EXPLORE

Newsletter for
the Association
of Exploration
Geochemists

NUMBER 108

JULY 2000

PRESIDENT'S MESSAGE

www.aeg.org

Paul Taufen

I'd like to take this opportunity to focus AEG membership attention on our Internet web page at www.aeg.org. Although we have made a good start with the web page we need to consider changes to make it more useful; a site we will all enjoy visiting and browsing. Some additions which have been proposed so far include:

- List of commercial laboratories with contact numbers and addresses.
- Current list of member names, postal addresses and email contacts, and an updated and downloadable version of the exploration geochemistry bibliography.
- List and descriptions of available exploration consulting services or individuals, with explanations of what particular skills and expertise parties have to offer.
- Periodic table of the elements with analysis methods available at the click of a mouse; a cross link to interesting geoscience web sites would serve to keep us current with parallel disciplines.
- Electronic file versions of EXPLORE, available to members.
- Section on member news and Regional Councilor reports.
- " Writing Geochemical Reports, Version 2" available as a PDF file to download when it is completed by Lynda Bloom later this year.
- On line membership fee payment.
- List of preferred software routines useful in the processing of exploration and environmental geochemical data. Some of these are quite inexpensive or even available at no charge, and could become available through the AEG web site.
- Software reviews likewise would be of interest, and a help to geochemists considering purchase of particular software packages.
- A "chat room" might be of interest to allow exploration geochemistry questions to be posed and answered. This could be available in a "members" section.

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TECHNICAL NOTE

Regional geochemical surveys in eastern and southern Africa – an overview

Introduction

An inventory of regional geochemical surveys in eastern and southern Africa was compiled by the International Institute for Aerospace Survey and Earth Sciences (ITC), and the NITG (Dutch Geological Survey) from 1996 to 1999. This program comprised part of the European Union (E.U.) sponsored Geoscience Data Compilation for Eastern and Southern Africa (GEODESA) Project. The GEODESA project is hosted by the Southern and Eastern African Mineral Centre (SEAMIC) in Dar es Salaam, Tanzania.

The objective of the geochemical inventory was to create a database containing descriptive information for all regional geochemical surveys previously conducted in the region, and for which data is held by the National Geological Survey Organizations in the region. The inventory was initiated, because most of the existing geochemical data in the region were difficult to access due to the lack of systematic cataloguing and proper data archiving procedures, and the fact that most of it was still in analogue/paper format.

In the initial phase of the program geochemical data held by the national geological survey organizations (Figure 1) were reviewed in order to determine their nature and extent (Figure 2). This was done with the cooperation of these organizations and involved extracting information from previous inventories, visiting data-archives and communication with staff geoscientists. In the second phase the technical details of the surveys, data formats and data locations were put in a Geographic Information System (GIS) database in order to make the information more accessible. The third phase involves digitizing the survey data, including geographic coordinates and chemical analyses, to facilitate data transfer, storage and use.

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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 regular mail to 7059 East Briarwood Drive, Englewood, CO 80112, USA. Only in rare situations should FAX be sent (303-741-5199).

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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EXPLORE

Newsletter No. 108 JULY 2000
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EXPLORE is published quarterly by the Association of Exploration Geochemists, P.O. Box 25046, MS 973, Denver Federal Center, Denver, CO 80225.
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Type and layout of EXPLORE is handled by Vivian Heggie, Heggie Enterprises, Thornton, CO (303) 288-6540; <vjmheggie@uswest.net>

President's Message

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- Membership polls and votes on the web page. We could learn quickly how membership views critical issues affecting our association. This would allow AEG Council to be more responsive to membership views.

This is not an exhaustive list, and I invite readers to communicate what they would like to see on the AEG website. What would be useful to you and your work? I invite you to seriously consider this request for ideas on how the AEG website can be developed, and communicate your thoughts on web page improvements to:

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Let's create a web site we will want to surf!

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Regional Geochemical Surveys…

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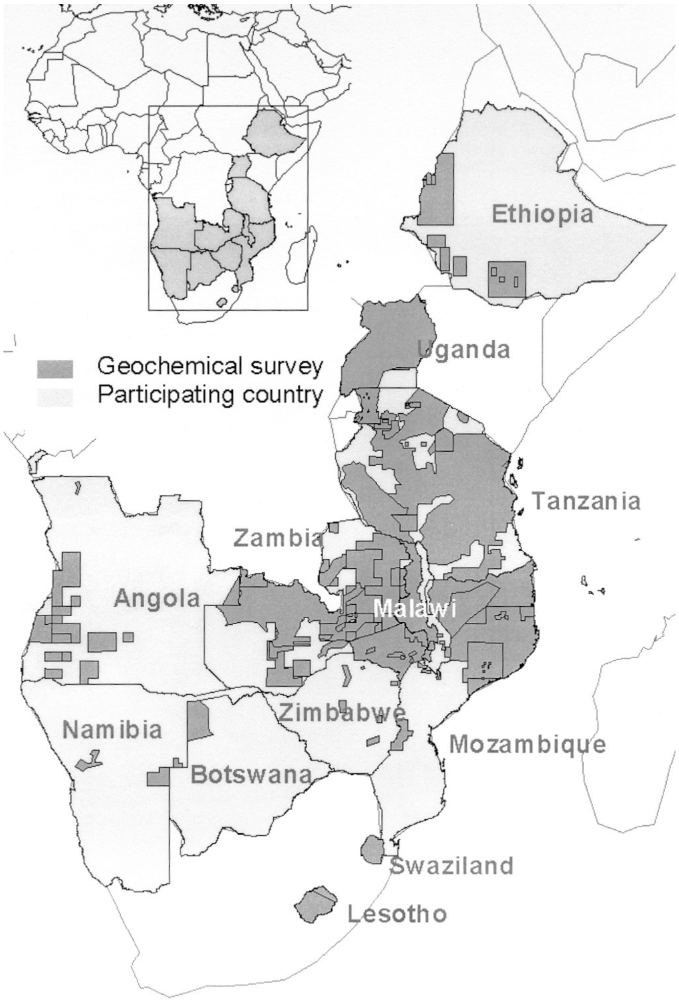

Figure 1: Regional geochemical survey coverage in eastern and southern Africa

The information that is presented in this paper is derived from the second phase of the program.

Regional geochemical surveys

Information was collected on 120 regional geochemical surveys mostly carried after 1970 by local and overseas geological survey organizations, private companies, and aid agencies. Overseas geological survey organizations involved included the British Geological Survey (BGS), in Zimbabwe and Zambia; the German Bundesanstalt fur Geowissenschaften und Rohstoffe (BGR) in Uganda and Tanzania; and the French Bureau de Recherche Geologique et Minieres (BRGM) in Uganda, Mozambique. Aid agencies active in the area include the United Nations Development Program (UNDP) in most of the regional countries, the Japanese International Cooperation Agency (JICA) in Zimbabwe and Malawi, and the Canadian International Development Agency (CIDA) in Swaziland.

Exploration targets included base-metals and gold as well as carbonatites and kimberlites. Prior to the early 80's samples were commonly only analyzed for a small suite of elements, including Co, Cu, Ni, Pb, Zn and a few others, depending on the exploration target. In more recent surveys most samples were analyzed by multi-element techniques. For a summary of some survey details see figure 2.

It is not possible to create a database containing all geochemical data collected in the region, as private companies have not always released data to the local Geological Survey Organizations. Even when they do they sometimes require that it remain confidential, at least for a specific period of time.

Data Quality

The quality of the geochemical data ranges from good to poor. Inadequate descriptions of the sampling and analytical procedures is the most common problem. This information is often no longer retrievable. This is unfortunate as information regarding sample size fractions analyzed, methods of decomposition, detection limits, analytical precision and accuracy, and descriptions of quality control procedures (duplicates, standards, etc.) is a prerequisite for effective interpretation of geochemical data.

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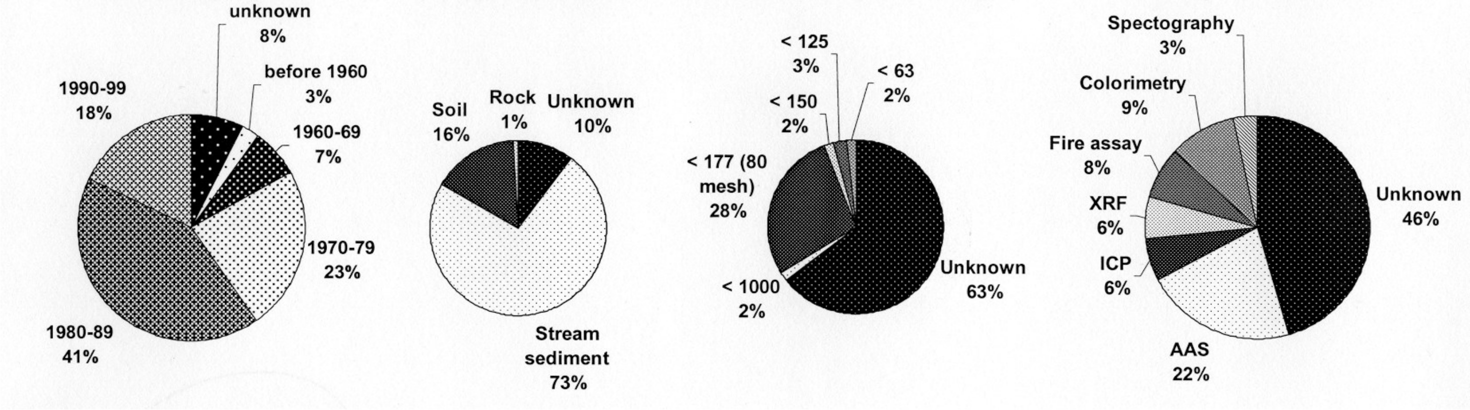
Figure 2: Technical details of the geochemical surveys



Regional Geochemical Surveys…

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In some of the older surveys, samples were analyzed with less accurate and precise analytical methods, including DC Arc-Emission Spectroscopy (DC-AES). However, although these analyses are usually of lower quality than those achievable today, they can still be used to study the broad distribution trends of several elements. Inconsistencies between different batches of analyzed samples are of concern in some of the large surveys. The spatial accuracy of the sample location coordinates appears to be generally good because the majority of sample locations were originally plotted on base maps derived from government topographic maps. This does of course assume relatively high levels of navigation skill and map accuracy. Spatial accuracy is probably less in cases where, prior to digitization, the data locations were re-plotted on to maps with different scales.

