Hydrogeochemical surveys in Newfoundland - Geological mapping with REEs in lake waters.

A major component of the research carried out in the past several years by the Analytical Methods Development Section at the Geological Survey of Canada (GSC) has focused on the design and implementation of cost-effective methods to determine trace and ultra-trace elements at their "natural" (anthropogenic) levels in surface waters. Currently thousands of lake and stream sediments and their corresponding waters are collected across Canada under the federal-provincial National Geochemical Reconnaissance (NGR) Program in support of the exploration and mining industry. Unlike the extensive range of elements determined in the sediments, those measured in waters are generally limited to U, F, pH, Ca and Mg. This is a reflection of the priorities at the initiation of the program, during the "uranium boom days" of the 1970s, and at a time when analytical capability for other trace elements was poor. Since then, dramatic advances have been made in water analysis, mainly due to the establishment of the techniques of inductively coupled plasma emission spectrometry (ICP-ES) and mass spectrometry (ICP-MS). Both techniques enjoy such features as multi-element detection and a wide linear dynamic range (approximately 10^5) but the sensitivity of ICP-MS is significantly superior to that of ICP-ES, generally by several orders of magnitude. Under a Mineral Development Agreement (MDA) with Newfoundland, the GSC has applied this new analytical methodology in a lake water survey in Bay d'Espoir in 1991 and a stream water survey in Bay Verte in 1992. This paper describes results from the former project for the rare earth elements (REEs).

Research to date on the distribution of the REEs in surface waters appears to have been concentrated almost exclusively in the area of marine geochemistry, more specifically on the degree to which river input and estuarine processes define the seawater composition of these elements (Hoyle et al., 1984; Goldstein and Jacobsen, 1988; Elderfield et al., 1990).

Ground water contents of the REEs have been measured at selected analogue sites in nuclear waste assessment studies to predict future mobility of both lanthanides and actinides. Miekley et al. (1992) determined "dissolved" (empirically defined as <0.45 μm) and particulate-held REEs in 42 near-surface and deeper ground water samples from the Osamu Utsumi uranium mine and the Morro do Ferro thorium and REE deposit in Brazil. The analytical methods employed by these workers are much too cumbersome and time-consuming to apply on a large scale. Typically, from 2 to 20 litres of sample are collected and lengthy ion exchange procedures are invoked to achieve adequate detection levels.

The method developed at the GSC is based upon preconcentration and separation of the REEs, from 50 ml of sample, using chelation and analysis of the eluant by nebulisation ICP-MS. The resin used, marketed by Dionex Corp. (Sunnyvale, CA, U.S.A.), is known as the

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Information for Contributors to EXPLORE

Scope This Newsletter endeavors to become a forum for recent advances in exploration geochemistry and a key informational source. In addition to contributions on exploration geochemistry, we encourage material on multidisciplinary applications, environmental geochemistry, and analytical technology. Of particular interest are extended abstracts on new concepts for guides to ore, model improvements, exploration tools, unconventional case histories, and descriptions of recently discovered or developed deposits.

Format Manuscripts should be double-spaced and include camera-ready illustrations where possible. Meeting reports may have photographs, for example. Text is preferred on paper and 5- or 3-inch IBM-compatible computer diskettes with ASCII (DOS) format that can go directly to typesetting. Please use the metric system in technical material.

Length Extended abstracts may be up to approximately 1000 words or two newsletter pages including figures and tables.

Quality Submittals are copy-edited as necessary without re-examination by authors, who are asked to assure smooth writing style and accuracy of statement by thorough peer review. Contributions may be edited for clarity or space. All contributions should be submitted to:

EXPLORE
C/o USGS, Box 25046, MS973, Denver Federal Center
Denver, CO 80225, USA

Information for Advertisers

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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 or negative. Business card advertising is available for consultants only*. Color separation and typesetting services are available through our publisher, Network Graphics, Inc.

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<td>May 31, 1994</td>
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<td>85</td>
<td>October 1994</td>
<td>August 31, 1994</td>
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<td>January 1995</td>
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<td>April 1995</td>
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Owen Lavin
Editor EXPLORE
During 1990 and 1991 a Committee chaired by Alan Coope worked very hard to produce a comprehensive “Report on the Identity of the Association of Exploration Geochemists.” I refer you to EXPLORE No. 73 of October 1991 in which the nine recommendations of this Committee were detailed. Many of these recommendations have already been implemented and Council is presently discussing ways of initiating others such as Penrose-type lectures.

Geochemistry is still a major weapon in the armory of many companies as they expand their exploration activities into South America, the S.W. Pacific, S.E. Asia and West Africa, as is evidenced by the number of membership applications from geoscientists working in these areas. There is no doubt that this trend will continue as the alienation of prospective land and environmental considerations make exploration in Canada, USA and Australia less attractive. And yet, these three countries have, and still do, provide the majority of the membership of the Association.

What are these members now doing? Many of them are now involved in disciplines which are removed from our core business of exploration geochemistry. Some of them have ceased membership in the AEG because their career is no longer in the exploration industry. There are others, such as the petroleum geochemists, who are members of other scientific organizations but whose activities could be encompassed within an expanded AEG. It seems to me that a broadening of our charter would benefit both AEG and the many geochemists in the community.

A more immediate reason to reconsider our charter is occasioned by the present negotiations with Elsevier for the journal contract. There is potential to widen the scope of the Journal of Exploration Geochemistry to embrace disciplines other than exploration geochemistry and which may require a title change. I have already discussed these matters with the Negotiating Committee and there is general consensus within the committee that we should at least considering some changes.

To aid this process I will prepare a discussion paper for the next issue of EXPLORE. In the meantime, I urge you to reread EXPLORE No. 73 and provide me with your vision for AEG in the 21st Century.

The ballot to change the By-laws to reflect coincidence of the term of office of the Executive and Councilors with the financial (calendar) year was overwhelmingly in the affirmative. The present Executive and Council will hold office until 31 December 1994. It is my desire that as we approach our 25th year, we can do so in the knowledge that the AEG is vibrant and assured of another quarter century of service to geochemistry.

Graham F. Taylor
AEG President

As many of you know, the scheduled Annual General Meeting (AGM) of the Association of Exploration Geochemists had to be canceled because our President, Graham Taylor, had to return to unexpectedly to Australia, and the Association’s finances had not been audited. We have rescheduled the AGM for April 27, 1994. Because of these unusual circumstances the AGM will be held via conference telephone in both Ottawa, Ontario, Canada and Denver, Colorado, USA. In Ottawa the conference call will be at 5PM EDT at the Geological Survey of Canada, 601 Booth Street and in Denver at 3 PM MDT at the Denver Federal Center, Building 20, Branch of Geochemistry, Room 1111. All available members are encouraged to attend the AGM if at all possible.

