usually very difficult when logging drill hole cuttings, and examination with a hand lens doesn't help much.

Quantification of the major rock-forming elements can give an early discrimination between weathering and hydrothermal alteration. As a first step, it is essential to document the changes in composition due to weathering, by analysing weathered and fresh examples of the same rock type. Samples of all of the profile from deeply weathered to fresh rock in a few non-core drill holes will provide this database. Krauskopf (1967) provides an example of the chemical changes associated with weathering in Table 2.

The example was chosen for its simplicity, as it illustrates the changes in composition arising from weathering in a temperate climate. The compositional data show an early reduction in alkali and calc-alkali content, an increase in water content as clay minerals are formed, little movement of silica until the final stage, and a modest change in iron content.

These are the changes associated with formation of saprolite, and are carried much further in lateritisation, for which the end products are dominated by their iron and alumina content. When compared with the composition of fresh igneous rocks (Table 1), it can be seen that changes in the Ca, Mg, K and Na content are the most distinctive.

CHEMICAL CHANGES ASSOCIATED WITH WEATHERING				
COMPONENT	1	2	3	4
SiO ₂	71.5	68.1	70.3	55.1
Al ₂ O ₃	14.6	17.3	18.3	26.1
Fe ₂ O ₃	0.7	3.9	1.5	3.7
FeO	1.6	0.4	0.2	2.5
MgO	0.8	0.5	0.2	2.5
CaO	2.1	0.1	0.1	0.1
Na ₂ O	3.8	0.1	0.1	0.1
K ₂ O	3.9	3.5	2.5	0.1
H ₂ O	0.3	5.6	5.91	0.4
Others	0.7	0.6	0.0	0.6

Table 2. Chemical composition of fresh and weathered quartz-feldspar gneiss, from Krauskopf (1967, p. 101)

Rock 1 is fresh and the degree of weathering generally increases from 2 to 4.

Continued on Page 8

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Fiddling with Numbers... *Continued from Page 7*

GUIDELINE 2

Most of the changes produced by weathering can be identified by analyses for Si, Al, Fe, Mn, Mg, Ca, Na, K, Ti and Zr. All except Si can be determined at low cost by the total digestion followed by ICP-AES, and the data are also useful for defining rock type, as explained in Guideline 1.

ALTERATION

Chemical methods of recognising hydrothermal alteration are gaining favour, and can be particularly useful in 'roadside' drilling programs, where the geological setting is often poorly known. The changes due to hydrothermal alteration can be related to the composition of hydrothermal fluids, as shown in Table 3.

If the down-hole chemical composition profile is known, to establish the usual changes associated with weathering, then the changes in composition caused by ore solutions can be recognised.

Tracing a chloritoid rock to its amphibolite, pre-mineralisation precursor and then to its pre-metamorphic basalt parent at Bronzewing is described by Phillips et al (1998). The procedure involved calculating a chemical balance, assuming that Ti, Zr, Nb, La, Ce, Sm, Eu, Ga, Tb, Yb and Y were immobile, which demonstrated a close similarity in composition between the amphibolite and the chloritoid rock. The procedure also showed major changes in the

COMPOSITION OF HYDROTHERMAL SOLUTIONS

COMPONENT	1	2	3	4
SiO ₂	>0.05	NA	NA	NA
Fe	1560	2290	298	NA
Mg	33	54	1730	570
Mn	1450	1400	NA	690
Ca	27,400	19,708	36,400	7,500
K	16,700	409	538	3,700
Na	53,000	76,140	59,200	19,700
Cl	151,000	157,000	158,200	46,500

*Values converted to oxides from ppm, calculating all Fe as FeO. Solution 1 is the Salton Sea geothermal brine, 2 is the Cheleken geothermal brine, 3 is an oilfield brine from central Mississippi, and 4 is a fluid inclusion in sphalerite from Creede, Colorado

Table 3. Composition* of three modern and one ancient hydrothermal solutions, from Skinner (1997, p.8).

level of mobile elements such as Si, Ca, K, Na and Sr, with the principal changes in the formation of the chloritoid being addition of Si and loss of Ca.