In general the overall quality of the geochemical surveys improved with time due to improvements in analytical techniques, quality control procedures, and documentation of the sampling and analytical procedures.

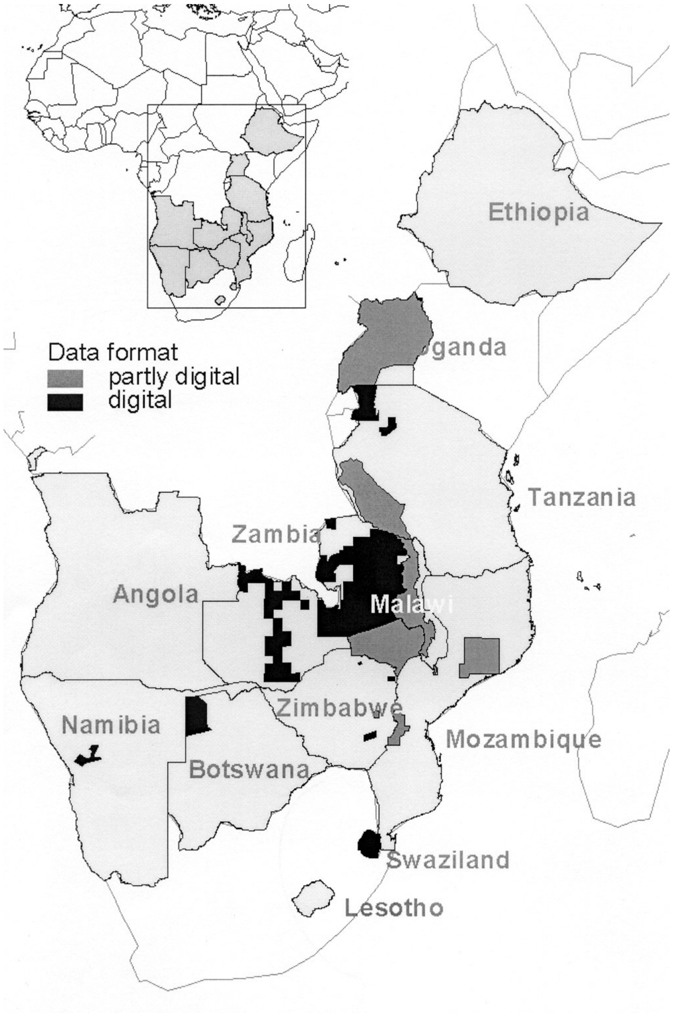

Figure 3a: Map showing the survey data that is (partly) in digital format.

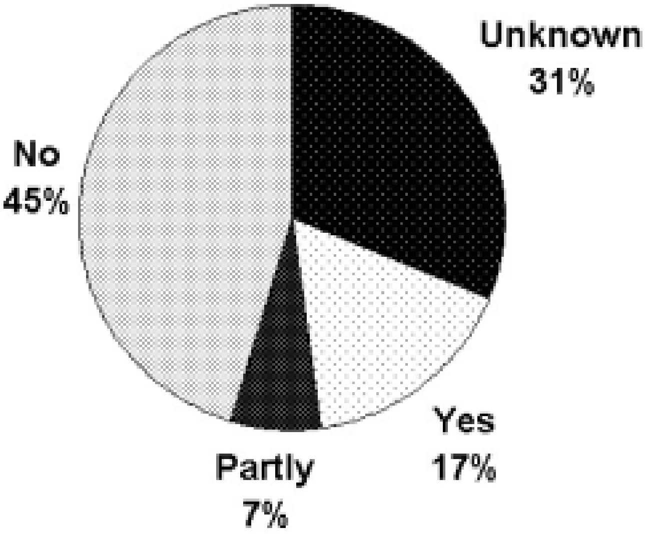

Figure 3b: Data in digital format

Summary

Regional geochemical exploration surveys that were conducted in fourteen eastern and southern African countries have been catalogued and put in a GIS. The catalogue improves the accessibility of the geochemical data of the region for exploration geochemists and other potential users. The quality of the geochemical data generally improved with time as a result of improvements in analytical techniques, QA/QC and proper documentation of sampling and analytical procedures. Significant progress has been achieved in the digitizing of the analogue geochemical data (Figures 3a and 3b). However, much work remains to be done.

In order to further improve the accessibility and use of the geochemical data, whenever possible, new geochemical data should be submitted in both digital and analogue formats to the national geological survey organization of the country in which it has been collected. The national surveys need to ensure that these data are properly catalogued and archived.

For more information about the inventory please contact either Geodesa@cats-net.com, the author, or consult the internet site: www.seamic.org.

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RECENT PAPERS

This list comprises titles that have appeared in major publications since the compilation in **Explore** Number 107. 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) 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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TECHNICAL NOTE

Analytical issues in groundwater studies

INTRODUCTION

The aim of this study was to develop a commercial approach to the analysis of groundwaters containing high levels of dissolved solids, typically found in parts of Australia and similar environments. Detection limits by ICP-AES for trace elements in a representative groundwater matrix were determined and cost-effective methods for improving detection limits through matrix separation investigated. Based on results from a study of the Black Flag district, Western Australia (Giblin and Mazzuchelli), a solution 3M with respect to NaCl and 0.3M with respect to $MgSO_4$ was used as a model system to represent a 'worst case' hypersaline groundwater. The total dissolved solids (TDS) concentration from Na, Cl, Mg and S for this sample is ~19.2%.

EXPERIMENTAL

This study was limited to the use of ICP-AES as the analytical technique. By the very nature of the sampling technique in ICP-MS, it is more sensitive to degradation by TDS than is ICP-AES. A general approach to TDS in ICP-MS is to limit these levels to £ 0.1-0.2%. The analytes measured by ICP-AES include: Al, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, La, Mg, Mn, Mo, Ni, Pb, S, Si, Sr, Ti, V, Y and Zn. All reagents used in this project were Baker (Phillipsburg, NJ, USA) 'analyzed-reagent' grade, and the concentrated nitric acid, glacial acetic acid and 30% ammonium hydroxide were Baker 'Instra-Analyzed'. Standard solutions employed for calibration were purchased from High Purity Standards (Charleston, SC, USA). Distilled, de-ionized water was used throughout. The ICP-AES analysis was carried out using a Perkin-Elmer Optima Model 3000DV spectrometer.

RESULTS

1. *Detection Limits using Simple Dilution*

Detection limits (DLs) at dilution factors of 500, 100, 50, 10, 5 and 1 were investigated for spiked solutions of the model groundwater sample (3M NaCl, 0.3M $MgSO_4$ in 1% HNO_3). These dilutions correspond to concentrations of 0.15, 0.76, 1.5, 7.6, 15 and 76 g/l, respectively, of Na and Mg ions. The data are given in Table 1. Calibration standards in 1% HNO_3 were employed. The DLs are based on the concentration of analyte equivalent to three times the standard deviation of 11 'blank' solutions of 1% HNO_3, and the groundwater sample (3M NaCl, 0.3M $MgSO_4$ in 1% HNO_3) at the different dilution factors. The DLs listed in Table 1 have not been multiplied by the dilution factor, in order to more efficiently compare the effect of decreasing the dilution factor on DLs for analytes in the groundwater sample. The Optima Model 3000DV ICP-AES can operate in dual mode, i.e. radial and axial plasma viewing. By viewing the plasma in the axial or "end-on" direction, a longer path length is obtained which produces higher analyte emission, improved sensitivity and up to a 5- to 10-fold improvement in DLs (Boss and Fredeen, 1989). However, along with this enhancement, there are increased spectral interference problems. Both plasma views were examined and are reported here. Other issues for ICP-AES analysis are