Sherman P. Marsh
Secretary

Geologic Tours in the Las Vegas Area

The Nevada Bureau of Mines and Geology, in cooperation with the U.S. Bureau of Land Management and Department of Geosciences at the University of Nevada, Las Vegas, has published Geologic Tours in the Las Vegas Area (NBMG Special Publication 16), written by Becky Weimer Purkey, Earnest M. Duebendorfer, Eugene I. Smith, Jonathan G. Price, and Stephen B. Castor.

This 156-page book provides a geologic guide for interested local citizens and tourists as they drive the main roads, visiting the many sites of natural beauty and historical importance in the Las Vegas Valley area. Road logs for five trips are provided.

The guide is available for $12.00 at the NBMG sales office (Room 316, Scrugham Engineering-Mines Building, University of Nevada, Reno) or for $14.00 by mail from Nevada Bureau of Mines and Geology/178, University of Nevada, Reno NV 89557-0088. Mail orders must be prepaid by check or money order made out to “Board of Regents.” Telephone orders (702-784-6691), using Visa or MasterCard, are also accepted.

Graham F. Taylor
AEG President
Technical Notes

Continued from Page 1

MetPac CC-1 column and is similar to Chelex-100 in that it is based on ininodiacetate functionality. In the pH range of 5-6, the resin selectivity is optimized for retention of the REEs and transition metals relative to the alkali and alkaline earth elements. By using an ammonium acetate eluant in this pH range, alkaline earth elements can be eluted while the REEs (and transition metals) remain strongly bound. The resin does not concentrate anions such as halides, nitrate, sulphate, phosphate or organic anions. It should be noted that it is the free REE cation being chelated; elements bound as charged or neutral inorganic or organic complexes, or in colloidal form, are not preconcentrated. Nitric acid is the preferred eluant (at 0.8 M) for analysis by ICP-MS as isobaric spectral interferences are minimized. The preconcentration procedure was designed to be fully automated, for operator-free functioning overnight, so that the following morning a tray of 40 samples is ready for nebulisation into the ICP mass spectrometer. A preconcentration factor of 10 was selected, but this can be increased or decreased easily to suit the needs of the particular project.

The ICP mass spectrometer employed was the Perkin-Elmer/SCIEX Elan model 250, upgraded to the 500. Corrections were made for the isobaric interferences of the light REE oxides on the heavy REE isotopes. The relative standard deviations (RSD) of synthetic water standards taken through the procedure were in the range of 1-2 % (n=5).

Results for six replicate applications of this method to 50 ml aliquots of Ottawa River and Meech Lake control samples are given in Table 1. Note the excellent RSDs: for Ottawa River varying from ±3% for Pr at 31 ng l⁻¹ (ppt, parts-per-trillion) to ±17% for Tb at only 1.8 ng l⁻¹; and for Meech Lake ranging from ±2.3% for La at 33 ng l⁻¹ to a maximum of ±21% for Tb at 0.7 ng l⁻¹. Not surprisingly, higher RSDs tend to be associated with those elements present at very low concentrations. With the exception of Gd in Ottawa River, RSDs greater than ±10% occur for those elements whose concentrations are below 5 ng l⁻¹, namely Sm, Eu, Tb, and Lu. Also shown in Table 1 are control data for a bulk tap water control which has been analyzed 27 times (i.e., 27-50 ml amounts) over a period of approximately one year. Ottawa River is used for the supply of tap water, hence its similar concentrations. Note that precision has not degraded over time when these results are compared to those for the six replicates of Ottawa River carried out consecutively during the initial development of the method. Detection limits are in the range 0.2-1 ng l⁻¹ using a definition based upon that concentration equal to three times the standard deviation obtained in five replicate analyses of a 5 ng l⁻¹ synthetic standard solution.

Table 1. Reproducibility of results for the REEs in: Ottawa River (n=6); Meech Lake (n=6); and tap water (n=27). All in ng l⁻¹.

<table>
<thead>
<tr>
<th>Element</th>
<th>Ottawa River</th>
<th>Meech Lake</th>
<th>Tap water</th>
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</thead>
<tbody>
<tr>
<td>La</td>
<td>158 ± 8</td>
<td>33 ± 0.8</td>
<td>159 ± 9</td>
</tr>
<tr>
<td>Ce</td>
<td>154 ± 9</td>
<td>42 ± 1.7</td>
<td>156 ± 8</td>
</tr>
<tr>
<td>Pr</td>
<td>31 ± 1</td>
<td>7 ± 0.2</td>
<td>32 ± 2</td>
</tr>
<tr>
<td>Nd</td>
<td>119 ± 6</td>
<td>29 ± 2.4</td>
<td>120 ± 8</td>
</tr>
<tr>
<td>Sm</td>
<td>17 ± 0.8</td>
<td>5 ± 0.6</td>
<td>18 ± 1</td>
</tr>
<tr>
<td>Eu</td>
<td>3 ± 0.4</td>
<td>7 ± 0.3</td>
<td>3 ± 0.4</td>
</tr>
<tr>
<td>Gd</td>
<td>14 ± 2</td>
<td>5 ± 0.8</td>
<td>15 ± 3.7</td>
</tr>
<tr>
<td>Tb</td>
<td>1.8 ± 0.3</td>
<td>0.7 ± 0.15</td>
<td>2.0 ± 0.5</td>
</tr>
<tr>
<td>Dy</td>
<td>11 ± 1</td>
<td>4 ± 0.4</td>
<td>11 ± 1</td>
</tr>
<tr>
<td>Ho</td>
<td>2 ± 0.1</td>
<td>1 ± 0.1</td>
<td>3 ± 0.1</td>
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<tr>
<td>Er</td>
<td>8 ± 0.3</td>
<td>3 ± 0.2</td>
<td>8 ± 0.7</td>
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<tr>
<td>Tm</td>
<td>1 ± 0.1</td>
<td>0.5 ± 0.05</td>
<td>1 ± 0.1</td>
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<tr>
<td>Yb</td>
<td>6 ± 0.6</td>
<td>4 ± 0.3</td>
<td>7 ± 0.8</td>
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<tr>
<td>Lu</td>
<td>1 ± 0.2</td>
<td>0.8 ± 0.14</td>
<td>1 ± 0.2</td>
</tr>
</tbody>
</table>

SD : Standard Deviation

The lake and stream water survey was carried out in southern Newfoundland, north of Fortune Bay and east of Bay d'Espoir (Fig. 1). A total of 136 lake water samples, including 11 field (site) duplicates, were collected in one day using a float-equipped helicopter. Samples were collected about 20 cm below the surface after initial rinsing of the bottle with the lake water. Of these lakes, 108 had been sampled for the organic-rich centre lake bottom sediment in an NGR survey in 1980 (Friske and Hornbrook, 1991). Within 24 hr. of collection, samples were filtered through a 0.45 μm filter paper into a 250 ml bottle, using Millipore glass.