Investigation of the Lady Loretta Pb-Zn-Ag deposit by Large and McGoldrick (1998) has identified reliable indexes for stratiform, sediment hosted (SEDEX) deposits in dolomite-rich sedimentary basins. These are the alteration index (FeO + 10 MnO)/(FeO + 10 MnO + MgO) and the dolomite Mn content (MnO x 30.41)/CaO, with all values in ppm. The manganese content of dolomite shows the most consistent change, increasing from a regional background of about 0.2 wt% to about 4 wt% in the ore. Both indexes increase towards ore, across and along the strike — thus they can be used to identify permissive carbonate sequences and thence to focus exploration on favourable zones.

This index is a variant of the classic alteration index of Ishikawa et al (1976), calculated as 100MgO + K₂O/MgO + K₂O + CaO + Na₂O, which is about 90 for Kuroko type deposits.

Several indices of alteration in wall rock to Archaean lode-gold deposits in WA have been developed at the Key Centre for Strategic Mineral Deposits at The University of Western Australia, e.g. Eilu et al (1995). Applying several indices, and a range of pathfinder elements, maximises the chance of an ore search success. The commonest guides are the carbonation index, either CO₂/Ca or CO₂/[Ca+Mg+Fe-As-0.5(S-As)], the potassic alteration index (3K/Al), and the hydration index, H₂O/(H₂O+CO₂). Other common alteration indices are the sericitisation index (K₂O/K₂O + Na₂O) and variants of the 'magnesium number' (the Mg/Fe ratio, most commonly MgO/MgO + total FeO).

The useful elements in differentiating between weathering and hydrothermal alteration are summarised in Table 4.

GUIDELINE 3

Critical elements which can be readily determined by ICP, to differentiate between weathering and hydrothermal alteration, are the mobile elements Na, K, Ca, Mg, Fe, Mn, Sr, Cs, Li, Th, U and Ba, and the immobile elements Ti, Zr, Nb, Ta, Tl, Hf and Y. The preferred method for samples with a high Ba, Ti or Zr content is XRF.

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ELEMENTS CHANGED BY ALTERATION

TYPE OF CHANGE	GENERALLY MOBILE OR DEPLETED	GENERALLY MOBILE & ENRICHED	RELATIVELY IMMOBILE
Weathering	Ca, Mg, K, Na, Ba, Rb, Sr, Si, S, U	Al, Fe, REE	Ti, Zr, Nb
Ore-related alteration	Ca, Mg, Na	K, Mg, Fe, Cs, Rb, B, P, U, Th, Li, S, U	Al, Ti, Zr, Ta, Ti, Hf, Nb, Y, LREE

Table 4. The useful elements in differentiating between weathering and hydrothermal alteration.

DEPOSIT CLASS

Many 'false' nickel anomalies were drilled in the exciting days of the 'Poseidon' nickel boom of 1968-72, before a simple way of identifying the surface response of a nickel sulphide deposit was found. The problem arose because high Ni values in gossans capping nickel sulphide deposits could not be distinguished from the high Ni values in laterites developed on ultramafic rocks.

A reliable index was developed by Joyce and Clema (1974), which involves plotting ppm Cr versus ppm Cu x ppm Ni on log-log graph paper. In the published test case, 176 samples of gossan were analysed in a batch of 414 control samples, and only nine possible gossans were not correctly identified by the log-log scattergram.

Identification of SEDEX Pb-Zn-Ag deposits is possible by using the Zinc Ratio of Huston and Large (1987). The ratio, calculated as the mean of the assays of at least 15 ore samples, is $100 \text{ Zn}/(\text{Zn} + \text{Pb})$, and is within the range 60-77 with a standard deviation less than 15 for SEDEX deposits. Other types of Pb-Zn deposits have a Zinc Ratio of 39-61, and a standard deviation of +26. The index was later amended to a SEDEX metal index ($\text{Zn} + 100 \text{ Pb} + 100 \text{ Tl}$) by Large and McGoldrick (1998).