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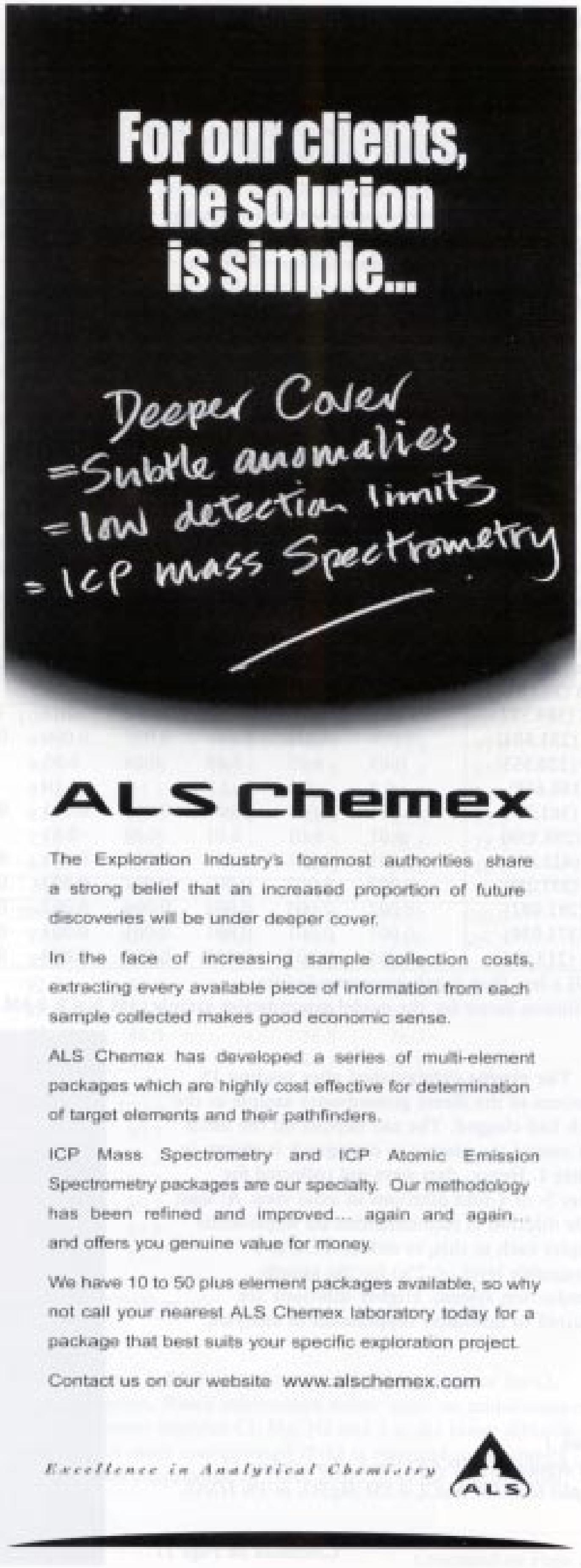

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suppression of analytes in the groundwater sample relative to the calibration standards, and clogging of the sample introduction system.

Table 1

Detection limits by ICP-AES (radial and axial plasma view), based on 3s of 11 'blank' solutions of 1% HNO_3, and the groundwater sample at different dilution factors (detection limits are not multiplied by the dilution factor)

	Detection limit# /ppm (mg ml^{-1})											
	RADIAL							AXIAL				
Matrix	**1% HNO_3**	**500x★**	**100x★**	**50x★**	**10x★**	**5x★**	**Direct★**	**1% HNO_3**	**500x★**	**100x★**	**50x★**	**10x★**
Element (l/nm)												
Al (308.215)	0.02	0.02	0.01	0.02	0.02	0.02	0.04	0.01	0.01	0.01	0.01	0.01
Ba (233.527)	0.001	0.001	0.002	0.002	0.003	0.004	0.03	0.001	0.001	0.001	0.001	0.001
Be (313.107)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Ca (315.887)	0.003	0.006	0.004	0.006	0.006	0.006	0.2	0.001	0.002	0.002	0.002	0.002
Cd (214.438)	0.001	0.001	0.001	0.001	0.001	0.002	0.004	0.001	0.001	0.001	0.001	0.001
Cd (226.502)	0.004	0.005	0.001	0.004	0.005	0.005	0.006	0.001	0.001	0.001	0.001	0.001
Cl (725.670)	80	80	81	96	260	400	6000	40	40	57	45	130
Co (228.616)	0.004	0.004	0.004	0.004	0.004	0.005	0.009	0.001	0.001	0.001	0.001	0.001
Cr (205.552)	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.001	0.002	0.003	0.002	0.002
Cr (267.716)	0.002	0.002	0.001	0.004	0.004	0.004	0.07	0.001	0.001	0.001	0.001	0.002
Cu (324.754)	0.002	0.002	0.003	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001
Fe (259.940)	0.003	0.002	0.002	0.002	0.003	0.002	0.03	0.001	0.001	0.002	0.001	0.001
K (766.491)	0.06	0.06	0.06	0.06	0.05	0.06	1	0.002	0.001	0.001	0.001	0.002
La (408.672)	0.002	0.003	0.003	0.002	0.003	0.002	0.007	0.001	0.001	0.001	0.001	0.001
Mg (279.079)	0.01	0.5	2	3	4	5	3	0.01	0.3	1.3	1.5	4
Mn (257.610)	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.001	0.001	0.001	0.001	0.001
Mo (202.030)	0.02	0.02	0.01	0.01	0.02	0.01	0.08	0.001	0.003	0.002	0.003	0.002
Na (589.592)	0.006	1	1.2	sat'd	sat'd	sat'd	sat'd	sat'd	sat'd	sat'd	sat'd	sat'd
Ni (231.604)	0.006	0.008	0.007	0.005	0.006	0.009	0.02	0.002	0.001	0.001	0.002	0.003
Pb (220.353)	0.03	0.05	0.05	0.04	0.05	0.04	0.09	0.01	0.01	0.01	0.01	0.01
S (180.669)	0.4	0.6	2.5	5	10	12	7	0.02	0.4	2	35	52
Sc (361.384)	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.001
Si (288.158)	0.01	0.01	0.01	0.02	0.01	0.01	0.5	0.004	0.003	0.004	0.004	0.004
Sr (421.552)	0.001	0.001	0.001	0.001	0.001	0.001	0.04	0.001	0.001	0.001	0.001	0.001
Ti (337.280)	0.002	0.002	0.002	0.002	0.002	0.002	0.01	0.001	0.001	0.001	0.001	0.001
V (292.402)	0.002	0.003	0.002	0.004	0.002	0.003	0.01	0.001	0.001	0.001	0.001	0.001
Y (371.030)	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.001	0.001
Zn (213.856)	0.001	0.003	0.005	0.002	0.003	0.002	0.004	0.001	0.001	0.004	0.001	0.001

DLs less than 1 ppb were rounded up

★ Dilution factor for the model groundwater sample (3M NaCl, 0.3M $MgSO_4$ in 1% HNO_3)

The plasma extinguished after reading 15 solutions of the direct groundwater sample as the torch had clogged. The salt deposit on the torch that caused the plasma to extinguish is shown in Figure 1. Hence, data were not collected for either 5- or 1-fold dilutions in axial view. At least a 10x dilution is recommended for hypersaline samples such as this, to reduce TDS to a manageable level (< 2%) for the sample introduction system. Higher dilutions are required to minimise suppression of analytes.

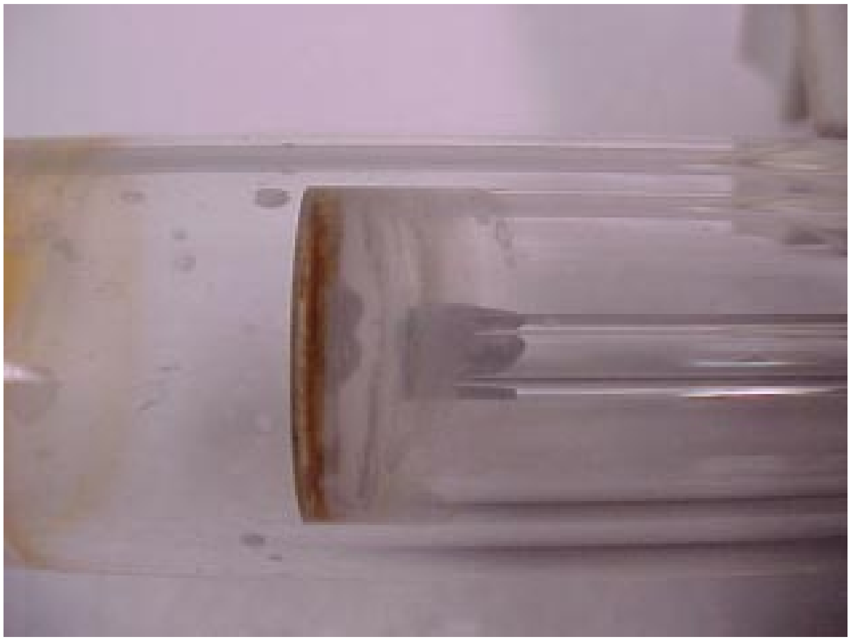

Figure 1
Salt deposit on ICP-AES torch after reading 15 samples with 3M NaCl, 0.3M $MgSO_4$ in 1% HNO_3

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In the presence of high dissolved salts, the plasma is much cooler and provides less energy for ionisation. This can result in inferior DLs, particularly for elements with emission wavelengths below 220 nm. The DLs in Table 1 for both plasma views remain relatively constant for the groundwater sample up to a 10-fold dilution (excluding the major analytes). These DLs also compare well to those obtained in 1% HNO_3. A more significant increase is observed for Ba (3x), Ca (2x), Cr-267.7nm (2x) and Zn (3x) in radial view, and for Ca (2x), Cr (2x) and Mo (2x) in axial view. As expected, DLs for the major analytes Cl, Mg, Na and S increase significantly as the dilution factor decreases. Sodium saturated the detector in radial view at dilution factors of less than 100, and it could not be determined at all in axial view as a result of its high sensitivity. In general, DLs using axial viewing are improved as a result of the increased sensitivity for analytes, although this improvement varies considerably from one element to another. The mean ratio for the DL using radial viewing to the DL using axial viewing is 4.65, with a maximum value 30 for K and a minimum value of 1 for a range of elements (Ba, Be, Cd, Mg, Mn, Sc, Sr, Y, Zn). Note, however, the inferior DLs for S using axial viewing at 50- and 10-fold dilution.

Despite the inferior DLs achieved using radial viewing, its major advantage over axial viewing is reduced spectral interference problems. This is an important consideration for groundwater analysis where the concentrations of interfering elements are high and can vary significantly. Data showing the suppression of analytes in spiked solutions of the groundwater sample at different dilutions relative to the calibration standards in 1% HNO_3, are given in Table 2 for radial view, and Table 3 for axial view. Analyte concentrations of 1 ppm (mg ml^{-1}), except for K, Na, S, Si (10 ppm) and Cl (1000 ppm), were used for both the calibration standards and spiked groundwater sample. Analyte drift during analysis was corrected for. Spike recoveries for the major analytes at low dilution factors could not be determined as the concentration of the spike was too low compared to its concentration in the groundwater sample.