Continued on Page 5
Table 2. Field duplicate data for REEs in lakes and streams in Bay d'Espoir. All measurement in ng l$^{-1}$

<table>
<thead>
<tr>
<th>Sample</th>
<th>La</th>
<th>Ce</th>
<th>Pr</th>
<th>Nd</th>
<th>Sm</th>
<th>Eu</th>
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<td>133</td>
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apparatus and acidified with 1 ml of 16 M HNO$_3$ (Ultrex). Earlier studies indicated that: (1) acidification to 0.1 or 0.4 % in HNO$_3$ stabilized the REEs in solution at ng l$^{-1}$ levels for at least two months, and (2) the Nalgene bottles used "as is" rather than acid-washed did not lead to contamination problems. About 50 elements, including the REEs, have been determined in these waters from Bay d'Espoir.

Data for the REE contents of 11 field duplicate lake water samples are given in Table 2. Precision appears to be excellent, even for the less abundant REEs, and is not noticeably inferior to the analytical precision shown previously by the control data (Table 1). A broader evaluation of precision is obtained by combining duplicate data from several concurrent hydrogeochemical projects and representing the enlarged dataset graphically as "Thompson and Howarth!! plots, as has been done for La, Sm, Er and Yb in Figure 2. In this approach, the absolute difference between the duplicate pair is plotted against their mean on a log-log scale and a 95th percentile line for a selected precision (twice the RSD) is then drawn according to the pattern of the data (Thompson and Howarth, 1978). Thus, the 95th percentile for the selected precision on each graph is an upper confidence limit (i.e., the "worst" case precision value) above which no more than 5% of the points should lie. Field duplicate data (n=23 pairs) have been distinguished from blind (lab) duplicate data (n=27), the former being labelled as stars and the latter as circles in Figure 2. Although greater variability would be expected in results for the field duplicates, rather than for sample splits, this was not apparent from the graphs and therefore data were viewed as one group. Note that numerous points fall on or just below the x-axis, indicating that there was no difference in values obtained for the duplicates. Hence, at concentrations in the range from several ng l$^{-1}$ to several hundred ng l$^{-1}$, a field and analytical precision of 25-30% (i.e. ± 15% RSD) or better can be
expected for Sm, Er and Yb. Superior precision of 15% is shown for the more abundant La, present in these 50 samples in the concentration range of 10-2400 ng l⁻¹.

Summary statistical data for the REEs in the 135 lake waters are given in Table 3. As mentioned previously, results were available for some of the REEs in the centre lake bottom sediments of most of these lakes from the National Geochemical Reconnaissance (NGR) database. The elements La, Ce, Sm, Eu, Tb, Yb and Lu had been measured in the minus 180 μm fraction by instrumental neutron activation analysis (INAA) in a multi-element commercial package.

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Table 3. Summary statistics for REE concentrations in 136 lake waters in Bay d'Espoir. All values in ng l\(^{-1}\).  

<table>
<thead>
<tr>
<th>Element</th>
<th>Range</th>
<th>Median</th>
<th>Mean</th>
<th>SD</th>
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<td>148</td>
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<td>Ce</td>
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<td>152</td>
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<td>Pr</td>
<td>2 - 139</td>
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<tr>
<td>Nd</td>
<td>8 - 489</td>
<td>113</td>
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<td>86</td>
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<td>Sm</td>
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<td>2.9</td>
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</table>

There was a problem with the INAA data for Lu, mostly reported erroneously low at the method's detection limit of 0.02 \(\mu g\) g\(^{-1}\) and therefore comparison with the water data was not possible. Spearman rank correlation coefficients between the two media for the 108 coincident sites are: 0.38 for La; 0.45 for Ce; 0.48 for Sm; 0.31 for Eu; 0.60 for Tb; and 0.76 for Yb. Data for Eu in both sediment and water are probably too close to the method's detection limits to have confidence in this correlation. This is not the case for the other five REEs. A correlation coefficient greater than 0.40 is significant at the 99.9% confidence level. Clearly, a strong correlation is present for Yb in the two media and that for Tb is high, despite the low and restricted concentration range, from <1 to 17 ng l\(^{-1}\) of Tb, in the lake waters.

Examples of the distribution patterns in both lake water and sediment media are shown for Yb, Tb and La in Figure 1. The survey area is divided into two contrasting geological terrains separated by the northeast trending Hermitage Bay fault. To the southeast, the older Avalon Zone comprises predominantly volcanic, sedimentary and intrusive rocks of Tadrynian age which are intruded by a Devonian high-silica granite. To the northwest, the Gander and Durnage Zones are composed of clastic-sedimentary and volcanic rocks, also intruded by granites (Colman-Sadd et al., 1990). The earlier VGR sediment survey showed the area to the northwest of the fault to be higher in the elements As, Ba, Co, Cu, Cs, Ni and Sb, and lower in F, U and the REEs in comparison to the area to the southeast. The similarities in both sediment and water maps for Yb, and to a lesser extent, Tb are striking (Fig. 3). The north-western area of both media maps has considerably lower contents of Yb and Tb than the southeast, reflecting the contrasting geology - the west being dominantly fine-grained siliciclastic terrain and the east mainly granitic. The southern section of the area, east of the fault, elevated in REE concentrations (dark shading), is underlain by a late marginal phase of the granite that is
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Figure 3. Elemental contour maps for (a) Yb; (b) Tb; and (c) La in lake water and lake sediment. Geology is as follows: 1: granite; 2: bimodal volcanic rocks; 3: siliciclastic sedimentary rocks; 4: clastic and volcanic rocks; 5: felsic and mafic volcanic rocks; 6: siliciclastic sedimentary rocks; 7: granite; 8: high-silica granite.

region north-west of the fault, there appears to be a ridge of high REEs extending north-east from Bay d’Espoir parallel to the stratigraphic and structural trends and is likely due to REE enrichment in one or more stratigraphic units. The single high in the extreme northwest is evident in Figures 3b (Tb in water) and 3c (La in water) should be disregarded as it is a small lake near a road and has anomalous concentrations of SO₄ (12.5 mg l⁻¹) and Cl (13.2 mg l⁻¹).