Skarn mineralisation can be identified by the trace element composition of magnetite, a typical skarn accessory mineral. Common substituting elements in the magnetite lattice include Au, Ag, As, Cu, Ni, Zn, W, Ti, Al, Cr, Ca, Mn and Mg, and possibly Ga and Sn. Skarn-derived magnetite commonly has lower Ca, and higher Mg, Mn and Zn values when compared with magnetite from granitic and volcanic rocks, which generally have higher Cr, Ti and V values (McQueen and Cross, 1996).

GUIDELINE 4

Elements readily detectable by ICP, which may indicate the style of mineralisation, are Ag, As, Ba, Bi, Cd, Co, Cr, Cu, Li, Mn, Mo, Ni, Pb, Sb, Se, Sn, Sr, Te, Th, Ti, Tl, U, V, W, Y and Zn.

PATHFINDERS

Analyses for the elements commonly associated with an ore mineral can serve several purposes. The zone of primary dispersion of some pathfinders is much larger than the ore zone,

and thus the haloes for these more mobile elements present a larger exploration target. The lead and zinc mineralisation peripheral to a porphyry copper deposit is a well known halo of this type.

Most explorers are convinced that gold is the best indicator of gold mineralisation, but many also accept that the relatively inexpensive determination of a few other pathfinders is a useful check and confirmation. Pathfinders for gold deposits include As, Bi, B, Ca, Cu, Hg, Mo, Se, Ag, Te, Sn and W, of which As, B, Bi, Cu, Te and W are most commonly used.

An example is the delineation of greenstone belts favourable for nickel deposits in the Sir Samuel area of WA by *Kojan et al* (1996). Samples of regolith from mineralised greenstone belts in the Sir Samuel 1:250 000 sheet area were found to contain elevated Ni, Cr, Cu and V, when compared with samples of regolith from unmineralised belts. The same study found that a 'greenstone chalcophile index value', which is an indicator of gold mineralisation, could be calculated from the As, Bi, Mo, Sb, Sn and W values.

Exploration for base metal deposits is simpler, and direct analysis for copper, lead, zinc and nickel has guided the discovery of the dozens of major discoveries on which our industry has grown in the last 40 years. In these exploration programs the pathfinder abundance reinforces the validity of signs of ore. We are comforted when a copper anomaly is associated with high zinc values, or a lead anomaly is accompanied by high silver and cadmium analyses.

A less familiar example is the extensive dispersion of iron, manganese, thallium and zinc beyond the ore limits at the Lady Loretta lead-zinc deposit (Large and McGoldrick, 1998). Anomalous values for all four indicator elements extend beyond the orebody margins for at least 100 metres up and down section, and zinc anomalism in the host carbonate-bearing sediments extends for up to 1.5 kilometres along strike.

Selection of an appropriate suite of trace elements may begin with one of the lists of pathfinders, such as those in Berkman (1995, p. 56) or in Rose, Hawkes and Webb (1979, p. 27). The relative mobility of each element should be considered, and each of the elements selected should be tested for efficiency as an ore indicator by an orientation survey.

GUIDELINE 5

Analyses for an appropriate suite of pathfinder elements, in addition to the ore metals, can define promising areas at low cost, detect a mineralised halo at some distance from ore, confirm a direct indication of mineralisation and indicate the style of mineralisation.

PROCEDURES

Identification of an element or several elements that are definitely immobile in the project area is an essential first step in the chemical study of alteration. This begins with the selection of several probable immobile elements (perhaps Ti, Zr, Nb, Y, Sc and Th) and plotting their values against the values for probable mobile elements (perhaps Ca, Mg, K and Na). A definite immobile-mobile pair will plot on a simple binary graph as a strongly correlated straight line, which passes through or near the origin.

