

# EXPLORE

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## Newsletter for the Association of Exploration Geochemists

NUMBER 83

APRIL 1994

### TECHNICAL NOTES

#### 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. Miekeley et al. (1992) determined "dissolved" (empirically defined as  $<0.45 \mu\text{m}$ ) 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

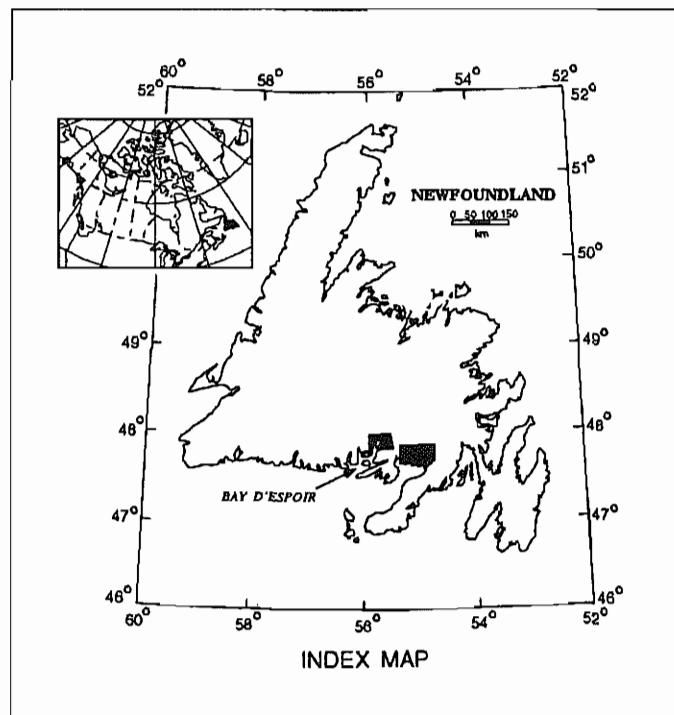


Figure 1. Bay d'Espoir location.

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

*Continued on Page 4*

## CONTENTS

Technical Notes .....	1	SME Annual Meeting .....	16
Hydrogeochemical surveys in Newfoundland - Geological mapping with REEs in lake waters		Tauson International Symposium .....	16
Ideal CHIM with the Newly-Developed, NEOCHIM Electrode	10	Calendar of Events .....	18
Notes from the Editor .....	2	New Members .....	19
President's Message .....	3	Book Review .....	20
Annual General Meeting .....	3	Recent Papers .....	20
News Release .....	3	AEG Application for Admission .....	26
Correction .....	15	AEG Committees .....	27
Upcoming JGE .....	15	List of Advertisers .....	28

## 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:

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## 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 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**.

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## EXPLORE

Newsletter No. 83

APRIL 1994

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## NOTES FROM THE EDITOR

Despite claims of demise of the mineral exploration industry, technical notes continue to be submitted to **EXPLORE**. This issue features an article by Gwendy Hall and John McConnell on hydrogeochemical surveys in Newfoundland and an article by Reinhard Leinz and Don Hoover that updates us on developments with the CHIM method.

In the *President's Message* for this issue, Graham Taylor draws our attention to the changing times in the mineral exploration industry. This is a subject that the AEG Council has given considerable attention to recently. Most agree that the AEG must change in response to changing conditions in our industry in order to meet the needs of the membership, but the type and direction of change remains a topic of lively discussion. Some would have the AEG change its mandate and audience to the extent that a name change would be required, while others are basically happy with the organization as it was originally founded and is currently functioning. No AEG member should ignore this debate over fundamental issues. You are all urged to watch the pages of **EXPLORE** for continued discussion. Most importantly, be aware of any votes by the membership over the next several months and make sure your opinion is heard.

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

<u>Issue</u>	<u>Publication date</u>	<u>Contributor's deadline</u>
84	July 1994	May 31, 1994
85	October 1994	August 31, 1994
86	January 1995	November 30, 1994
87	April 1995	February 28, 1995

Owen Lavin  
Editor **EXPLORE**



## PRESIDENT'S MESSAGE

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 be 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



## ANNUAL GENERAL MEETING

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



## NEWS RELEASE

### 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 310, Scrogg 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.



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## Technical Notes

Continued from Page 1

MetPac CC-1 column and is similar to Chelex-100 in that it is based on iminodiacetate 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  $\pm 3\%$  for Pr at  $31 \text{ ng l}^{-1}$  (ppt, parts-per-trillion) to  $\pm 17\%$  for Tb at only  $1.8 \text{ ng l}^{-1}$ ; and for Meech Lake ranging from  $\pm 2.3\%$  for La at  $33 \text{ ng l}^{-1}$  to a maximum of  $\pm 21\%$  for Tb at  $0.7 \text{ ng l}^{-1}$ . 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  $\pm 10\%$  occur for those elements whose concentrations are below  $5 \text{ ng l}^{-1}$ , 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  $0.2\text{-}1 \text{ ng l}^{-1}$  using a definition based upon that concentration equal to three times the standard deviation obtained in five replicate analyses of a  $5 \text{ ng l}^{-1}$  synthetic standard solution. We have reported all survey data to lower limits of  $1.0 \text{ ng l}^{-1}$  as the noise encountered with the ICP-MS measurement fluctuated with its performance (aging instrument) from day to day.

**Table 1.** Reproducibility of results for the REEs in: Ottawa River (n=6); Meech Lake (n=6); and tap water (n=27). All in  $\text{ng l}^{-1}$ .