Table 2

Recovery of analytes in spiked* groundwater samples (3M NaCl, 0.3M $MgSO_4$ in 1% HNO_3) at different dilutions, relative to calibration standards in 1% HNO_3 (radial view)

	Analyte Recovery (%)										
Matrix	**Al**	**Ba^1**	**Ba^2**	**Be**	**Ca**	**Cd^1**	**Cd^2**	**Cl**	**Co**	**Cr^1**	**Cr^2**
1% HNO_3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
500x	100.4	99.6	100.2	100.7	97.9	97.3	97.2	100.2	98.0	97.6	97.6
100x	98.5	98.3	100.2	98.4	95.6	94.5	94.3	105.3	95.6	95.4	95.5
50x	98.6	98.5	100.8	94.7	92.7	91.2	91.1	104.2	92.1	92.1	92.5
10x	95.8	50.1	52.2	86.8	84.2	82.2	82.6	88.4	84.4	85.6	85.5
5x	85.0	34.9	-	76.7	76.4	75.5	76.2	-	77.5	78.3	78.8
Direct	57.8	18.6	-	45.6	46.8	43.1	43.7	-	44.8	47.2	46.7
Matrix	**Cu**	**Fe**	**K**	**La**	**Mg**	**Mn**	**Mo**	**Na**	**Ni**	**Pb**	**S**
1% HNO_3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
500x	98.3	97.9	98.3	98.4	87.9	97.8	100.5	93.3	97.4	94.0	109.5
100x	96.2	95.9	98.2	96.1	-	95.5	99.6	-	94.8	92.9	-
50x	93.4	92.8	100.4	96.6	-	92.3	94.8	-	91.6	90.0	-
10x	88.4	85.3	100.6	90.7	-	85.2	88.9	-	83.1	83.9	-
5x	82.0	77.9	89.6	82.1	-	77.9	81.5	-	76.5	76.7	-
Direct	53.7	45.7	73.4	53.7	-	46.0	47.7	-	44.1	47.5	-
Element	**Sc**	**Si**	**Sr**	**Ti**	**V**	**Y**	**Zn**				
1% HNO_3	100.0	100.0	100.0	100.0	100.0	100.0	100.0				
500x	101.4	100.9	98.8	100.0	100.5	100.8	99.1				
100x	100.7	100.3	97.6	98.9	99.4	100.1	96.2				
50x	101.9	98.2	98.5	96.2	96.1	102.7	93.5				
10x	98.9	93.3	93.0	90.5	89.6	96.6	85.3				
5x	85.4	82.8	80.7	83.1	81.8	83.6	80.9				
Direct	55.2	54.5	53.5	50.7	49.4	53.9	51.7				

* Analyte spikes of 1 ppm were employed except for K, Na, S, Si (10 ppm) and Cl (1000 ppm)

In radial view, less than 5-10% suppression of the signal is observed at dilution factors of 500, 100 and 50, where the concentration of Na and Mg is 1.5 g/l or less. At 10x dilution (7.6 g/l Na and Mg) 10-20% suppression of most analytes occurs. At the limit of the hypersaline groundwater, about 50% of the signal for the 1% HNO_3 reference is achieved. The low Ba data at 10, 5 and 1 dilution factors are likely the result of $BaSO_4$ precipitation. Blank subtraction either over- or under-corrects for the major analytes Cl, Mg, Na and S at the lower dilution factors. A more concentrated spike is required to accurately determine suppression of these analytes at the low dilution factors.

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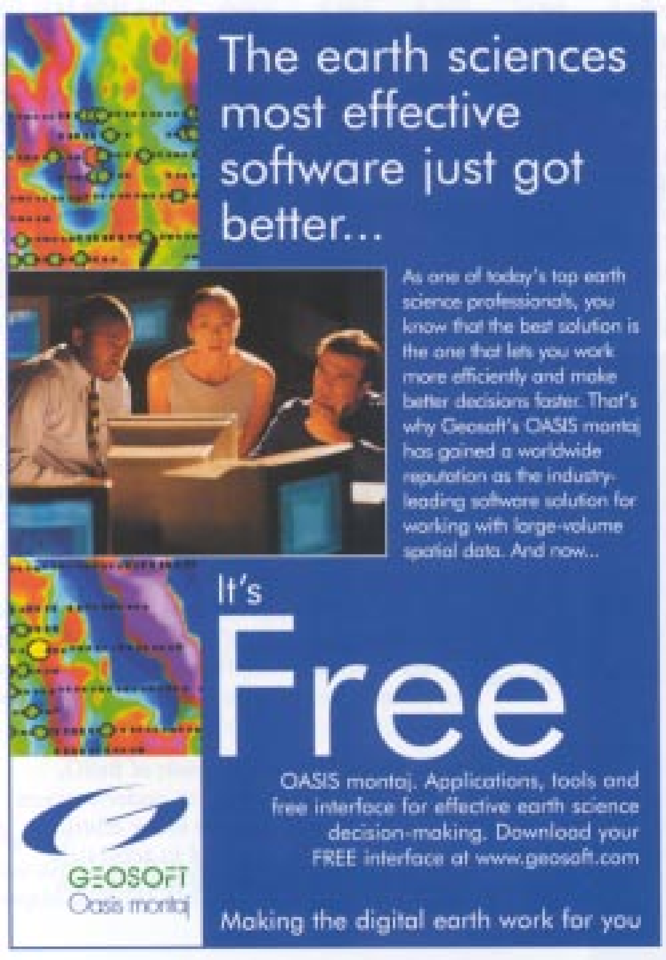
Table 3

Recovery of analytes in spiked* groundwater samples (3M NaCl, 0.3M $MgSO_4$ in 1% HNO_3) at different dilutions, relative to calibration standards in 1% HNO_3 (axial view)

	Analyte Recovery (%)										
Matrix	**Al**	**Ba**	**Ba**	**Be**	**Ca**	**Cd**	**Cd**	**Cl**	**Co**	**Cr**	**Cr**
1% HNO_3	100.0	100.0	-	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
500x	101.9	98.5	-	99.0	96.6	95.1	95.5	102.6	95.0	96.5	96.4
100x	104.1	97.4	-	96.7	94.0	91.2	92.4	102.1	91.4	94.1	94.6
50x	106.6	97.2	-	91.5	89.7	86.9	88.2	101.5	87.3	90.1	91.0
10x	102.5	26.5	-	83.1	80.3	75.7	78.6	95.9	76.3	81.5	83.6
Matrix	**Cu**	**Fe**	**K**	**La**	**Mg**	**Mn**	**Mo**	**Na**	**Ni**	**Pb**	**S**
1% HNO_3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	-	100.0	100.0	100.0
500x	101.7	95.0	-	97.3	90.5	95.0	98.5	-	96.7	95.3	107.5
100x	103.8	91.6	-	95.2	-	89.2	96.8	-	94.1	92.6	-
50x	102.4	87.3	-	95.4	-	85.1	92.3	-	89.8	88.3	-
10x	101.7	77.8	-	89.4	-	78.3	83.5	-	79.9	79.0	-
Matrix	**Sc**	**Si**	**Sr**	**Ti**	**V**	**Y**	**Zn**				
1% HNO_3	100.0	100.0	100.0	100.0	100.0	100.0	100.0				
500x	101.5	99.7	95.4	99.7	98.6	100.4	97.9				
100x	102.6	98.2	92.7	99.1	97.7	100.2	95.4				
50x	103.6	96.3	90.9	96.0	94.6	102.6	91.5				
10x	101.1	91.1	81.9	91.2	88.8	97.6	84.2				

* Analyte spikes of 1 ppm were employed except for K, Na, S, Si (10 ppm) and Cl (1000 ppm)



Using axial viewing, the suppression of analytes is somewhat enhanced in comparison to radial viewing, e.g. >20% for some elements at 10x dilution. There is an enhancement of K emission in axial view at all dilutions of the groundwater sample, most likely resulting from the high Na concentrations and the easily ionised element (EIE) effect. The EIEs are those elements that are ionised at lower temperatures than other elements (e.g. Li, Na and K). Work on the problem of EIEs in plasma-based analysis has been reported since the early eighties (Roederer et al., 1982, Gunter et al., 1985). In samples that contain high concentrations (>1000 ppm) of EIEs, suppression or enhancement of emission signals, depending on the analyte, can occur. Not only the EIEs, but other elements such as Ca, Mg and Fe may also cause similar interferences when present at high concentrations, but to a lesser extent (Ramsey and Thompson, 1985). Additions of Li or Cs can be used to control ionisation in the plasma and reduce the impact of EIE interferences (Faires et al., 1983). These additions would, however, obscure some of the geochemical data obtainable from samples. This was not examined in the present study, but could be considered in future groundwater studies.

RECOMMENDATIONS

- At least a 10x dilution is recommended for ICP-AES analysis of hypersaline groundwaters such as the model sample examined here, to reduce TDS to a manageable level (<2%) for the sample introduction system. The 3s DLs for the groundwater sample at 10-fold dilution compare reasonably well with those for 1% HNO_3 in Table 1.
- To minimise suppression of analytes (< 10%), a dilution factor of at least 25 is required for radial view ICP-AES analysis of the hypersaline groundwater (reducing the Na and Mg concentration to 3 g/l or less). In axial view, at least a 50-

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fold dilution is recommended. A summary of DLs using radial and axial viewing at 25- and 50-fold dilutions, respectively, is given in Table 4.