The immobile-mobile graphs can then be easily plotted using simple software, of which the Chart Wizard in Microsoft Office 97 is the commonest. Many other diagrams can then be

Continued on Page 10

Fiddling with Numbers... *Continued from Page 9*

constructed, following the methods shown in MacLean and Barrett (1993).

GUIDELINE 6

Mobile and immobile elements can be defined by simple plots of assumed mobile versus assumed immobile elements.

This article was commissioned by Australian Laboratory Services (ALS) and written by Don Berkman as part of an extensive series of articles called "ALS NEWS" which ALS provides to its customers to add value to their geochemical data. For further details, please contact ALS at one of the sites listed in their advert in this volume of **EXPLORE**.

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CALENDAR OF EVENTS

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

■ March 6-9, 2000, **Annual meeting of Society for Mining, Metallurgy, and Exploration (SME)**, Salt Lake City, Utah. INFORMATION: Shaffer Parkway, P. O. Box 625002, Littleton, Colo., 80162-5002, 303-973-9550. E-mail: smenet@aol.com.

■ March 13-15, 2000, **Northwestern GSA Sectional Meeting**, New Brunswick New Jersey. INFORMATION: Robert E. Sheridan, e-mail: rsheridn@worldnet.att.net.

■ March 23-24, 2000, **Southeastern GSA Sectional Meeting**, Charleston, South Carolina. INFORMATION: Michael P. Katuna, e-mail: kautnam@cofc.edu.

■ April 3-4, 2000, **South-central GSA Sectional Meeting**, Fayetteville, Arkansas. INFORMATION: Doy L. Zachry, Jr., e-mail: dzachry@comp.uark.edu.

■ April 16-19, 2000, **8th International Symposium on Experimental Mineralogy, Petrology and Geochemistry (EMPG VIII)**, Bergamo, Italy. INFORMATION: EMGG VIII Organizing Committee, Dipartimento Scienze della Terra, Università di Milano, Via Botticelli 23, 20133 Milano, Italy. WWW: <http://imiucca.csi.unimi.it/~spoli/empg.html>.

■ April 17-18, 2000, **Rocky Mountain GSA Sectional Meeting**, Missoula, Montana. INFORMATION: Donald W. Hyndman, e-mail: dhyndman@selway.umt.edu.

■ April 24-28, 2000, **5th International Symposium on Environmental Geochemistry**, Cape Town, South Africa.

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Calendar of Events *Continued from Page 10*

INFORMATION: 5ISEG, Department of Geological Sciences, University of Cape Town, Private Bag, Rondebosch, 7701, South Africa, FAX 27-21-650-3783. Email: 5iseg@geology.uct.ac.za.

■ April 27–29, 2000, **Cordilleran GSA Sectional Meeting, Vancouver, British Columbia.** **INFORMATION:** Peter S. Mustard, pmustard@sfu.ca.

■ May 12-14, 2000, **Europe's major base metal deposits, Galway, Ireland.** **INFORMATION:** Leo Fusciardi, Irish Association for Economic Geology, Minorco Services Ireland, Ltd., Killoran, Moyne, Thurles, Co., Tipperary, Ireland, +353.504.54369. FAX: +353.504.45344, e-mail: lfusciardi@minorco.ie.

■ May 15-18, 2000, **Geology and ore deposits 2000: The Great Basin and beyond, Reno/Sparks, Nevada, USA.** **INFORMATION:** Geological Society of Nevada. 702-323-3500, ax 702-323-3599, e-mail: gsnsymp@nbgm.unr.edu.

■ May 21-24, 2000, **ICARD 2000, 5th International Conference on Acid Rock Drainage, Denver, Colo.** **INFORMATION:** SME, PO Box 625002, Littleton, Colo. 80162-5002. E-mail: davis@smenet.org.