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

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  $0.45 \mu\text{m}$  filter paper into a 250 ml bottle, using Millipore glass

Continued on Page 5

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## Technical Notes

Continued from Page 4

Table 2. Field duplicate data for REEs in lakes and streams in Bay d'Espoir. All measurement in ng l<sup>-1</sup>

Sample	La	Ce	Pr	Nd	Sm	Eu	Tb	Gd	Dy	Ho	Er	Tm	Yb	Lu
91-54	186	440	46	183	36	7	5	31	23	5	16	1	7	1
91-55	196	468	48	192	36	8	5	36	23	5	16	2	7	1
91-61	131	303	34	133	25	6	4	26	21	5	15	2	9	1
91-62	130	306	34	136	29	6	4	27	21	5	15	2	10	1
91-80	31	46	7	26	5	2	1	7	5	1	3	<1	3	<1
91-81	34	52	7	30	7	2	1	7	5	1	3	<1	3	<1
91-94	118	122	24	87	15	3	2	16	8	2	4	<1	2	<1
91-95	97	104	21	78	14	3	2	13	7	1	4	<1	2	<1
91-105	135	116	26	94	18	3	2	16	10	2	5	1	4	<1
91-106	139	123	27	99	19	4	2	18	10	2	5	1	4	<1
91-131	70	134	15	57	10	1	2	12	11	3	10	1	12	2
91-132	46	91	10	39	7	1	1	7	8	2	7	1	7	1
91-141	33	48	9	31	8	<1	2	8	12	3	11	2	15	2
91-142	43	64	11	42	10	<1	2	13	16	4	14	2	19	3
91-146	199	188	50	197	50	2	13	59	76	20	70	12	87	14