Another way to compare water and sediment information for the REEs is to examine their chondrite-normalized plots; these were drawn for all 108 coincident sites. For every lake, the similarity between the plots for REEs in water and sediment is remarkable. Forty seven sites are clearly located over the biotite-bearing Ackley granite and their chondrite-normalized plots are typified by those for samples 126 and 150 in Figure 4a. All show distinct Eu negative anomalies, flat heavy REEs patterns and various degrees of enrichment in the light REEs (e.g., greater for sample 126 in Fig. 4a). Weak negative Ce anomalies in the waters usually correspond to slight Ce enrichments in the sediment, probably indicating oxidation of Ce³⁺ to Ce⁴⁺ and subsequent precipitation of the less soluble species. There is no apparent dependence of the shape of the plot on the textural classification of the granite, that is, as fine or coarse grained, equigranular or porphyritic. Plots for waters collected within siliciclastic sedimentary drainage basins resemble those shown in Figure 4b for samples 47 and 94, overlying the Riches Island Formation of green-grey pelite and siltstone with graphitic slate, quartzite and psammite. These patterns exhibit a very gradual decline from the light to heavy REEs and are devoid of features such as significant Eu or Ce anomalies. Rather similar to these are patterns for waters collected over a semi-pelitic and psammitic paragneiss (samples 69 and 70 in Fig. 4c), but here more distinct Eu anomalies are shown by the sediments and not by the waters. Signatures of the lake waters and sediments overlying felsic and mafic volcanics are shown by samples 158 and 159 in Figure 4d. Again, light REE enrichment is evident, together with Eu negative anomalies, though of much less intensity than shown earlier by the granitic lithology. These findings suggest that: (1) there is little fractionation of the REEs as they become fixed by the lake sediment; and (2) the elemental patterns in the waters may be quite stable over time, though overall concentrations undoubtedly do change (e.g., with climatic conditions).

In summary, application to 135 lakes in Bay d’Espoir has demonstrated the potential of REE signatures in lakes, streams and ground waters to be used to trace fluxes and identify their origins. There appears to be negligible fractionation of the REEs during processes of dissolution and precipitation, as evidenced by the similarity between chondrite-normalized plots of lake water and matching sediment and by the distinct features of these plots within lithologies. The excellent productivity of this method, at about 100 samples a day, and the sample volume requirement of only 50 ml or less will ensure a rapid growth in information in the future on the geochemical cycling of the REEs. A later report on this area will describe the application of this and other new analytical methodologies to examine the potential of stream chemistries in exploration for base metal and Au mineralisation in the Bay Verte Peninsula, Newfoundland.

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Figure 4. Chondrite-normalized plots for (a) samples 126 and 150 over Ackley granite; (b) samples 47 and 94 over pelite and siltstone; (c) samples 69 and 70 over semi-pelitic and psammitic gneiss; and (d) samples 158 and 159 over felsic and mafic volcanics. [Lu in sediment is erroneously low]
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Acknowledgements

This work was funded under the Canada-Newfoundland Cooperation Agreement on Mineral Development 1990-1994. The authors are grateful to J.E. Vaive and J.C. Pelchat of the Analytical Method Development Section of the GSC for superb analyses, and to Chris Finch for his participation in the fieldwork.

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References Cited


Ideal CHIM with the Newly-Developed, NEOCHIM Electrode

Review

CHIM is an electrogrochiral exploration method developed more than twenty years ago in the former Soviet Union where it has been used successfully for locating buried mineral deposits (Goldberg et al., 1990). In principle, CHIM uses an electric field to cause ions at depth to migrate into special collector electrodes. Russian investigators stated that CHIM effectively transported cations from a buried deposit through 100 meters or more of overburden to the electrodes placed on the soil surface. They hypothesized that the cations were transported mainly by the strong electric field applied in CHIM. There is little mention in the Russian literature regarding the transport and collection of anions.

We recently reported results in this newsletter (Leinz and Hoover, 1993) that indicate that ions collected by conventional CHIM are, for the most part, generated in situ in chemical reactions proximal to the electrode and that they are transported into the electrode predominantly by diffusion. We attribute these results to the fact that conventional CHIM electrodes, as described by Goldberg et al. (1990) and Smith et al. (1993), permit the loss of acid from the electrode to the soil by diffusion. Acid is used in the conventional electrode to neutralize hydroxyl (OH-) ions produced in the electrode by electrolysis during operation (2H_2O + 2e^- → 2OH^- + H_2↑). Generally, nitric acid is used. Goldberg et al. (1990) call for the addition of concentrated HNO_3 to the electrode, as necessary, to prevent alkalization of the soil by OH^- ions. Such alkalization would impede the mobility of cations.

Problems caused by acid loss

Ideally, CHIM should affect the transport of only those ions soluble in the soil moisture. The presence of a large quantity of H^- ions proximal to the electrode promulgates conditions that are not permissive for conducting ideal extractions because: 1) the H^- ions react with soil matter, releasing cations which are otherwise not available for electrical extraction. The acid-soluble ions may or may not be associated with buried ore; 2) the H^- ions are transported back into the electrode by the electric current in preference over other cations. Our tests with the conventional electrode indicated that cations other than H^- account for a maximum of only 0.1% of the charge transfer delivered by the current. Most of this amount is likely due to diffusion; and 3) the large number and high mobility of the H^- ions also constrain the volume of soil sampled. Of the mobile cations drawn towards the electrode by the current, few enter the electrode. Most of them accumulate in the zone flooded with H^+ from which the H^- is preferentially transported.

We recognized that the loss of acid from the conventional electrode was not permissive for conducting the ideal extractions possible of CHIM, at least in principle. Subsequently, we developed an electrode that overcomes the problem. We have tested the new electrode and are encouraged by results that we feel are closer to those expected of ideal extractions.
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**The new electrode briefly described**

Our new electrode (patent pending, 1993, Fig. 1) is comprised of two chambers, an outer chamber containing an electrolyte fluid, which receives the collected ions, and an inner chamber containing an electrolyte fluid in which a graphite or metal working electrode is immersed. The two chambers are separated by a conductive salt bridge. As with the conventional CHIM electrode, electrical contact is made through a disk of synthetic parchment sealed into the bottom of the outer chamber. The salt bridge is a gel salt solution, it is held in place at the bottom of the inner chamber by a second parchment disk. The salt bridge has a two-fold function: 1) to allow the passage of current from the inner to the outer chamber; and 2) to prevent undesirable ions in the inner chamber from entering the outer chamber. This design can function as either an anion or cation collector.