■ May 30–June 2, 2000, **International Symposium on Environmental Issues and Waste Management in Energy and Mineral Production (SWEMP 2000), Calgary, Canada.** **INFORMATION:** Raj Singhal, P.O. Box 68002, Crowfoot Postal Out-let, 28 Crowfoot Terrace N.W., Calgary, AB, T3G 1Y0, Canada, phone (403) 241-9460, fax 403- 241-9460. *Continued on Page 12*

The 20th International Geochemical Exploration Symposium (IGES)

“Geochemistry and Exploration in Latin America”

Santiago de Chile - May 6th to May 10th, 2001

A wide-ranging and varied technical program is planned to attract the practicing exploration geologist to a forum for a frank interchange of ideas and models. Applications of Bleg, Rego Leach, Enzyme Leach and MMI have all proven of value in mineral exploration here in recent years. Applications of environmental geochemistry are also increasing rapidly in South America, including sampling the sea bed and water at mineral export ports. Discussion of these, as well as testing conventional stream sediment, soil and rock geochemistry, using broad ranges of low levels of less common elements that are now available due to rapid strides made in instrumentation, is proposed.

In South America, multidisciplinary approaches continue to dominate the exploration scene with exploration geochemistry as one of the principal tools. The search for major copper and gold ore bodies in the Andes has rapidly evolved from the targeting of outcropping deposits to finding those under cover, with several major successes in this world-class mining belt. Further east, the less rugged areas of Argentina and Bolivia are also yielding major finds while the Archaean shield and adjacent parts of Brazil also figure prominently on recent discovery lists in which geochemistry played a significant role, often with appropriate geology and geophysics.

The technical programme, including short courses and workshops will include, but not be limited to:

1. Exploration for concealed gold, diamond, porphyry copper and other base metal deposits. (Notable Chilean copper finds include La Escondida - the world's largest copper producer, Spence and the Ujina deposit at Collahuasi).
2. Methods and Case Histories.
3. Arid saline environment exploration geochemistry.

4. Port site sea water and sea bed geochemistry.
5. Exploration in deeply weathered areas empathizing partial extractions
6. Isotope geochemistry applied to ore search.
7. Industrial Mineral Exploration for Lithium, Iodine, Boron, Borates and Nitrates.
8. Geochemical Bridges : Environment and Exploration Applications.

A full slate of workshops will be held before the Conference begins.

Field trips emphasizing geochemical exploration are planned to include:

1. Covered and partly covered porphyry copper deposits in Chile.
2. Weakly mineralized tops of high sulphidation gold deposits in the Maricunga and El Indio belts of Chile and Argentina.
3. Skarn deposits of the Tintaya area of Peru and the Cuzco area.
4. Several low sulphidation gold deposits of the Andes.
5. Operating lithium, nitrate and borate mines in Chile and Argentina.
6. Ore deposits and exploration geochemistry in Brazil.

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The Santiago LOC needs to know the extent of AEG member interest in various activities: please use the AEG Web site (www.aeg.org) and respond using the electronic form that is posted there.

Colin Brooks, General Chair
Peter Rogers, Registration Chair

Calendar of Events *Continued from Page 11*

■ May 31, June 3, 2000, **AGU Spring Meeting**, San Francisco, CA. INFORMATION: AGU Meeting Department, 2000 Florida Ave., NW, Washington, DC 20009, TEL: 202-462-6900. FAX: 202-328-0566. E-mail: meetings@kosmos.agu.org.

■ August 6-17, 2000, **31st International Geological Congress**, Rio de Janeiro, Brazil. INFORMATION: Secretariat Bureau, Casa Brazil 2000, Av. Pasteur, 404 Urca, Rio de Janeiro-RJ-Brazil, CEP 22.290-240, phone 55 21 295 5847, fax: 55 21 295 8094. E-mail: 31igc@31igc.org, <http://www.31igc.org>.

■ August 30–September 1, **Geoanalysis 2000: 4th International Conference on the Analysis of Geological and Environmental Materials**, Abbaye des Prémontrés, Pont à Mousson, Lorraine, France. INFORMATION: Jean Carignan, CRPG-CNRS, 15 rue Notre Dame de Pauvres, B.P. 20, 54501 Vandœuvre-lès-Nancy cedex, France, phone 33-3-83-59-42-17, fax 33-3-83-51-17-98.