91-147	204	189	53	192	47	2	12	61	74	20	71	12	91	14
91-150	228	324	57	228	54	3	12	57	65	17	56	9	65	10
91-151	214	319	56	221	53	4	12	66	69	17	57	10	70	10
91-175	202	277	50	177	34	2	8	39	48	12	39	7	43	6
91-176	200	272	51	177	40	2	8	46	49	12	40	7	47	7
91-179	107	152	27	100	23	2	6	33	39	10	34	6	42	6
91-180	105	141	26	97	25	1	5	29	38	10	35	6	42	6

apparatus and acidified with 1 ml of 16 M HNO<sub>3</sub> (Ultrax). Earlier studies indicated that: (1) acidification to 0.1 or 0.4 % in HNO<sub>3</sub> stabilized the REEs in solution at ng l<sup>-1</sup> 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<sup>-1</sup> to several hundred ng l<sup>-1</sup>, a field and analytical precision of 25-30% (i.e. ± 15% RSD) or better can be

Continued on Page 6



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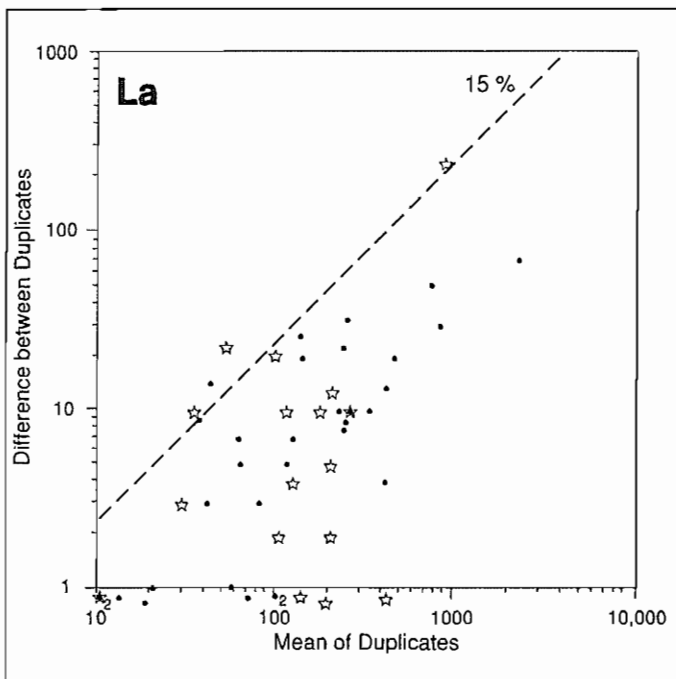
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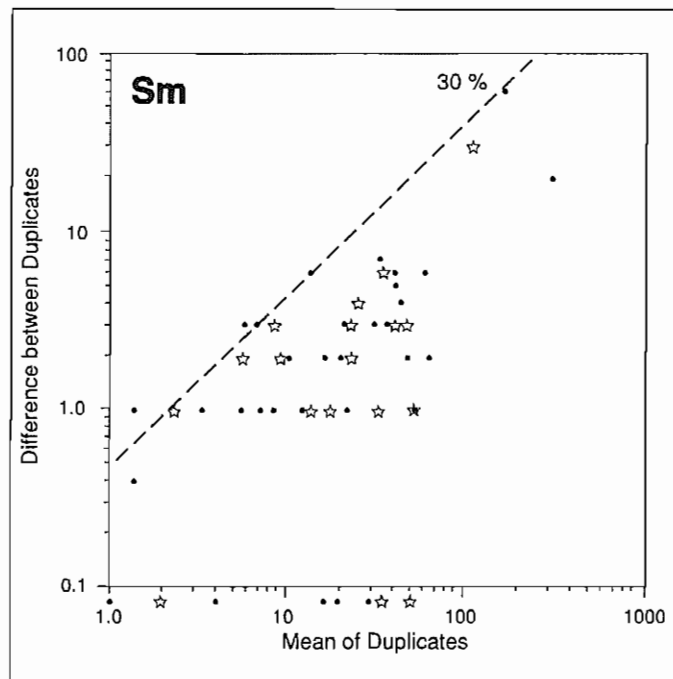
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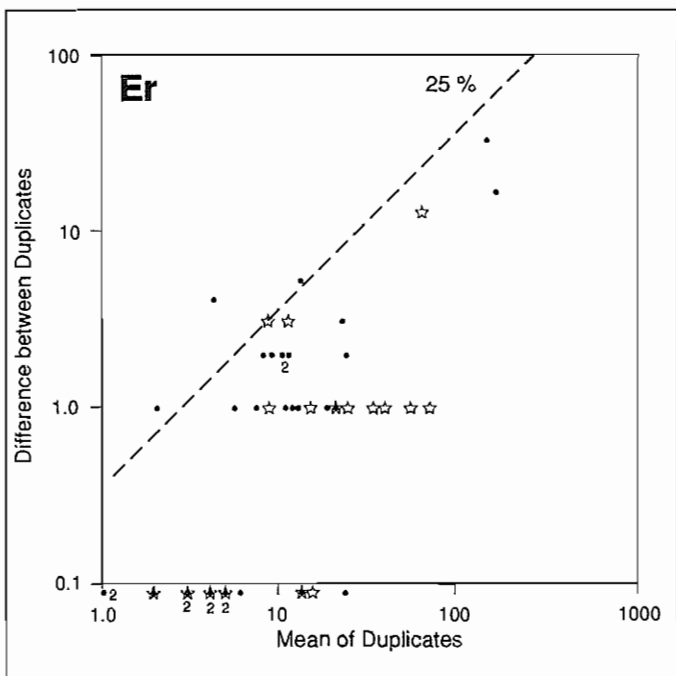
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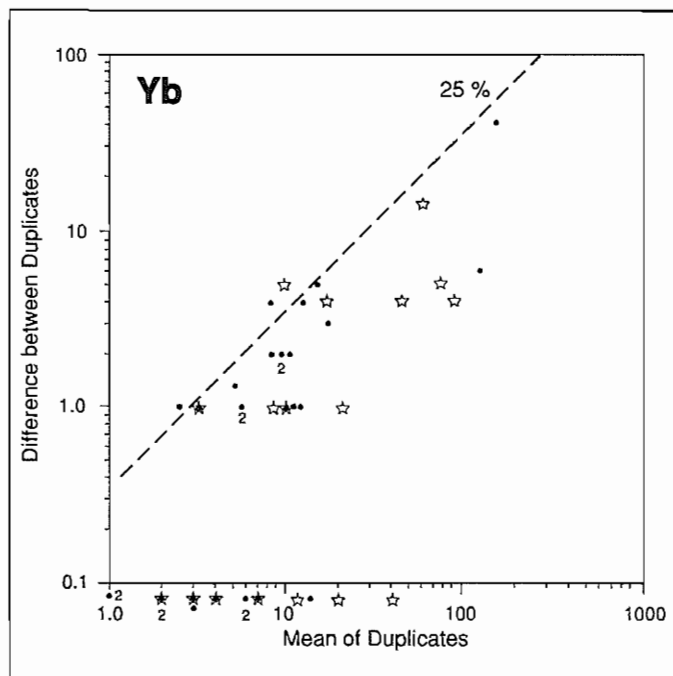
a.