Besides the requirement of conductivity, there are few constraints on selecting the composition of the fluids and the salt bridge. The parchment membrane is permeable to ions, not only can the electric field drive ions through but diffusion of ions across the membrane can occur as well. During operation of the electrode as a cation collector, cations from the soil are brought into the outer chamber fluid and anions present in the fluid migrate out into the soil. The reverse happens when the electrode is used as an anode collector. Because of this, consideration of the reactivity of...
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he soil with the ions in the fluid is necessary. In an ideal HIM run, the ions moving out of the electrode are passive awards soil matter and serve only to conduct current. The fluids in the two chambers and the salt bridge normally should be unreactive towards each other and to the products of electrolysis in the inner chamber. Finally, the ion concentration of the fluids and the salt bridge must be sufficient to balance the charge transfer of the applied current.

Results of field tests

We tested our new electrode, which we have named the NEOCHIM electrode, in four separate experiments at the Kokomo mine in the Central City district, west of Denver, Colorado, where we conducted some of our previous CHIM experiments (Smith et al., 1993; Leinz and Hoover, 1993). The four experiments were conducted using both cation and anion collector electrodes in each run. Electric power was provided by a 10kW generator with 800 volts applied to the electrodes. Line and site placement were the same as for the previous CHIM experiments (Smith et al., 1993). Site 00 is located over a gold-bearing, base-metal vein concealed by 3 meters of transported overburden. Cathodes and anodes were separated by a distance of about 3 meters. The parameters for each of the experimental runs are summarized in Table 1.

The quantity of ions collected is dependent on the total charge transferred to the electrodes by the current. The amount of charge transfer depends on the duration of the run and the current at each electrode. For the most part, Table 2 shows that the quantity of Cu, Pb, and Zn collected increases with time as expected. Normalizing the data to the limit of detection. Overall, our results indicate the NEOCHIM electrode yields extraction efficiencies more than two orders of magnitude better than the conventional CHIM electrode. The efficiencies were determined by ratioing the total equivalents of cations collected by each electrode to the amount of electrical charge supplied to the electrode.

The collection of gold and other anionic species

Most notable of our anode results (Table 3) is the occurrence of gold in some of the solutions of run IV. It is important to note that gold was not recovered in detectable amounts in any of the cathode solutions. Run IV was planned with the specific intent to test gold collection. The larger electrode and more concentrated fluids allowed us to conduct the extended run we felt necessary for collecting detectable amounts of gold that might be present in ionic form in soil moisture. Several months prior to run IV, we collected soil samples at each electrode site.

| Table 1. Parameters of four experimental CHIM runs conducted in 1993 at the Kokomo mine, Central City district, Colorado, to test the newly developed NEOCHIM electrode. Electrical power was supplied by a 10kW generator. |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| RUN I | RUN II | RUN III | RUN IV |
| Electrode | Cathode | Anode | Cathode | Anode | Cathode | Anode | Cathode | Anode |
| Duration of Run | 0.5 Hrs | 1.5 Hrs | 3.5 Hrs | 20 Hrs |
| Diameter, mm | 40 | 40 | 40 | 40 |
| Volume, ml | 50 | 50 | 50 | 50 |
| Composition | KNO3 | KNO3 | KNO3 | KNO3 | KNO3 | KNO3 | KNO3 | KNO3 |
| | KCI | KCI | KCI | KCI | KCI | KCI | KCI | KCI |
| Diameter, mm | 25 | 25 | 25 | 25 |
| Volume, ml | 25 | 25 | 25 | 25 |
| Composition | KNO3 | KNO3 | KNO3 | KNO3 | KNO3 | KNO3 | KNO3 | KNO3 |
| | KCl | KCl | KCl | KCl | KCl | KCl | KCl | KCl |
| Diameter, mm | 25 | 25 | 25 | 25 |
| Volume, ml | 25 | 25 | 25 | 25 |
| Composition | KNO3 | KNO3 | KNO3 | KNO3 | KNO3 | KNO3 | KNO3 | KNO3 |
| | KCI | KCI | KCI | KCI | KCI | KCI | KCI | KCI |
| Diameter, mm | 25 | 25 | 25 | 25 |
| Volume, ml | 25 | 25 | 25 | 25 |
| Composition | KNO3 | KNO3 | KNO3 | KNO3 | KNO3 | KNO3 | KNO3 | KNO3 |
| | KCl | KCl | KCl | KCl | KCl | KCl | KCl | KCl |
| Diameter, mm | 25 | 25 | 25 | 25 |
| Volume, ml | 25 | 25 | 25 | 25 |
| Composition | KNO3 | KNO3 | KNO3 | KNO3 | KNO3 | KNO3 | KNO3 | KNO3 |
| | KCl | KCl | KCl | KCl | KCl | KCl | KCl | KCl |
| Diameter, mm | 25 | 25 | 25 | 25 |
| Volume, ml | 25 | 25 | 25 | 25 |
| Composition | KNO3 | KNO3 | KNO3 | KNO3 | KNO3 | KNO3 | KNO3 | KNO3 |
| | KCl | KCl | KCl | KCl | KCl | KCl | KCl | KCl |
| Diameter, mm | 25 | 25 | 25 | 25 |
| Volume, ml | 25 | 25 | 25 | 25 |
| Composition | KNO3 | KNO3 | KNO3 | KNO3 | KNO3 | KNO3 | KNO3 | KNO3 |
| | KCl | KCl | KCl | KCl | KCl | KCl | KCl | KCl |