■ September 3-8, 2000, **Goldschmidt 2000**. Oxford, UK. INFORMATION: P. Beattie, Cambridge Publications, Publications House, PO Box 27, Cambridge, UK CB1 4GL. TEL: 44-1223-333438, FAX: 44-1223-333438, E-mail: gold2000@campublic.co.uk.

■ November 13-16, 2000, **Annual Meeting of the Geological Society of America**, Reno, Nev. INFORMATION: TEL 1-800-472-1988, meetings@geosociety.org.

■ December 14 - 19, 2000, **Pacificchem 2000**, Honolulu. INFORMATION: Congress Secretariat, c/o American Chemical Society, 1155 16th St. N.W., Washington, D.C. 20036, fax: 202-872-6128. E-mail: pacificchem@acs.org.

■ December 15-19, 2000, **AGU Fall Meeting**, San Francisco, CA. INFORMATION: AGU Meeting Department, 2000 Florida Ave., NW, Washington, DC 20009, TEL: 202-462-6900. FAX: 202-328-0566. E-mail: meetings@kosmos.agu.org.

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

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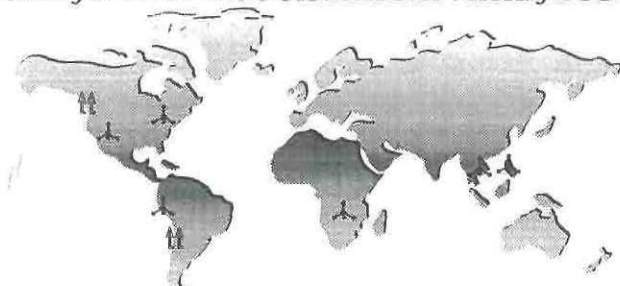
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• Group 1F 35 Element Ultratrace	\$16.65	\$12.85
• Group 3B Au-Pt-Pd Geochem	\$12.00	\$9.25
• Group 4A Whole Rock ICP	\$14.00	\$10.80
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ELECTION RESULTS NEW COUNCILORS

The ballots have been counted and the results approved by Council. The new Councilors for 2000-2001 are: Richard Carver, David Cohen, Philippe Freyssinet, David Garnett, and Todd Wakefield. Past-President Erick Weiland will serve *ex officio*.

We thank Andrew Bajc and Eric Hoffman, and the new Councilors for offering their services.

Shea Clark Smith
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RECENT PAPERS

This list comprises titles that have appeared in major publications since the compilation in **EXPLORE** Number 105. 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 (CGS Paper) and Open File Report (GSC OFR); Bulletin of the Canadian Institute of Mining and Metallurgy (CIM Bull); Transactions of Institute of Mining and Metallurgy, Section B: Applied Earth Sciences (Trans. IMM). Publications less frequently cited are identified in full. Compiled by **L. Graham Closs**, Department of Geology and Geological Engineering, Colorado School of Mines, Golden, CO 80401-1887, Chairman AEG Bibliography Committee. Please send new references to Dr. Closs, not to **EXPLORE**.

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AEG-SPONSORED WORKSHOP

Geochemical sampling methods to detect buried ore deposits:

Gary Baschuk and Richard Wells collect soil samples over Barrick's Rodeo deposit on the Carlin Trend in Northeast Nevada for the Nevada Selective Leach Orientation Survey. The Rodeo headframe and Barrick's roaster complex are in the left background.

This AEG-sponsored workshop co-chaired by S. Clark Smith, Ken Lovstrom, and Todd Wakefield to be presented May 13-14, 2000 in Reno, Nevada is part of the Geological Society of Nevada's Symposium 2000. The cost is US\$150 which includes a proceedings volume, lunch and snacks. A social evening poster session is also being planned. We anticipate 50 to 100 in attendance, including a long list of "experts". Make plans now to be a part of this important discussion on ion migration from deeply buried mineralization.