b.



c.



d.

Figure 2. Thompson and Howarth plots representing precision for: (a) La; (b) Sm; (c) Er; and (d) Yb. Values in  $\text{ng l}^{-1}$  (ppt). Stars represent field duplicates, and circles represent blind (lab) duplicates.

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  $10\text{--}2400 \text{ ng l}^{-1}$ .

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  $180 \mu\text{m}$  fraction by instrumental neutron activation analysis (INAA) in a multi-element commercial package.

Continued on Page 7

## Technical Notes

Continued from Page 6

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

Element	Range	Median	Mean	SD
La	10 - 883	130	148	119
Ce	12 - 766	208	233	152
Pr	2 - 139	29	35	23
Nd	8 - 489	113	132	86
Sm	2 - 83	23	27	17
Eu	<1 - 16	2	3.3	2.7
Tb	<1 - 17	4	4.9	3.6
Dy	2 - 96	23	29	20
Ho	2 - 112	21	27	22
Er	<1 - 29	4	6.4	5.6
Tm	1 - 99	15	21	19
Yb	<1 - 17	2	3.1	3.1
Lu	1 - 113	10	20	22
	<1 - 17	1	2.9	3.4

There was a problem with the INAA data for Lu, mostly reported erroneously low at the method's detection limit of  $0.02 \mu\text{g g}^{-1}$  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  $\text{ng l}^{-1}$  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 Cadrynian age which are intruded by a Devonian high-silica granite. To the northwest, the Gander and Dunnage Zones are composed of clastic-sedimentary and volcanic rocks, also intruded by granites (Colman-Sadd et al., 1990). The earlier NGR 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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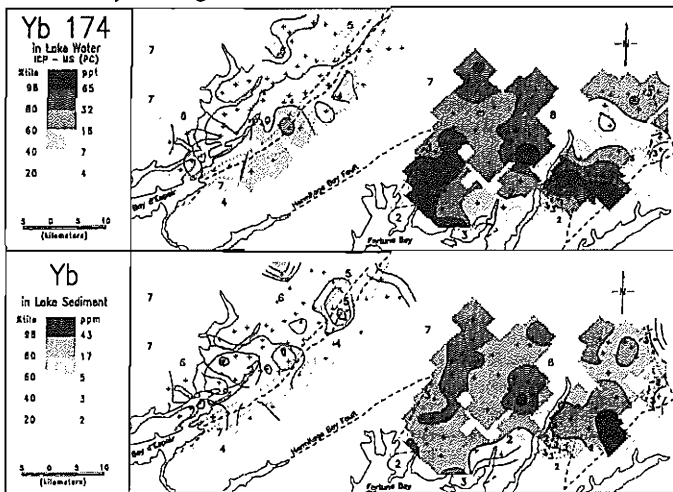
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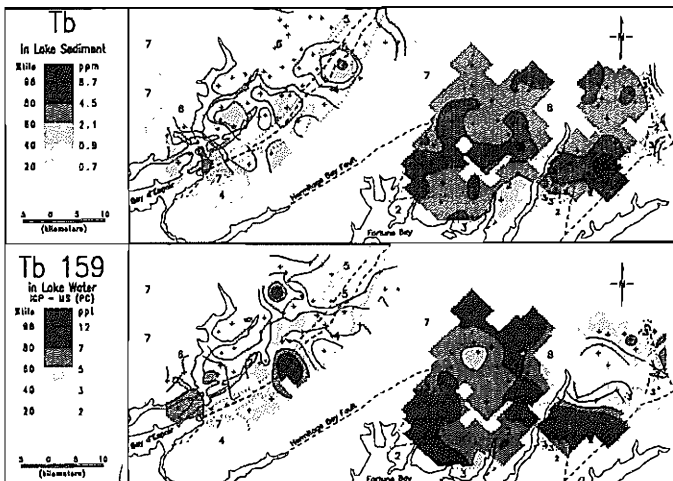
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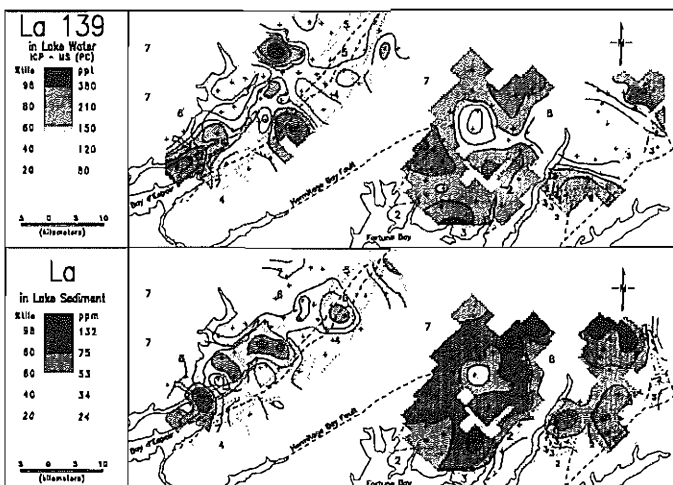
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3a



3b



3c

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  $\text{SO}_4$  ( $12.5 \text{ mg l}^{-1}$ ) and  $\text{Cl}$  ( $13.2 \text{ mg l}^{-1}$ ).

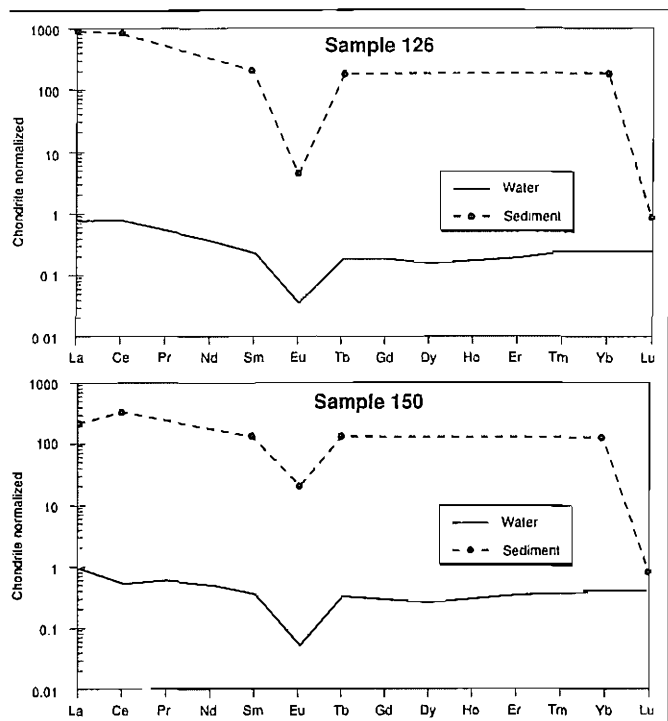
Another way to compare water and sediment information for the REEs is to examine their chondrite-normalized plots; these were drawn for all 108 coincident sites. For every lake, the similarity between the plots for REEs in water and sediment is remarkable. Forty seven sites are clearly located over the 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  $\text{Ce}^{3+}$  to  $\text{Ce}^{4+}$  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.