- The TDS concentration in the model sample (3M NaCl, 0.3M $MgSO_4$ in 1% HNO_3) from Na, Cl, Mg and S is ~19.2%. For ICP-MS analysis, a minimum dilution of 200x would be required to reduce TDS to 0.1%, thereby substantially degrading DLs. Molecular interferences resulting from high concentrations of Cl and S would also need to be considered when employing ICP-MS analysis.
- For ICP-AES analysis, radial viewing is recommended for samples where concentrations of analytes that contribute to interelement interferences are likely to be high and variable. Suppression of analytes is more evident in axial view. If the interfering element concentrations are likely to be relatively constant for a particular study, axial viewing could be considered, as it gives better sensitivity and DLs for most elements.

Table 4

Detection limits by ICP-AES for the model groundwater sample (3M NaCl, 0.3M $MgSO_4$ in 1% HNO_3) - detection limits include the dilution factor

Detection limit /ppm (mg ml^{-1})

ELEMENT	RADIAL 25x dilution	AXIAL 50x dilution	ELEMENT	RADIAL 25x dilution	AXIAL 50x dilution
Al	0.5	0.5	**Mg**	100	75
Ba	0.08	0.05	**Mn**	0.03	0.05
Be	0.03	0.05	**Mo**	0.05	0.2
Ca	0.2	0.1	**Na**	sat'd	sat'd
Cd^1	0.03	0.05	**Ni**	0.2	0.1
Cd^2	0.1	0.05	**Pb**	1	0.5
Cl	6500	2500	**S**	250	2000
Co	0.1	0.05	**Sc**	0.03	0.05
Cr^1	0.3	0.1	**Si**	0.3	0.2
Cr^2	0.1	0.05	**Sr**	0.03	0.05
Cu	0.08	0.05	**Ti**	0.05	0.05
Fe	0.08	0.05	**V**	0.05	0.05
K	1	0.05	**Y**	0.03	0.05
La	0.08	0.05	**Zn**	0.08	0.05

2. *Detection Limits using Chelating Resins for Matrix Separation*

Separation and pre-concentration of transition and/or rare-earth elements has been examined with the use of the MetPac® CC-1 chelating resin (Dionex Corp., Sunnyvale, CA, USA) in an automated mode prior to analysis by ion chromatography (Shiriraks et al., 1990) and ICP-MS (Hall et al., 1995, 1996). The purpose here is to examine alternative methods to the automated system in order to reduce capital outlay for commercial laboratories.

Two chelate resin minicolumns, Amberlite® IRC718 (1 g in 3 ml polypropylene filtration tube with polyethylene frit) from Rohm and Haas Co. (Philadelphia, USA), and Extract-Clean™ IC-Chelate cartridges (0.5 ml bed volume) from Alltech (Illinois, USA) were used to examine recovery of analytes and separation of matrix. The columns contain macroporous iminodiacetate chelating resins with capacities of 1.1 and 0.4 meq/ml, respectively. Mineral acids such as HCl and HNO_3 are effective eluants, however it is worth noting that HNO_3 and other strong oxidizing agents can cause explosive type reactions when mixed with ion exchange resins. Care should be exercised to prevent any rapid buildup of pressure when using concentrated solutions of nitric acid with these resins. The minicolumns are disposable and intended for single-use only. They can be used with a vacuum manifold for efficient operation.

The apparent selectivity of any ion exchange resin for a given metal depends upon its concentration, the presence of other species and pH. As a general rule, the relative selectivity of an iminodiacetate resin is: REEs>Hg>Cu>UO_2>Ni>Pb>Zn>Co>Cd>Fe>Mn>Ba>Ca>Sr>Mg>> Na. It is normally the free hydrated ion that is chelated by the resin; samples containing elements of interest bound as charged or neutral compounds, inorganic or organic complexes, or in colloidal form may need to be digested first if a total concentration is required. In the pH range of 5-6, the iminodiacetate resin selectivity is optimised for retention of the transition metals and REEs relative to the alkaline and alkaline-earth elements. Employing an ammonium acetate eluant in this pH range allows elution of alkali and alkaline-earth elements while the transition metals (and REEs) remain strongly bound. The resin does not bind anions such as halides, nitrate, sulphate, phosphate or organic anions. Although analysis in this work is by ICP-AES, in consideration of the future use of ICP-MS, the preferred eluant for analysis is nitric acid as opposed to hydrochloric or sulphuric acid, as molecular interferences are minimised for ICP-MS.

For ultratrace work, ultrapure acids would need to be used and the ammonium acetate would need to be pre-cleaned using chelate resin. Ammonium acetate, at 1.5M and pH 5.4 ± 0.1, was used as sample buffer and eluant and is prepared by diluting 91 g of acetic acid in ~400 ml of distilled de-ionized water, adding 71 g of 30% ammonium hydroxide and making up to 1000 ml with water. If necessary, the pH is adjusted to 5.4 ± 0.1 with additional acetic acid or ammonium hydroxide. The Amberlite® IRC718 resin was pre-cleaned in batch mode with 5% HNO_3 and water, and conditioned with 1.5M NH_4OAc before transferring ~1 g of resin to the 3 ml polypropylene filtration tubes. The IC-Chelate cartridges were pre-cleaned with 5 ml of 5% HNO_3 then 5 ml of water, and conditioned with 5 ml of 1.5M NH_4OAc. Synthetic solutions for chelation were prepared separately in 1% HNO_3, and the groundwater sample (3M NaCl, 0.3M $MgSO_4$ in 1% HNO_3) by spiking at analyte concentrations of 1 ppm (mg/ml), except for K, Na, S (10 ppm). The buffered sample (pH ~5.0) is prepared by adding 5 ml of sample to 5 ml of 1.5M NH_4OAc (pH 5.4), and is loaded onto the column. The alkaline and alkaline-earth elements are eluted with 5 ml of 1.5M NH_4OAc. The column is then rinsed with water to minimise the concentration of NH_4OAc in the final solution. The transition metals are eluted with 5% HNO_3. Recoveries of analytes through the chelation procedure were measured using calibration standards in 5% HNO_3. Elution profiles of the analytes were studied by collecting 1 ml fractions of the 5% HNO_3 eluant and analysing those by ICP-AES. Elution profiles for the elements of interest from the Amberlite® IRC718 resin are illustrated in Figures 2A and 2B for the spiked groundwater sample. Based on these results, the void volume (~1 ml) is discarded, and the following 5 ml is collected in a calibrated polypropylene centrifuge tube. Percent recoveries of spiked analytes for a 5 ml sample taken through the chelation procedure are given in Table 5 for the two minicolumns.

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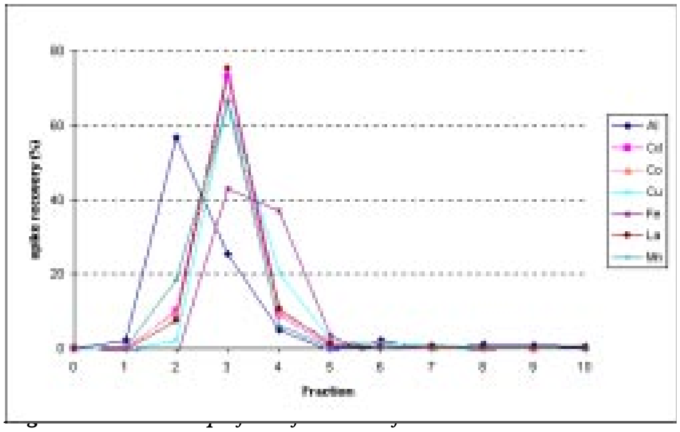
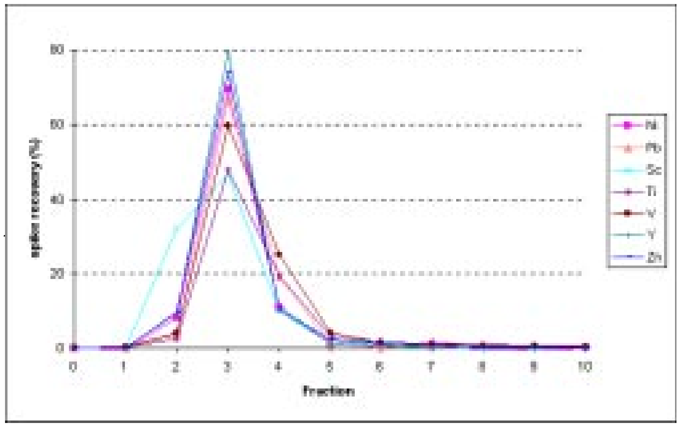
Table 5

Percent recoveries of spiked analytes for 5 ml sample taken through the chelation procedure (GW = 3M NaCl, 0.3M $MgSO_4$)

Element	Recovery (%) Amberlite 1% HNO_3	Amberlite GW 1% HNO_3	Alltech 1% HNO_3	Alltech GW 1% HNO_3
Al	91.3	96.3	84.2	86.5
Ba	97.9	4.6	28.8	20.1
Be	85.9	3.7	49.5	2.5
Ca	96.4	1.5	38.9	0.6
Cd	98.2	92.0	95.6	62.3
Co	92.7	95.9	92.3	99.2
Cr	47.0	0.7	8.7	2.2
Cu	94.9	94.9	92.6	98.8
Fe	73.3	62.1	62.7	37.7
La	95.8	82.0	96.6	55.0
Mn	99.2	58.4	87.6	32.2
Mo	29.1	81.4	23.7	82.5
Ni	96.1	94.8	91.2	98.5
Pb	99.6	87.5	92.2	65.8
Sc	91.6	95.3	88.7	87.0
Sr	94.7	1.5	26.0	0.6
Ti	71.4	57.6	64.4	57.6
V	94.0	94.1	90.9	96.3
Y	97.3	75.8	97.6	50.4
Zn	95.6	96.4	97.3	100.6



resin for spiked groundwater sample (3M NaCl, 0.3M $MgSO_4$ in 1% HNO_3)



resin for spiked groundwater sample (3M NaCl, 0.3M $MgSO_4$ in 1% HNO_3)

Recoveries for the majority of analytes in both matrices are higher for the Amberlite® resin. This may be a result of the small bed volume (0.5 ml) in the Alltech cartridges. A larger bed volume is available (1.5 ml), but at a higher cost (CAD\$10 vs. CAD\$4 per cartridge). Since the Amberlite® resin minicolumns are cheaper (< CAD\$1.50 per cartridge), easy to prepare, and produced better results for the elements of interest, this cartridge is recommended. Percent recoveries for the Amberlite® resin alone are shown in Figure 3.