THEME:

Several popular geochemical methods currently in use in the Great Basin and other semi-arid and arid environments of the world detect bedrock mineralization at depths of tens to hundreds of meters from the surface. These methods include partial and selective leaches, biogeochemistry, soil gas geochemistry, hydrogeochemistry, geomicrobiology, and electrochemistry. Collectively, these non-conventional geochemical methods will likely be responsible for major discoveries in the 21st century.

The focus of this shortcourse/workshop will be interdisciplinary presentations from a wide range of experts with a central theme of determining how ions migrate from deep ore through (barren) overburden to the surface where they can be chemically detected. Invited experts will co-mingle with attending experts to discuss where these methods work, how they work, and ultimately why they work.

Case histories will abound, and every attendee will be encouraged to present examples where multiple, integrated techniques (including geology and geophysics) have been utilized. These informal 20 minute presentations (overheads & chalk boards) will be followed by a thorough discussion of the theoretical implications led by the experts. Discussion will touch on aspects of sampling, preparation, analysis, and quality assurance, with special emphasis on techniques of data interpretation.

This workshop will also be the venue for the Nevada Selective Leach Orientation Survey, organized by Todd Wakefield. Approximately 100 soil samples will be taken over each of five buried gold deposits in Nevada (SSX, Rodeo, Achimedes, Ken Snyder, and Mike). The results from several selective leach methods will be displayed, discussed, and compared to the geology as presented by geologists who know each site. For further details, please contact Todd Wakefield.

TOPICS and SPEAKERS:

Partial & Selective Leaches:

Dave Kelley (WMC)
Dave Seneshen (WMC)
Todd Wakefield (Consultant)
Mary Doherty (BHP)

Soil Gas:

Patrick Highsmith (ALS-Chemex)
Jeff Jaacks (Consultant)
Ron Klusman (Colorado School of Mines)
John Lovell (Inspectorate / Barringer)
Paul Lechler (Nevada Bureau Mines & Geology)
Patty & Warren Rehn (Quicksilver Systems)

Biogeochemistry:

Colin Dunn (Consultant)
Ken Lovstrom (Consultant)
Shea Clark Smith (Consultant)

Geomicrobiology:

Nancy Parduhn-Jackson (Consultant)
Gordon Southam (N. Arizona University)

Electrochemical:

Robert Jackson (Newmont)

Hydrogeochemistry:

Erick Weiland (Consultant)

Continued on Page 16

AEG-Sponsored Workshop

Continued from Page 15

A FEW PROPOSED TITLES:

"Seasonal variation in soil, sagebrush, and soil gas determinations: Implications for element mobility and dispersion processes in the Great Basin" — *Mary Doherty*

"Organic gas signatures over sediment hosted gold deposits" — *Jeff Jaacks*

"Plants, the ultimate selective leach" — *Colin Dunn*

"The potential role of water vapor and carbon dioxide as carriers for ultratrace gases and colloid-sized particulates: Results of computer modeling of flow velocities and flux rates" — *Ron Klusman*

"The potential use of bacterial signatures in exploration" — *Gordon Southam*

Please contact the co-chairmen for further information, and sign-up at the GSN Website:

<http://www.seismo.unr.edu/GSN>

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to the Association of Exploration Geochemists
 Please complete the section relevant to the class of membership sought and supply your address on this form.
 Mail the completed application, together with annual dues, to the address below.

MEMBER

I _____ wish to apply for election as a Member of the Association of Exploration Geochemists. I am presently employed by:

_____ as a _____
 (employer) (employment title)

I am actively engaged in scientific or technological work related to geochemical exploration and have been so for the past two years. Upon receipt of the Code of Ethics of the Association I will read them and, in the event of being elected a Member, agree to honour and abide by them. Witness my hand this _____ day of _____ 19_____.