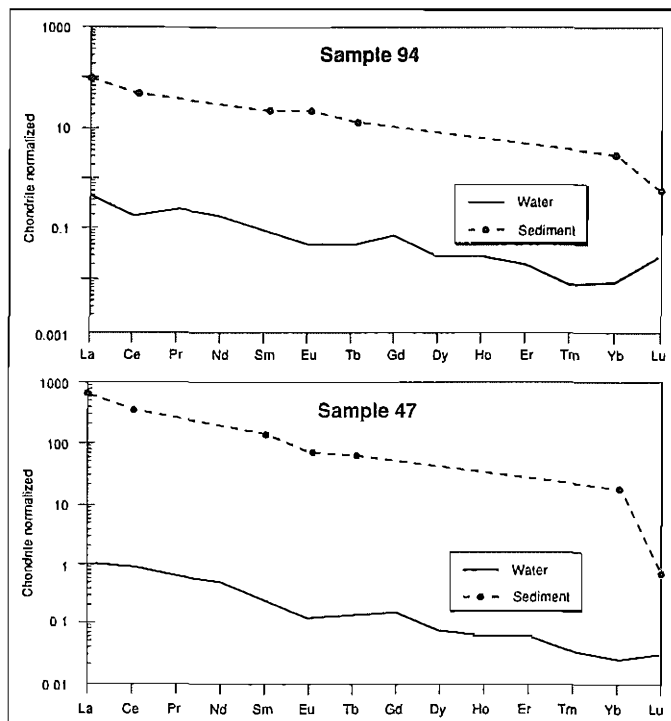
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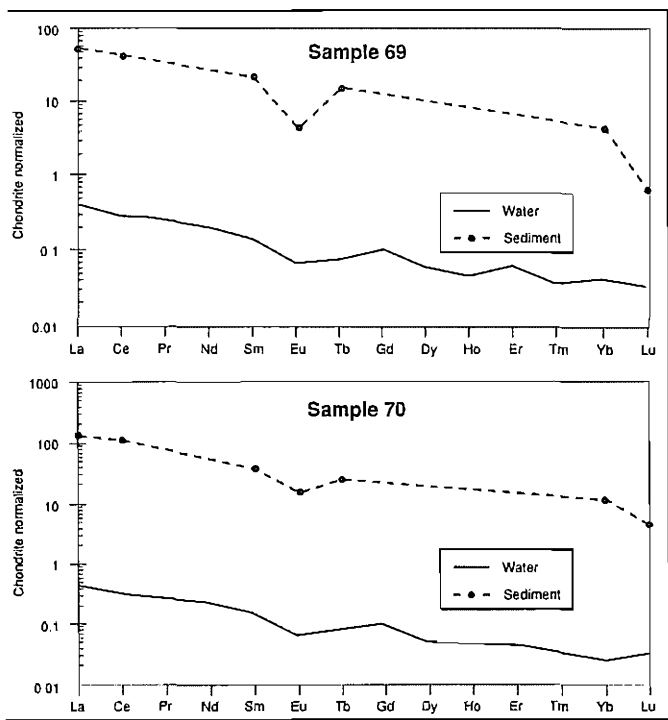
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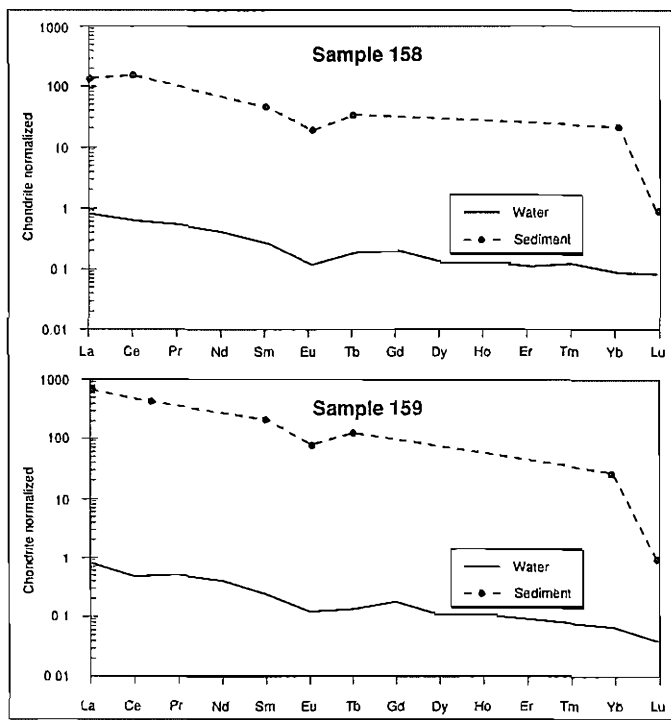
a



4b



4c



4d

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]

## Technical Notes

Continued from Page 9

### 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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Geol. Surv. Branch

### References Cited

- Colman-Sadd, S.P., Hayes, J.P. and Knight, I., 1990. Geology of the Island of Newfoundland, Map 90-01, Newfoundland Department of Mines and Energy, Geological Survey Branch.
- Elderfield, H., Upstill-Goddard, R. and Sholkovitz, E.R., 1990. The rare earth elements in rivers and coastal seas and their significance to the composition of ocean waters. *Geochim. Cosmochim. Acta*, 54: 971-991.
- Friske, P.W.B. and Hornbrook, E.H.W., 1991. Canada's National Geochemical Reconnaissance Programme. *Trans. Inst. Min. Metall. (Sect. B: Appl. Earth Sci.)*, 100: B47-B56.
- Goldstein, S.J. and Jacobsen, S.B., 1988. REE in the Great Whale estuary, northwest Quebec. *Earth Planet. Sci. Lett.*, 88: 241-252.
- Hoyle, J., Elderfield, H., Gledhill, A. and Greaves, M., 1984. The behaviour of the rare earth elements during mixing of river and sea waters. *Geochim. Cosmochim. Acta*, 48: 143-149.
- Miekeley, N., Coutinho de Jesus, H., Porto da Silveira, C.L., Linsalata, P. and Morse, R., 1992. Rare-earth elements in ground waters from the Osamu Utsumi mine and Morro do Ferro analogue study sites, Pocos de Calda, Brazil. *J. Geochem. Explor.*, 45: 365-387.
- Thompson, M. and Howarth, R.J., 1978. A new approach to the estimation of analytical precision. *J. Geochem. Explor.*, 9: 23-30.



## Ideal CHIM with the Newly-Developed, NEOCHIM Electrode

### Review

CHIM is an electrogeochemical 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<sup>-</sup>) ions produced in the electrode by electrolysis during operation (2H<sub>2</sub>O + 2e<sup>-</sup> → 2OH<sup>-</sup> + H<sub>2</sub>↑). Generally, nitric acid is used. Goldberg et al. (1990) call for the addition of concentrated HNO<sub>3</sub> to the electrode, as necessary, to prevent alkalization of the soil by OH<sup>-</sup> 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<sup>+</sup> ions proximal to the electrode promulgates conditions that are not permissive for conducting ideal extractions because: 1) the H<sup>+</sup> 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<sup>+</sup> 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<sup>+</sup> 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<sup>+</sup> 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<sup>+</sup> from which the H<sup>+</sup> 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.