Recoveries with the Amberlite® resin are in the range 92-97% for Al, Cd, Co, Cu, Ni, Sc, V and Zn in the groundwater sample. Mn, being weakly bound to the resin, shows poor recovery at 58%, down from 99% in 1% HNO_3. Surprisingly, Pb gives poor recovery in the groundwater sample at 88%, down from 99%, as does La (82% down from 99%) and Y (76% down from 97%). Recoveries of Fe and Ti show a decrease in the groundwater sample, but were also low in 1% HNO_3. This is likely a result of these elements being unstable in the buffered solutions (pH > 5) and could probably be improved by adding the buffer immediately prior to loading the sample onto the column. A relatively high but constant level of Fe (~0.7 ppm) was observed in all blank solutions taken through the Amberlite® resin, which was not improved by pre-cleaning the resin. This would increase the relative standard deviation of Fe recoveries. A more rigorous pre-cleaning procedure may improve this. It is likely that with subsequent refinement of the

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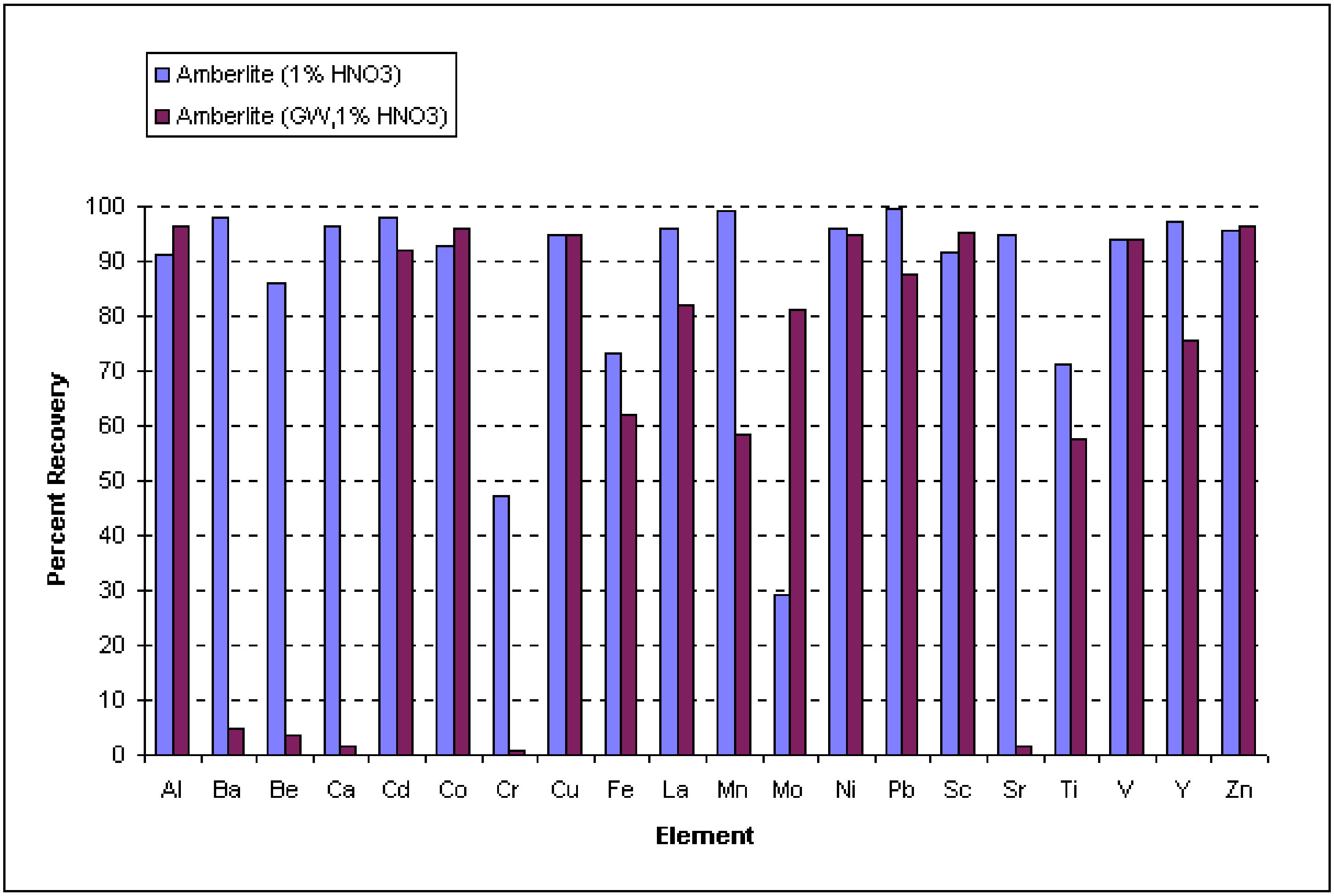

Figure 3 *Percent recoveries of analytes through chelation procedure with Amberlite® resin (GW = 3M NaCl, 0.3M MgSO*$_4$*)*

method and a more detailed study, analyte recoveries could be improved. Any low recoveries for the elements of interest in real samples could probably be compensated for by calibrating against standard solutions carried through the identical chelation procedure. The Cr and Mo are likely to be present as neutral and/or oxyanion species in solution and hence show poor recoveries, although surprisingly Mo shows better recovery in the groundwater sample at 81% compared to 29% in 1% HNO_3. If analysis of the REEs is of interest, the results above indicate that the Amberlite® resin minicolumns would also show good recoveries for these elements given that their selectivity for the resin is greater than that of the transition elements (Hall et al., 1995). The alkaline-earth elements Be, Ba, Ca and Sr, show high recoveries in 1% HNO_3 which decrease to < 5% in the groundwater sample. Less than 10% Mg (< 700 ppm) remained in the groundwater solutions after chelation. This may need to be improved by further elution with NH_4OAc, particularly if ICP-MS analysis is employed, but without compromising the recovery of the more weakly bound trace elements such as Mn.

To summarise, matrix separation and good recoveries of most trace analytes examined were achieved using the prescribed chelation method with Amberlite® IRC718 resin minicolumns. It is possible that with subsequent refinement of the method and a more detailed study, analyte recoveries could be further improved. This study does, however, demonstrate that the chelation procedure is a viable option for obtaining better detection limits for the analytes of interest via matrix separation.

RECOMMENDATIONS

- Matrix separation with Amberlite® IRC718 chelate resin minicolumns together with ICP-AES or -MS provides a cost-effective, rapid method for analysis of the trace elements Al, Cd, Co, Cu, Fe, Ni, Pb, Sc, V and Zn (and most likely the REEs) at close to instrumental detection limits in hypersaline groundwaters.
- The advantage of matrix separation for analysis of these elements in groundwaters is improved DLs since the dilution factor is eliminated, hence DLs for 1% HNO_3 in Table 1 could be obtained. Furthermore, suppression of analytes is eliminated.

ACKNOWLEDGEMENTS

Advice from J.E. Vaive and P. Pelchat on analytical method development and comments on the manuscript are much appreciated, as are the constructive reviews by G.E.M. Hall.

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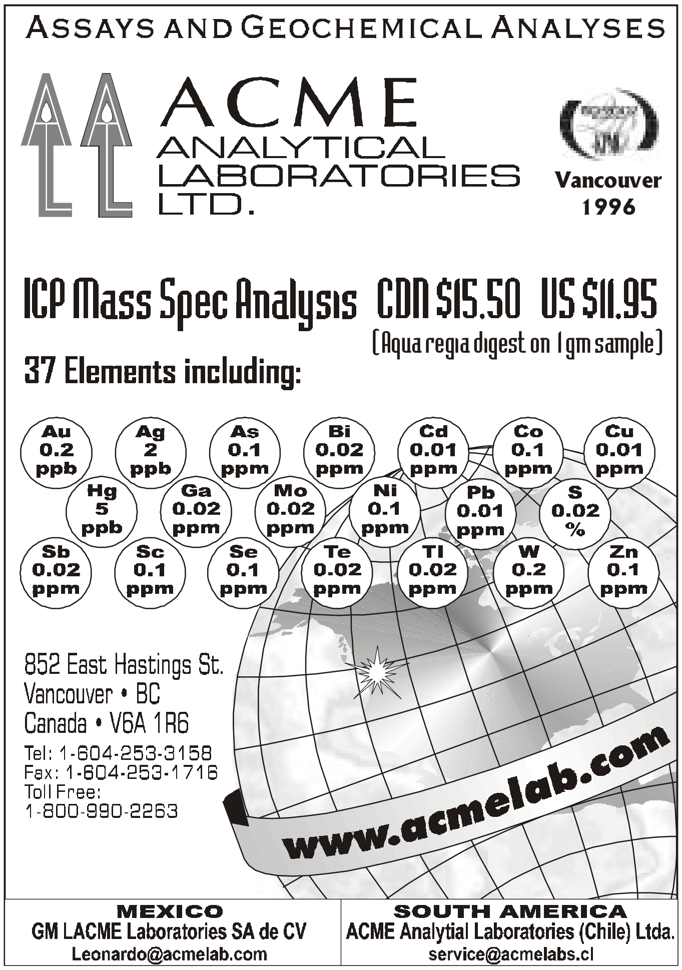

TECHNICAL NOTE - COMMENTS

Thallium Data for Soil

I just received the April # 107 issue of Explore with the very interesting Technical Note about thallium in soil. Yes, chemists are not always understanding geochemistry and universities turning them out are not as good as they used to be. A kind of vicious cycle. Sometimes I am confronted with teaching methods and certainly there is more emphasis on orbitals than there is on basic chemistry and even less on geochemistry.