(Signature of applicant)

STUDENT MEMBER

I _____ wish to apply for election as a Student Member of the Association of Exploration Geochemists. I am presently engaged as a full-time student at _____, where I am taking a course in pure or applied science. Upon receipt of the Code of Ethics of the Association and in the event of being elected a Student Member agree to honour and abide by them. Witness my hand this _____ day of _____ 19_____.

(Signature of applicant)

Student status must be verified by a Professor of your institution or a Fellow of the Association of Exploration Geochemists. I certify that the applicant is a full-time student at this institution.

(Signature)

(Printed Name and Title)

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(to be completed by all applicants)

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Annual Dues

All applications must be accompanied by annual dues. Select one or two below:

1	2000 member dues	US\$	70	_____
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	If your check is not drawn from a U.S.A. or Canadian bank, add		15	_____
	TOTAL			_____

All payments must be in US funds. Payment by check, International Money Order, UNESCO Coupons, International Postal Orders, VISA and Master Card are acceptable. For users of VISA or Master Card, minor variations in your billing may reflect currency exchange rate fluctuations at time of bank transaction.

If you pay by charge card, please provide the following information: type: Master Card _____ VISA _____

Credit card account number: _____ Expiration date: _____

Name: _____ Signature: _____

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

Association of Exploration Geochemists, P.O. Box 26099, 72 Robertson Road, Nepean, Ontario, CANADA K2H 9R0
 TEL: (613) 828-0199, FAX: (613) 828-9288, email: aeg@synapse.net

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

FROM THE EDITORS

This is our last issue as Editors of **EXPLORE**. Having served under six Presidents, it is time for new leadership and ideas for this Newsletter. We have enjoyed the friendship of 'pen pals' around the world, and we thank the many members who have contributed to **EXPLORE**. Many good things have happened over these years. In our first years, FAX was a major tool (and annoyance, requiring that text be keyed into the PC). The emergence of email has been a boon to communication, and our friends Down Under use it so well that they seem to live down the hall. The development of high quality color printing, at reasonable cost, has allowed us to present a number of issues that have included photos and geochemical maps in full color. The credit for color and countless other features that you see in print is due to Vivian Heggie, who continues to be at the heart of **EXPLORE**. Vivian knows many of you very well. We think she deserves to be given Honorary Fellow status for her contributions.

We are delighted that our colleague in Denver, Lloyd James, is taking over the lead. And we are pleased that several members have volunteered to be new Associate Editors. We know that Lloyd, the Associates, and Vivian, have the qualities to take **EXPLORE** to higher levels, and we hope that more of you will participate by providing news and technical papers. As our Presidents have been saying for years, AEG and **EXPLORE** are for you: reach out, contribute, and we'll all benefit.

Thank you, again, for your friendship and support over the years. We'll be here to help in smaller ways, and will hope to be in touch with you down the trail.

Sherm and Tom

J. Thomas Nash

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Deadlines for the Next Four Issues of **EXPLORE**

Contributors's deadlines for the next four issues of **EXPLORE** are as follows:

<u>Issue</u>	<u>Publication date</u>	<u>Contributor's Deadline</u>
107	April 2000	February 28, 2000
108	July 2000	May 31, 2000
109	October 2000	August 31, 2000
106	January 2001	November 30, 2000

NEW MEMBERS

To All Voting Members:

Pursuant to Article Two of the Association's By-Law No.1 names of the following candidates, who have been recommended for membership by the Admissions Committee, are submitted for your consideration. If you have any comments, favorable or unfavorable, on any candidate, you should send them in writing to the Secretary within 60 days of this notice. If no objections are received by that date, these candidates will be declared elected to membership. Please address comments to David B. Smith, Secretary AEG, USGS, Box 25046, MS 973, Denver, CO 80225, USA.

Editors note: Council has decided that all new applicants will receive the journal and newsletter upon application for membership. The process of application to the Nepean office, recommendation by the Admissions Committee, review by the Council, and publication of applicant's names in the newsletter remains unchanged.

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