Continued on Page 11

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Continued from Page 10

## 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 performs the 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, so 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 anion collector. Because of this, consideration of the reactivity of

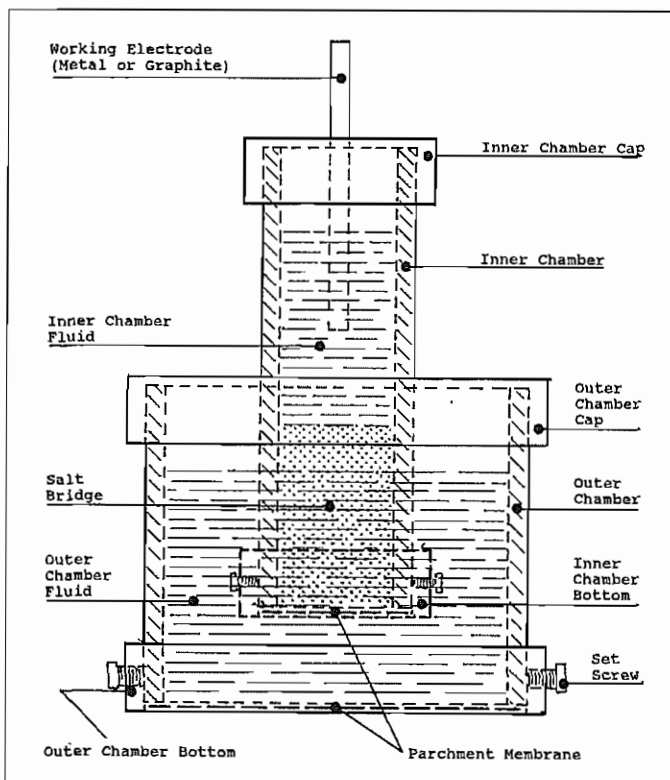


Figure 1. The NEOCHIM electrode, patent pending, by Hoover and Leinz, 1993. The prototype is constructed from chemical-resistant plastic.

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## Technical Notes

Continued from Page 11

The soil with the ions in the fluid is necessary. In an ideal CHIM run, the ions moving out of the electrode are passive towards 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 transfer supplied 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 ampere-hours reveals that strikingly similar amounts of zinc were collected per unit charge in each of the four runs (Fig. 2), a vivid demonstration of comparable efficiencies of the electrical extractions. This is near the result expected of ideal CHIM. The data for copper and lead depicted in Figure 2, though not as striking as the zinc data, reflect reproducibility previously not achievable with conventional CHIM electrodes. Deviations of Cu from the norm in run IV (Fig. 2) are attributed to the effects of chloride entering the soil from the cathode fluid or, in some cases, to analytical uncertainty at

**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. The working electrode for each run was a 5mm-diameter graphite rod. Electrical power was supplied by a 10kW generator.

	RUN I		RUN II		RUN III		RUN IV	
	Cathode	Anode	Cathode	Anode	Cathode	Anode	Cathode	Anode
<b>Outer Chamber</b>								
Diameter, mm	40	40	40	40	40	40	100	100
Volume, ml	50	50	50	50	50	50	400	400
Composition	.01N KNO <sub>3</sub>	.01N KNO <sub>3</sub>	.1N KNO <sub>3</sub>	.1N KNO <sub>3</sub>	.1N KNO <sub>3</sub>	.1N KNO <sub>3</sub>	.7N KCl	.7N KCl
<b>Inner Chamber</b>								
Diameter, mm	25	25	25	25	25	25	40	40
Volume, ml	25	25	25	25	25	25	70	70
Composition	1N HNO <sub>3</sub>	1N HNO <sub>3</sub>	1N HNO <sub>3</sub>	1N HNO <sub>3</sub>	1N HNO <sub>3</sub>	1N HNO <sub>3</sub>	4N HCl	4N KOH
<b>Salt Bridge</b>								
Diameter, mm	25	25	25	25	25	25	40	40
Volume, ml	20	20	20	20	20	20	70	70
Composition (in 5% agar gel)	1N KNO <sub>3</sub>	1N KNO <sub>3</sub>	1N KNO <sub>3</sub>	1N KNO <sub>3</sub>	1N KNO <sub>3</sub>	1N KNO <sub>3</sub>	4N KCl	4N KCl
Date of Run (1993)	July 27		July 27		Aug. 12		Sept. 21, 22	
Duration of Run	0.5 Hrs		1.5 Hrs		3.5 Hrs		20 Hrs	

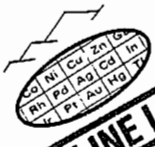
**Table 2.** Total micrograms ( $\mu\text{g}$ ) of copper, lead, and zinc collected in the cathode solution during four experimental CHIM runs conducted at the Kokomo mine, Central City district, to test the NEOCHIM electrode.