| Table 2. Total micrograms (µg) of copper, lead, and zinc collected in the cathode solution during four experimental CHIM runs conducted at the Kokomo mine, Central City district, to test the NEOCHIM electrode. |
|-----------------|-------------|
| Copper | Zinc |
| RUN | I | II | III | IV | I | II | III | IV |
| SITE | | | | | | | | |
| 50N | 0 | 0 | 2.5 | 12 | 0 | 0 | 30 | 530 | 3.5 | 9.0 | 35 | 144 |
| 40N | 8.5 | 49 | 185 | 680 | 35 | 230 | 750 | 2160 | 3.0 | 150 | 100 | 440 |
| 30N | 1.0 | 5.0 | 3.5 | 640 | 5.0 | 25 | 1120 | 35 | 9.5 | 25 | 35 | 640 |
| 20N | 8.5 | 1.5 | 8.5 | 640 | 5.0 | 45 | 10 | 45 | 75 | 560 |
| 10N | 6.5 | 2.5 | 75 | 1640 | 5.0 | 15 | 70 | 400 | 80 | 550 | 900 | 4500 |
| 00 | 7.0 | 16 | 14 | 2480 | 10 | 15 | 55 | 1480 | 42 | 230 | 175 | 2680 |
| 105 | 1.0 | 1.0 | 3.0 | 0 | 0 | 30 | 35 | 0 | 2 | 16 | 40 | 294 |
| 205 | 1.0 | 1.0 | 7.0 | 0 | 0 | 25 | 0 | 3.5 | 14 | 125 | 80 |
| 305 | 5.0 | 0 | 3.0 | 36 | 0 | 35 | 0 | 2.0 | 7.0 | 35 | 606 |
| 405 | 5.0 | 0 | 3.0 | 36 | 0 | 35 | 0 | 1.5 | 6.5 | 35 | 180 |
| 505 | 1.0 | 1.0 | 4.5 | 0 | 0 | 5.0 | 50 | 700 | 3.0 | 13 | 50 | 168 |
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in the cathode solutions of four separate CHIM runs at the Kokomo mine, Central City district, Colorado, using the newly developed NEOCHIM electrode. The data are normalized to the amount of current (ampere-hours) delivered to each electrode, placed along a line at 10-meter intervals. A gold-bearing base-metal vein is located 3 meters beneath the surface at site 00.

bulk sample was collected near site 00 over the vein. Six splits of the bulk sample were analyzed by graphite furnace atomic absorption (Meier, 1980) for water-soluble gold, gold associated with organic matter (Gregoire, 1985), and total gold. We were unable to detect any water-soluble gold but found 95 to 97 percent of the gold associated with the organic matter in each of the splits. The data in Figure 3 shows a strong correlation between the gold associated with the organic matter in the soils from each site and the gold collected in the anodes during run IV. The mobility of gold as anionic organic complexes has been suggested by some investigators (Curtin et al., 1970; Baker, 1978; VarshaI et al., 1990; Vlassopoulos et al., 1990). Ong and Swanson (1969) have suggested that gold migrates in association with complex organic acids as colloids of negative charge.

Anode data for zinc, sulfur, and arsenic (Table 3) implies the occurrence of zinc as both anions and cations with the cationic forms predominating in the surface environment at the Kokomo mine. There is a strong correlation between the sulfur determined in the anode solution and sulfate ion determined in water extracts of the soil samples from each site.

Table 3. Total quantities of zinc, sulfur, arsenic, and gold collected in the anode solution of experimental CHIM run IV conducted at the Kokomo mine, Central City district, to test the NEOCHIM electrode. (---) means not determined.

<table>
<thead>
<tr>
<th>SITE</th>
<th>Zn Total µg</th>
<th>S Total µg</th>
<th>As Total µg</th>
<th>Au Total ng</th>
</tr>
</thead>
<tbody>
<tr>
<td>50N</td>
<td>12</td>
<td>1200</td>
<td>---</td>
<td>0</td>
</tr>
<tr>
<td>40N</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
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<tr>
<td>30N</td>
<td>90</td>
<td>2200</td>
<td>---</td>
<td>110</td>
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<td>20N</td>
<td>40</td>
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<td>---</td>
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</tr>
<tr>
<td>20S</td>
<td>55</td>
<td>6700</td>
<td>52</td>
<td>12</td>
</tr>
<tr>
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<td>110</td>
<td>0</td>
<td>26</td>
<td>0</td>
</tr>
<tr>
<td>40S</td>
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<td>50S</td>
<td>60</td>
<td>0</td>
<td>---</td>
<td>0</td>
</tr>
</tbody>
</table>

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Figure 3. Total nanograms of gold (ng) collected in the anode solution of CHIM run IV at the Kokomo mine using the NEOCHIM electrode, and total nanograms of gold associated with organic matter in soil samples collected from the sites of electrode placement. Site 00 lies over the mineralized vein. The anode solution at site 405 was not recovered.

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Conclusion
The NEOCHIM electrode overcomes the problems resulting from acid loss suffered by the conventional electrode. With the new electrode, we can more confidently use CHIM for its intended purpose: to provide representative samplings of electrically mobile, naturally occurring ions in the soil. It is now possible to more definitively determine the utility of CHIM for mineral exploration or other geochemical purposes. This new technology may also benefit the understanding of the mobility and transport of chemical elements under natural conditions, especially those of low abundance, such as gold, in the earth's surface environment.

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CORRECTION

An astute reader noted an error in Table 1 of the article The Use of Silica Sand Cleaners in Pulverizing Mills to Reduce Cross Contamination by Lynda Bloom in EXPLORE No. 82. The corrected table is reproduced below.

Table 1. Determination of gold in silica sand cleaners

<p>| Wt. of | Sample | Gold Assays (ppm) | Weighted Average (ppm) | % Carry-over |</p>
<table>
<thead>
<tr>
<th>Gold(g)/Wt. of Sand(g)</th>
<th>Weight (g)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0034/100</td>
<td>166.06</td>
<td>20.5, 13.4, 16.6, 18.5, 17.2, 16.9</td>
<td>17.2</td>
<td>1</td>
</tr>
<tr>
<td>Cleaner 1</td>
<td>134.42</td>
<td>0.18, 0.19, 0.43, 0.11, 0.10</td>
<td>0.21</td>
<td>Nil</td>
</tr>
<tr>
<td>Cleaner 2</td>
<td>68.70</td>
<td>Tr, Nil, Nil</td>
<td>Nil</td>
<td></td>
</tr>
<tr>
<td>0.0034/100</td>
<td>99.16</td>
<td>37.7, 33.2, 27.9, 28.4</td>
<td>32.5</td>
<td></td>
</tr>
<tr>
<td>Cleaner 1</td>
<td>69.46</td>
<td>0.44, 0.32, 1.02</td>
<td>0.47</td>
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</tr>
<tr>
<td>Cleaner 2</td>
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<td>0.04, 0.04, 0.06</td>
<td>0.04</td>
<td>0.3</td>
</tr>
</tbody>
</table>

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Volume 50 Nos. 1-3 March 1994

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L.P. James

The 1994 SME Annual Meeting convened in Albuquerque, New Mexico, on February 14-17. Of the 77 sessions scheduled, the geochemistry session entitled Geochemical Exploration for Gold: "Using Old Techniques for New Discoveries" and the six geology sessions, including an excellent session entitled Ore Deposits of Chile, were of greatest interest to explorationists. Between 40 and 60 explorationists attended the geochemistry session.