I have done several hundred analyses of thallium using spectrophotometry (ref. 1 & 2) and can confirm the values described in the note. Thallium is being lost from soil at a rate similar to K. Therefore, in ephemeral spring water I found levels increasing toward the end of flow in summer, typically from <1 ppb to about 10 ppb from areas bearing about 1 ppm Tl. Lately, bioremediation for thallium contaminated soils has been proposed (ref.3).

Spectral methods are not always the best. For AAS the sample has to be cleaned by ion exchange. Korkisch suggests acidifying the sample to 0.15M HBr and adding bromine water. Then filtration and exchange with Dowex 1 follows. Elution with SO2-containing water and determination with AAS is possible (ref.4).

References.

1. E.L.Kothny: Trace Determination of Mercury, Thallium and Gold with Crystal Violet. The Analyst, 94(1116), 198-203 (1969). Note: when analyzing Tl, the only element interferring is Au. This can be corrected by subtracting Au after analyzing specifically for it.

2. Compare reference 1 with: E.L.Kothny: A Micromethod for Mercury. American Ind.Hyg.Assoc. J. 31, 466 (1970).

3. Prof. Dr. Robert R. Brooks, personal communication.

4. J. Korkisch and I. Steffan: Determination of Thallium in Natural Waters. Int. J. Environ. Anal. Chem. 1979, 6, 111-118. This paper contains data of Tl in various waters.

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NOTE TO MEMBERS - IMPORTANT

"BY-LAWS" MAY SOUND BORING, BUT THIS IS IMPORTANT. PLEASE READ IT!

The focus of a professional association such as AEG is enshrined in its By-Laws. These establish its "reason for being", and provide the rules under which it operates. A healthy association will, from time to time, review its By-Laws to ensure they are up-to-date, and reflect the changing world around us. For some time now a sub-committee of the AEG, chaired by past President David Garnet, has been reviewing our By-Laws. Many issues have been considered, and soon AEG Council will present the proposed changes to the voting Members for discussion, and ultimately for acceptance or rejection.

Council feels that one issue is of a different nature to the others and requires separate consideration. It concerns the very scope of the Association, and its definitions of eligibility for membership. **Put simply, do we expand the eligibility criteria to include specifically geochemists in the Environmental side of our science, or do we have the By Laws state the AEG is solely focussed on Exploration Geochemistry?** AEG will always be focussed on exploration geochemistry, but do we want to focus on it to the exclusion of environmental geochemistry?

The current By-Laws of the AEG limit (non voting) Membership to persons who are "actively engaged in geochemical exploration at the time of his application and for at least two years prior thereto;" (Clause 2.09 (i)). Fellowship of the Association is limited to persons who "have completed a period of training and professional experience of at least six years in pure or applied science which shall include at least two years in applying, developing, researching, or teaching geochemical exploration methods;" (Clause 2.06 (ii)) and are also "actively practicing exploration geochemistry at the time of his application;" (Clause 2.06 (iii)).

The AEG's web-site currently displays a different interpretation of these conditions, stating that Membership is available to "persons actively engaged in scientific or technological work related to geochemical exploration or environmental geochemistry for the past 2 years." Similarly the conditions for Fellowship include the condition that the candidate shall be "actively practicing exploration or environmental geochemistry". **So there is a conflict between the By-Laws and the web-site and at the very least the web-site must be changed to better reflect the By-Laws.** As the By-Laws are currently under revision, it is opportune to bring this issue to the Members' attention.

Whenever AEG Members get together, for example at the AGM in Vancouver last year, vigorous (and healthy) debate inevitably arises concerning any widening of membership requirements, especially with regard to admission of persons actively engaged in environmental not exploration geochemistry. The last time this issue was addressed formally was in 1990 when Council appointed a sub-committee, chaired by Alan Coope. Its findings are published in Explore number 73, October 1991.

The issue continues to be raised for discussion, and after a 9 year hiatus, during which time our industry has changed almost out of sight, it may be time for Council to review the issue formally once more. The purpose of this note is to outline some of the options and to stimulate amongst the members a debate on the issue, which may ultimately lead to a vote of the Fellows. Once such a vote takes place, the issue must then be deemed closed for the foreseeable future.

So what are our options? We don't **HAVE** to do anything. The Association meets the objectives set out when it was formed, and if the Mineral Exploration industry revives, as many of us fervently hope it will, the health of the Association may revive with it. By the way, I don't think the Association is at present "critically ill", far from it, but it has some symptoms of a "long term wasting illness". Membership numbers are falling slowly and our membership is ageing. This implies we are not as relevant to our industry as we were and we are not attracting as many young geoscientists as we once did.

In addition to leaving well alone, and there's a strong case for doing just that, there are several alternative options that should be discussed. I will address some of these in order of increasing "radicalism".

In an attempt to widen Membership, but not Fellowship, of the Association, we could, for example, in Clause 2.09 (i) regarding qualification for Membership replace "exploration geochemistry" with either "geochemistry relating to the Minerals Industry" or even just with "Geochemistry". These options would allow a wider definition of Membership, but leave the Fellowship criteria unaffected, and of course the focus and objectives of the Association unchanged.

A more "radical" approach might be to make the above changes to Membership criteria, and to similarly widen the criteria for Fellowship. Again the changes to Clauses 2.06 (ii) and (iii) could include reference to either "geochemistry in the Minerals Industry", or simply to "Geochemistry". However, the focus and objectives of the Association would remain unchanged.

A yet more radical option would be to change the name of the Association to reflect a wider interest group. Environmental geochemists argue they are not interested in joining a professional association that does not have the word "environment" in its title. Many of the environmental geochemists we do have in our ranks are people who originally were explorationists, and who have migrated into environmental work. People trained specifically in environmental aspects of geochemistry may well not see AEG as a natural "home". Our Journal now reflects "Exploration: Environment: Analysis", so it can be argued that the name of the Association could do the same to become "The Association of Exploration and Environmental Geochemists". This would require serious revision of the objectives of the Association.

There are numerous alternatives to these options. The above is presented, hopefully without reflection of the author's personal views, as a basis for discussion by the Members and Fellows of AEG. All are encouraged to use the columns of **EXPLORE** to express their feelings and to provide alternative wording for the various options.

Ultimately I believe the voting membership will have to rule on the matter, and then the rest of the Association will abide by the decision. Members (as opposed to Fellows) who feel strongly about the issue would do well to upgrade their Membership to Fellowship, so that their voices may be heard if or when the vote comes!

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e.mail: nigel.radford@normandy.com.au

CALENDAR OF EVENTS

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

■ July 3–7, 2000, **15th Australian Geological Convention, Sydney, Australia**. INFORMATION: Convention Secretariat: 15th AGC Convention Manager, PO Box 236, Roseville NSW 2069 Australia, phone: 61-2-9411-4666, fax: 61-2-9411-4243.

■ July 31-August 4, 2000, **Denver X-ray Conference, Denver, Colo.** INFORMATION: Cenise Flaherty, 12 Campus Blvd., New Square, PA, 19073, Phone: 610-325-9814 E-Mail: Flaherty@icdd.com Web: http://www.dxcicdd.com

■ 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 6-10, 2000, **11th International Conference on Heavy Metals in the Environment**, Ann Arbor, Mich., by the Department of Environmental & Industrial Health of the University of Michigan. INFORMATION: Dept. of Env. & Industrial Health, University of Michigan, 109 Observatory St., Ann Arbor, MI 481109-2029, Phone: 734-615-2596 E-Mail: heavy.metals@umich.edu, Web: http://www.sph.umich.edu/eih/heavymetals/

■ August 20-24, 2000, **220th ACS National Meeting, Washington, D.C**. INFORMATION: American Chemical Society Meetings Department, 1155 Sixteenth Street, N.W., Washington, D.C. 20036 USA, Phone: (202) 872-4396, Fax: (202) 872-6128. E-mail: natlmtgs@acs.org

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Copies of the
Abstract Volume for the 19th International
Geochemical Exploration Symposium,
Exploration Geochemistry into the 21st Century,
held in April 1999, Vancouver, Canada,
are available from the AEG office.
This 146 page volume edited by
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Ontario, K2H 9RO, Canada
TEL. (613) 828-0199 FAX (613) 828-9288
E-mail aeg@synapse.net

■ August 30–September 1, 2000, **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 Vandeouvre-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.

■ September 12–14, 2000, **Fifth International Symposium and Exhibition on Environmental Contamination in Central and Eastern Europe, Prague, Czech Republic**. INFORMATION: Prague 2000, Florida State University, 2035 E. Paul Dirac Dr., 226 HMB, Tallahassee, FL 32310-3700, (850) 644-7211, fax 850-574-6704.