RUN	Copper				Lead				Zinc			
	I	II	III	IV	I	II	III	IV	I	II	III	IV
SITE												
50N	0	0	2.5	12	0	0	30	520	3.5	9.0	35	144
40N	8.5	49	185	680	35	230	750	2160	40	165	500	1440
30N	1.0	.50	3.5	640	5.0	0	25	1120	9.5	24	35	640
20N	.50	1.5	8.5	64	0	5.0	45	0	10	45	75	560
10N	6.5	26	75	1640	5.0	15	70	400	80	550	900	4800
00	7.0	16	14	2480	10	15	55	1480	42	230	175	2680
10S	1.0	1.0	3.0	0	0	5.0	35	0	2	16	40	204
20S	1.0	1.0	7.0	0	0	0	25	0	3.5	14	125	800
30S	.50	0	3.0	36	0	0	35	0	2.0	7.0	35	600
40S	.50	.50	8.5	0	0	0	50	0	1.5	6.5	35	180
50S	1.0	1.0	4.5	0	5.0	5.0	50	200	3.0	13	30	168

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. An additional



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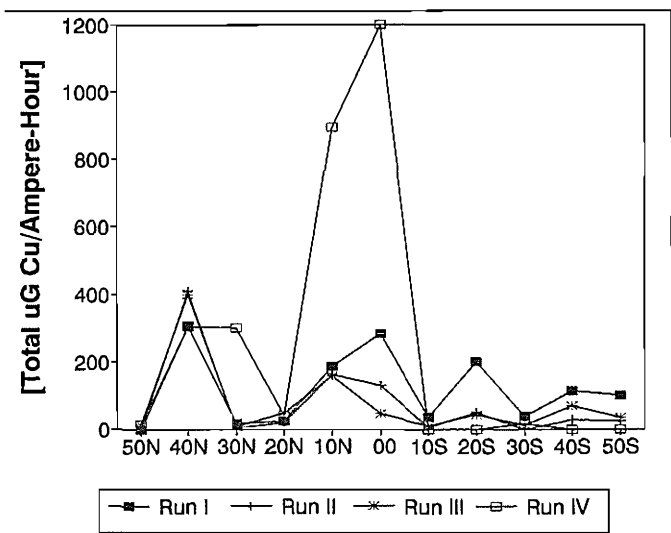
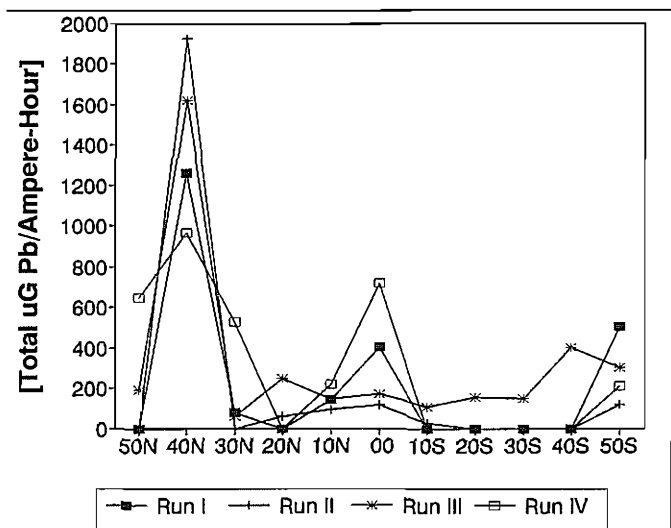
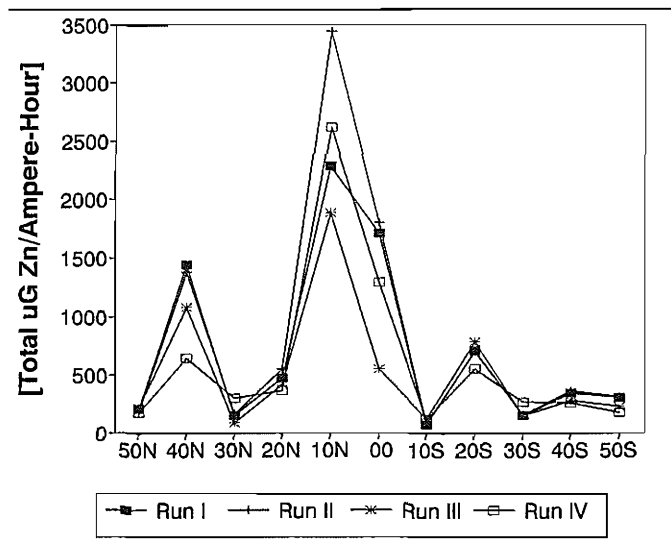
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Continued from Page 12



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; Varshal 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

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.

SITE	Zn Total $\mu\text{g}$	S Total $\mu\text{g}$	As Total $\mu\text{g}$	Au Total ng
50N	12	1200	---	0
40N	---	---	---	---
30N	90	2200	---	110
20N	40	1000	30	0
10N	90	3800	---	144
00	110	180	96	92
10S	55	0	---	20
20S	55	6700	52	12
30S	110	0	26	0
40S	40	0	---	0
50S	60	0	---	0

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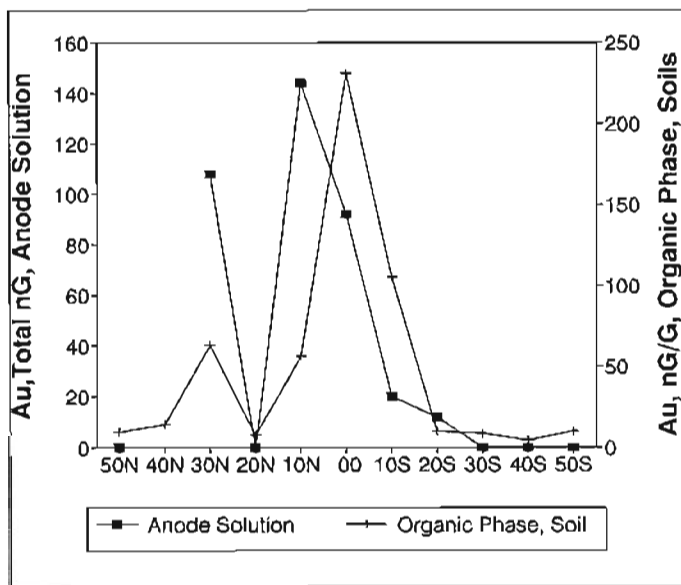


Figure 3. Total nanograms of gold (ng) collected in the anode solution of CHIM run IV at the Kokomo mine using the NEOCHIM electrode, and total nanograms of gold associated with organic matter in soil samples collected from the sites of electrode placement. Site 00 lies over the mineralized vein. The anode solution at site 40S was not recovered.