Several presentations proved very interesting. Alan Morris suggested, in his presentation of the surficial geochemistry over the Meikle deposit, Carlin Trend, Nevada, that deep (+800 ft.), high-grade gold mineralization beneath barren bedrock does, in fact, yield recognizable geochemical patterns on the surface. Charlie Tapper, in his presentation on the Twin Creeks Mine, Getchell Trend, Nevada, told of new discoveries and improved geologic understanding as a result of combining the Chimney and Rabbit Creek mines. John Roberts' presentation on the use of spontaneous potential electro-geochemistry for detecting faults and/or intense argillic alteration beneath shallow to moderate cover should spark increased experimentation and use of this technique in the Great Basin and elsewhere. Finally, Joyanto Routh's presentation on the impact of the Van Stone Pb-Zn mine, Washington, on the Columbia River and surrounding environment was an excellent example of the application of geology-based environmental geochemistry.

IV Joint International Symposium on Exploration Geochemistry, A Tribute to Academician L.V. Tauson.
September 7-10, 1994. Irkutsk, Russia

I. TECHNICAL SESSIONS

1. Geochemical mapping for solving fundamental problems of geology, environment and exploration
2. Geochemical methods of exploration and environment assessment
3. Memorial Session, dedicated to L.V. Tauson (geochemical classification of geological formations, geochemistry of ore-magmatic systems)
4. Reference samples of different geochemical media and analytical means of geochemical investigations
5. Recent methods of geochemical data processing and geochemical map compilation

II. WORKSHOPS

1. International Geochemical Mapping (including programmes "Geochemical map of Russia" and "Geocology of Russia")
2. Geochemical prospecting for precious metals in the northern hemisphere
3. Baikal International Geochemical Polygon (programmes "Baikal Drilling", "Global change of the Environment and Climate", "Baikal Polygon, Russia")
4. Geochemical mapping and monitoring aimed at medical and biological problems

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Tauson International Symposium

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III. SESSION OF INTERNATIONAL AND NATIONAL GEOCHEMICAL ORGANIZATIONS AND PROJECTS

- Council of International Association of Geochemistry and Cosmochemistry
- Council of Association of Exploration Geochemists
- Baikal Drilling Project
- Projects IGCP no. 360 "Global Geochemical Baselines"
- Session of Coordination Council on multi-purpose geochemical mapping and geoecology (Project "Geochemical map of Russia" and "Geoecology of Russia")
- Working Group "Global Geochemical Mapping" - IAGC

IV. EXCURSIONS

1. Environmental geochemistry of Irkutsk and its surroundings
2. Geochemical monitoring of the landscapes of the Western Baikal region
3. Murun charoite deposit
4. Gold deposits, Trans-Baikal region (Darasun, Balei)
5. Gold deposits, South-east Siberia (Zun-Khelba, Sukhoi Log)
6. Phlogopite and lazurite deposits of the South Baikal region
7. Geochemistry of the bottom sediments of Baikal lake and its tributaries
8. Geology and mineralogy of the Baikal region

OFFICIAL LANGUAGES: English and Russian

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International, National and Regional Meetings of Interest to Colleagues Working in Exploration and Other Areas of Applied Geochemistry.

- **May 10-14, '94**, Mining Latin America, mtg., Santiago de Chile, by Institution of Mining and Metallurgy and others (IMM, 44 Portland Place, London, W1N 4BR, England; TEL: 44 71 580 3802; FAX: 44 71 436 5388)
- **May 13-18, '94**, GAC-MAC, ann. mtg., and MDD-GAC Short Course on Alteration Processes, Waterloo (G. Roberts, Waterloo '94, Dept. of Earth. Sci., Univ. of Waterloo, Waterloo, Ontario N2L 3G1, Canada; TEL: (519) 885-1211; FAX: (519) 746-7484; short course contact D.R. Lentz, GSC, PO Box 50, Bathurst, New Brunswick E2A 3Z1, Canada; TEL: (506) 546-2070; FAX: (506) 546-3994)
- **May 16-18, '94**, Peru, First International Gold Symposium and Exhibition, Lima, Peru, by Comite Aurifero, Sociedad Nacional de Minero y Petroleo and Randol International Ltd. (Sandra Wells, Randol International Ltd., Golden, CO, USA; FAX: (303) 526-1650 or Dr. Guillermo Albareda, Comite Aurifero Sociedad Nacional de Minero y Petroleo, Las Flores 346, Lima 27, Peru; TEL: (511) 70-4260; FAX: (511) 70-4245)
- **May 17-19, '94**, GAC-MAC, ann. mtg., Edmonton, Alberta (J. W. Kramers, Alberta Geological Survey, Box 8330, Station F, Edmonton, T6H 5X2, Canada; TEL: (403) 438-7644; FAX: (403) 438-3364)
- **June 6-10, '94**, Mining History, mtg., Golden, CO, by Colorado School of Mines (Mining History Association, Box 15030, Denver, CO 80215)
- **July 17-19, '94**, Conf. on Lead and Arsenic Exposure in the Rocky Mountains, Salt Lake City, Utah (Society of Environmental Geochemistry and Health, Rocky Mountain Region, P.O. Box 70915, Salt Lake City, UT 84170, FAX: (801) 322-8398 or (801) 261-2194)
- **Aug. 28-Sept. 3, '94**, European Association of Geochemistry Meeting and 4th Goldschmidt Conference, Edinburgh (Dr. B. Harte, Department of Geology and Geophysics, Grant Institute, University of Edinburgh, West Mains Road, Edinburgh, EH9 3JW, UK)
- **Sept. 5-7, '94**, Prospecting in Areas of Glaciated Terrain, mtg., St. Petersburg, Russia (Institution of Mining and Metallurgy, 44 Portland Place, London W1N 4BR, UK; TEL: (071) 580 3802; FAX: (071) 436 5388)
- **Sept. 8-12, '94**, Joint International Symposium on Exploration Geochemistry, Irkutsk: a tribute to Academician L.V. Tauson (Pavel Koval, Institute of Geochemistry, P.O.Box 4019, 664033 Irkutsk-33, Russia; TELEX: 133 163 Taiga SU; TEL: 395(2) 46-59-78)
- **Sept. 12-15, '94**, 3rd Symposium on Environmental Geochemistry, Krakow, Poland (Dr hab. Edeltrauda Helios Rybicka, Faculty of Geology, Geophysics and Environmental Protection, University of Mining and Metallurgy, Al. Mickiewicza 30, 30-059, Poland; TEL: (48) 12-333290; FAX: (48) 12-332936)
- **Sept. 18-22, '94**, Mineral Exploration '94 (including a 1-day symposium on Latin American Mineral Deposits), Lake Tahoe, NV, U.S.A. (Dr. Phil Newall & Dr. Alan Butcher, CSM Associates Ltd., Pool, Redruth, Cornwall TR15 3SE, UK; TEL: 44 (0)209 717724; FAX: 44 (0)209 716977)
- **Sept. 19-21, '94**, Exploration and Mining Geology of World Class Deposits, Sudbury, Ontario, Sudbury Geological Discussion Group, and Canadian Institute of Mining, Metallurgy and Petroleum (Ruth Debicki, MNDM, A3-933 Ramsey Lake Road, Sudbury, Ontario P3E 6B5 Canada; TEL: (705) 670-5627; FAX: (705) 670-5622)
- **Oct. 2-5, '94**, 1994 Annual Meeting of the Geothermal Resource Council (GRC), theme: Restructuring the Geothermal Resource Council, Salt Lake City, UT, USA (Philip M. Wright, Geothermal Resource Council, PO Box 1350, Davis, CA 95617-1350, TEL: (916) 758-2360, FAX: (916) 758-2839)