■ September 17–20, 2000, **The Society for Organic Petrology (TSOP), 17th Annual Meeting,** Bloomington, Indiana. INFORMATION: Maria Mastalerz, Indiana Geological Survey, 611 North Walnut Grove, Bloomington, IN 47405, (812) 855-9416, fax 812-855-2862.

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

■ December 2–7, 2000, **Geochemistry of Crustal Fluids, Granada, Spain.** INFORMATION: J. Hendekovic, European Science Foundation, 1 quai Lezay-Marnésia, 67080 Strasbourg Cedex, France, phone 33-388-767135, fax 33-388-366987.

■ December 4-6, 2000, **Sixth MIGA African Mining Investment Symposium, Ouagadougou, Burkina Faso.** Also technical excursions. INFORMATION: M. Barry, tel 202-473-3561, fax 202-522-2650, e-mail: mbarry2@worldbank.org

■ December 14 - 19, 2000, **Pacifichem 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:pacifichem@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.

■ March 12-14, 2001, **Northeastern GSA Sectional Meeting**. Chair: Barry Doolan, Burlington, Vermont.

■ April 5–6, 2001, **Southeastern GSA Sectional Meeting.** Chair: Edward Stoddard, Raleigh, North Carolina.

■ April 9–11, 2001, **Cordilleran GSA Sectional Meeting.** Chair: Peter Weigand, Northridge, California.

■ April 23–24, 2001, **North-central GSA Sectional Meeting.** Chairs: Robert G. Corbett, Skip Nelson, Bloomington-Normal Illinois.

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Calendar of Events...

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■ April 29–May 2, 2001, **South-central and Rocky Mountain GSA Sectional Meeting.** Chair: Kevin Urbanczyk, Albuquerque, New Mexico.

■ May 6-10, 2001, **Geochemistry and exploration in Latin America, Santiago de Chile**. INFORMATION: 20th International Geochemical Exploration Symposium, Santiago, Chili. Phone: 56 2 748 6771. E-mail: proper3@attglobal.net.

■ May 27-30, 2001, **Joint Annual Meeting of Geological Association of Canada - Mineralogical Association of Canada,** St. Johns, Newfoundland, Canada , by the Geological Association of Canada and the Mineralogical Association of Canada. INFORMATION: E-Mail: dgl@zeppo.geosurv.gov.nf.ca Web: http://www.geosurv.gov.nf.ca)

■ June 10-15, 2001 **WRI-10: International Symposium on Water-Rock Interaction, Sardinia, Italy , by the International Association of Geochemistry and Cosmochemistry**. INFORMATION: Rosa Cidu, Department of Science della Terra, via Trentino 51, I-09127 Cagliari, Italy, E-Mail: cidur@unica.it

■ June 24-28, 2001, **Earth systems processes, Edinburgh, Scotland.** GSA-GSL International meeting. INFORMATION: Ian Datziel, Ian@utig.ig.utexas.edu or Ian Fairchild, i.j.fairchild@keele.ac.uk.

■ July 29-August 2, 2001, **International Conference on the Biogeochemistry of Trace Elements,** University of Guelph, Guelph, Ontario, Canada. INFORMATION: Dr. Kim Bolton, Department of Land Resource Science, University of Guelph, Guelph, Ontario, Canada, N1G 2W1, Phone: (519)824-4120 ext. 2531 E-Mail: icobte@lrs.uoguelph.ca Web: http://icobte.crle.uoguelph.ca

■ August 27- 29, 2001,**The 6th Biennial Society For Geology Applied To Mineral Deposits, Mineral Deposits at the Beginning of the 21st Century,** Krakow, Poland. http://galaxy.uci.agh.edu.pl/~sga

■ November 5–8, 2001, **Annual Meeting of the Geological Society of America**, Boston, Massachusetts. INFORMATION: TEL 1-800-472-1988, meetings@geosociety.org.

■ Oct. 5-12, 2001, **27th Ann. Conf. of Federation of Analytical Chemistry & Spectroscopy Societies.** Detroit, MI. INFORMATION: Div. of Analytical Chemistry. FACSS, (505) 820-1648, fax (505) 989-1073, Internet: http://FACSS.org/info.html

■ April 7-11,2002, **223rd ACS Natl. Mtg. Orange County Convention/Civil Center, Orlando, Fla**. INFORMATION: ACS Meetings, 1155 16th St., N.W., Washington, D.C. 20036-4899, (800) 227-5558, (202) 872-4396, fax (202) 872-6128, e-mail: natlmtgs@acs.org

■ October 27–30, 2002, **Annual Meeting of the Geological Society of America**, Denver, Colorado. INFORMATION: TEL 1-800-472-1988, meetings@geosociety.org.

■ November 2–5, 2003, **Annual Meeting of the Geological Society of America**, Seattle, Washington. INFORMATION: TEL 1-800-472-1988, meetings@geosociety.org.

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

Virginia T. McLemore
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NEWS OF MEMBERS

Mary E. Doherty has resigned her position as Principal Geochemist with BHP World Exploration to pursue geochemical consulting.

She may now be contacted at:

IGGC - International Geochemical Consultants
5763 Secrest Court
Golden, Colorado 80403
Phone 303-278-6876
Fax 303-278-6877
Email: metd@csn.net

THE ASSOCIATION OF EXPLORATION GEOCHEMISTS APPLICATION FOR NON-VOTING MEMBERSHIP*

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.

***Details of requirements and application forms for voting membership (fellowship) can be obtained from the AEG website (http://www.aeg.org) or business office.**

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)

NAME AND ADDRESS

(to be completed by all applicants)

Name: ________________________
Address: ________________________
____
____
____

Telephone:
bus: ________________________
fax: ________________________
home: ________________________
email:________________________

Annual Dues

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

1	2000 member dues	US$	70	____________
2	2000 student member dues		40	____________
	If you require a receipt, include a self-addressed envelope and add		2	____________
	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

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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Benn, Chris
Principal Geochemist
BHP
Santiago, CHILE

Bowell, Robert J.
Consulting Geochemist
SRK Consulting
Cardiff, WALES

Lottermoser, Bernd G.
Senior Lecturer
James Cook University
Cairns, QLD, AUSTRALIA

Schlatter, Denis
Project Geologist
Crew Development Corp.
Hoevik, NORWAY

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Outokumpo Tara Mines
Navan, IRELAND

Babovic, Oto
Chief Geochemist
Inner Core Exploration
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Mare, Marius P.H.
Exploration Geologist
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Jakarta, INDONESIA

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Missoula, MT, USA

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Hee-Youl, Park
Chonbuk National University
Iksan, KOREA

Deadlines for the Next Four Issues of EXPLORE

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

Issue	Publication date	Contributor's Deadline
109	October 2000	August 31, 2000
110	January 2001	November 30, 2000
111	April 2001	February 28, 2001
112	July 2001	May 31, 2001

NOTE FROM THE EDITOR

As is always indicated in small print on the second page, **EXPLORE** is designed to provide an informal forum for the members of our Association. Short to moderate length technical articles on case histories, field and analytical technique developments, reviews, new concepts, etc. are always welcome. This is also true for news of recent and upcoming exploration and environmental geochemistry meetings and news of individual member movements and activities. If you have something for inclusion in **EXPLORE**, don't hesitate, send it to me. As indicated in the newsletter the deadlines for each issue are at least 30 days before publication date (e.g. the deadline for the October issue - #109 is August 31, 2000)

As Paul Taufen has mentioned in his column we are currently investigating the feasibility of posting all or part of the newsletter on the AEG web-site, in addition to mailing hard copies. Access could be open or restricted to members only. Your ideas and comments would be welcome.

Lloyd James
7059 East Briarwood Drive
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TELE: 303-741-5199
FAX: 303-741-5199
Email: l-njames@ecentral.com

NORTH WESTERN MINING ASS'N

Mr. Greg Hahn, Chairman for the NWMA Program 2001, is looking for continued AEG Participation in their 2001 Program with a Geochemistry Session and a Geochemist Chairman.

Volunteers should contact Mr. Hahn at Summo Minerals in Denver, Colorado.

Phone:(303) 863-3925
Fax: (303) 863-1736

The Association of Exploration Geochemists

is pleased to announce the XRAL

2000 AEG
Student Paper Competition

The Association of Exploration Geochemists will hold its thirteenth biennial Student Paper Competition this year. Papers eligible[1] for the competition must address an aspect of exploration geochemistry and represent research performed as a student. The student must be the principal author, and the paper must have been published in any refereed scientific journal no more than five years after completion of the degree for which the research was performed. A nomination may be made by anyone familiar with the work of the student. Nominations must be accompanied by four copies of the paper. The deadline for receipt of the nominations is December 31, 2000.

Win $500

and receive a travel allowance to an AEG sponsored meeting

The prize consists of a $500 Canadian cash prize, donated by **XRAL Laboratories**, a Division of SGS Canada, a two-year membership to the Association of Exploration Geochemists with receipt of **Geochemistry - Exploration, Environment, Analysis** and **EXPLORE**, and up to US $500 for expenses to attend an AEG sponsored meeting. A photograph and curriculum vitae of the author and an abstract of the prize-winning paper will be published in **EXPLORE** as soon as possible after the announcement of the award.

Mail to: Dr. Ian D.M. Robertson
Chairman, Student Paper Competition
Cooperative Research Centre for Landscape Evolution and Mineral Exploration
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Private Bag 5.
WEMBLEY
WA 6913
AUSTRALIA
Phone: +61 8 9333 6748
FAX: +61 8 9383 9179
Email: i.robertson@per.dem.csiro.au

[1] Full details are available from the Chairman of the competition (address above) or from the AEG Home Page (http:www.aeg.org/) or, more specifically at http://www.aeg.org/studentspage.htm.

THE ASSOCIATION OF EXPLORATION GEOCHEMISTS

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