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Continued from Page 18

University, 1955 E. Sixth St., Tucson, AZ 85719-5224; TEL: (800) 955-8632; FAX: (602) 621-3269; E-mail (Internet): jlaukes.ccit.arizona.edu


- Oct. 26-29, '94, 4th Asia Pacific Mining Conference and Exhibition, Jakarta, Indonesia (Warjono Soemodinoto or Joe Widartojo, IMA Secretariat, Jl. Prof. Dr. Supomo SH No.10, Jakarta 12870, Indonesia; TEL/FAX: 62 (021) 828-0763 / 830-3632)

- Oct. 30-Nov. 1, '94, RANDOL Latin American Mining Opportunities, conference, Vancouver, British Columbia (RANDOL International Ltd., 21578 Mountsfield Drive, Golden, CO 80401, TEL: (303) 526-1626; FAX: (303) 526-1650)

- Mar. 6-9, '95, SME Annual Meeting and Exhibit, Denver, CO (Meetings Dept., SME Inc., PO Box 625002, Littleton, CO 80162-5002, TEL: (303) 973-9550; FAX: (303) 979-3461)

- Apr. 3-7, '95, Centennial Geocongress 1995, Johannesburg, The Geological Society of South Africa (The Congress Secretariat, Centennial Geocongress, PO Box 36815, Johannesburg 0102, South Africa; TEL/FAX: 2712 47 3398)

- Apr. 10-13, '95, Geology and Ore Deposits of the American Cordillera, Geological Society of Nevada Symposium III (Bob Hatch, Geological Society of Nevada, P.O. Box 12021, Reno NV 89550; TEL: (702) 323-4569; FAX: (702) 323-3599)

- May 15-19, '95, 17th International Geochemical Exploration Symposium, "Exploring the Tropics", Townsville, Queensland, Australia (Russell Myers, 17 IGES, National Key Centre in Economic Geology, James Cook University, Townsville, Queensland 4814, Australia; TEL: (077) 814486; FAX: (61) 77-815522)

- June 3-6, '95, International Field Conference on Carbonate-hosted Lead Zinc Deposits, SEG Anniversary Field Conference (David Leach or Martin Goldhaber, USGS, Branch of Geochemistry, MS 973, PO Box 25046, Federal Center, Denver, CO 80225, USA, FAX: (303) 236-3200, e-mail: dleach@helios.cr.usgs.gov)

- June 7-9, '95, African Mining '95, Windhoek, Namibia (IMM, 44 Portland Place, London W1N 4BR, UK; TEL: (071) 580-3802; FAX: (071) 436-5388)

- Nov. 6-9, '95, Geological Society of America, ann. mtg., New Orleans, LA (Vanessa George, 3300 Penrose Place, Boulder, CO 80301; TEL: (303) 447-2020; FAX: (303) 447-1133)

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

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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 Sherman P. Marsh, Secretary AEG, U.S. Geological Survey, Mail Stop 973, Box 25046, Federal Center, Denver, Colorado 80225, U.S.A.

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, Ontario 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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BOOK REVIEW

Randol International recently published the 1994 edition of their Mexican Mining Directory. This 248 page reference volume begins with tables of mining statistics for Mexico, then provides a listing of mining and exploration companies operating in Mexico. This is followed by listings of mines, government associations, a buyers guide, and a calendar of events. Anyone exploring, or considering exploring in Mexico would be well advised to obtain a copy of this $US85 volume. For more information contact Randol International Ltd, Golden Colorado at (303) 526-1626.

EXPLORE staff

RECENT PAPERS

This list comprises titles that have appeared in major publications since the compilation in EXPLORE Number 82. Journals routinely covered and abbreviations used are as follows: Economic Geology (EG); Geochimica et Cosmochimica Acta (GCA); the USGS Circular (USGS Cir); and Open File Report (USGS OFR); Geological Survey of Canada Papers (GSC Paper) and Open File Report (GSC OFR); Bulletin of the Canadian Institute of Mining and Metallurgy (CIM Bull); 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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Solubilite de l'or dans les eaux interstitielles de la laterite
coiffant le gite oursifere de Misseni, au Mali. Can. J.

Simpson, P.R., Edmunds, W.M., Breward, N., Cook, J.M.,
Geochemical mapping of stream water for environmental
studies and mineral exploration in the U.K. J. Geochem.
Explor. 49: 63-88.

An integrated remote sensing study of mineralized zones
associated with the Agassiz Metallotect, Lynn Lake,
Manitoba (I) (MEIS-II and biogeochemical study).

Metallotect: application of MEIS-II for biogeochemical
remote sensing and geochemical exploration, Lynn Lake

The implications to exploration of chalcophile corridors in the
Archean Yilgarn Block, Western Australia, as revealed by

probability plots and the gap statistic in the selection of
the thresholds for exploration geochemistry data
(Extended Abst.). J. Geochem. Explor. 32: 355-357.

Steenfelt, A., 1993. Geochemical mapping - progress in

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obtained from stream sediment, stream organics and till
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Dorlin, French Guyana (Abst.). J. Geochem. Explor. 32:
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volcanic centers, Arizona and New Mexico, USA
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Sn, and Te geochemistry of the J-M Reef, Stillwater
Complex, Montana: Constraints on the origin of PGE-
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Explor. 37: 51-73.

Zolotarev, V.G., 1989. Thermal and energy factors of metal
concentration in igneous plutons: An application to
metallogenic analysis and exploration. J. Geochem.
Explor. 32: 381-394.
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