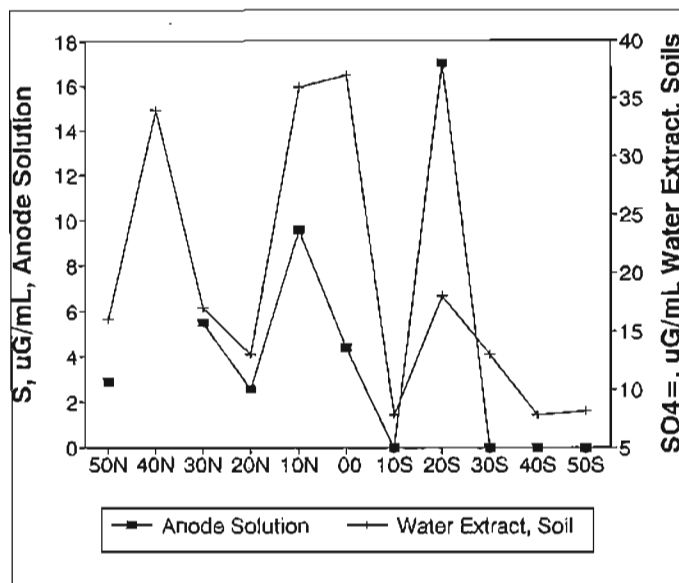


Figure 4. Concentrations, in  $\mu\text{g/ml}$  (ppm), of sulfur collected in the anode solution of CHIM run IV at the Kokomo mine using the NEOCHIM electrode, and concentrations of sulfate in water extracts of soil samples, in  $\mu\text{g/g}$  of soil (ppm), collected from the sites (50N-50S) of electrode placement. Site 00 lies over the mineralized vein. The anode solution at site 40S was not recovered.

site (Fig. 4). Arsenic was found in all four of the anode solutions selected for the analysis and was more abundant in the anode solution from site 00, 96 micrograms ( $\mu\text{g}$ ), than in the cathode solution from the same site (30  $\mu\text{g}$ ). Analytical constraints prevented analysis of the anode solutions for other naturally occurring anions.

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.

Reinhard W. Leinz  
 Donald B. Hoover  
 U.S. Geological Survey  
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 (303) 236-2449

References

- Baker, W.E., 1978. The role of humic acid in the transport of gold. *Geochim. et Cosmochim. Acta*, 42, 645-649.
- Curtin, G.C., Lakin, H.W., and Hubert, A.E., 1970. The mobility of gold in mull (forest humus layer). In: *Geological Survey Research 1970, U.S. Geological Survey Professional Paper 700C*, 127-129.

Continued on Page 15

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For more information, please contact:

Dr. J. Robert Clark  
 Enzyme-ACTLABS, LLC  
 12090 West 50th Place  
 Wheat Ridge, CO 80033  
 Office: 303-424-7718  
 Home: 303-424-4069  
 FAX/Modem: 303-420-6646

Dr. Eric L. Hoffman  
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 Ancaster, Ontario L9G 4V5  
 Office: 905-648-9611  
 FAX: 905-648-9813  
 Modem: 905-648-9688

## Technical Notes

Continued from Page 14

- Goldberg, I.S., Ivanova, A.V., Ryss, Yu. S., Veiker, A.A., Bakhtin, Yu.G., Alekseev, S.G., and Yakovlev, A.F., 1990. Exploration of ore deposits by the CHIM method. In: E. Bloomstein (Translator), Selected Translations of the Russian Literature on the Electrogeochemical Sampling Technique Called CHIM. U.S. Geological Survey Open-File Report 90-462, 172 pp.
- Gregoire, D.C., 1985. Selective extraction of organically bound gold in soils, lake sediments and stream sediments. *J. Geochem. Explor.*, 23, 299-313.
- Leinz, R.W. and Hoover, D.B., 1993. The Russian CHIM method — electrically- or diffusion-driven collection of ions? *EXPLORE* 79.
- Meier, A.L., 1980. Flameless atomic absorption of gold in geologic materials. *J. Geochem. Explor.*, 13, 77-85.
- Ong, H.L., and Swanson, V.E., 1969. Natural organic acids in the transportation, deposition, and concentration of gold. Quarterly of the Colorado School of Mines, 64, 395-425.
- Smith, D.B., Hoover, D.B., and Sanzolone, R.F., 1993. Preliminary studies of the CHIM electrogeochemical method at the Kokomo mine, Russel Gulch, Colorado. *J. Geochem. Explor.*, 46, 257-278.
- Varshal, G.M., Velyukhanov, T.K., and Baranova, N.N., 1990. Geochemical and analytical aspects of the reactions of gold with humic substances in natural waters, soils, and rocks. *Geochem. International*, Volume 27, No. 10, 10-19.
- Vlassopoulos, D., Wood, S.A., Mucci, A., 1990. Gold speciation in natural waters: II. The importance of organic complexing — experiments with some simple model ligands. *Geochim. et Cosmochim. Acta*, 54, 1575-1586.



## 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

Wt. of Gold(g)/ Wt. of Sand(g)	Sample Weight (g)	Gold Assays (ppm)	Weighted Average (ppm)	% Carry-over
0.0034/200	166.06	20.5, 13.4, 16.6, 18.5, 17.2, 16.9	17.2	1
Cleaner 1 Cleaner 2	134.42 68.70	0.18, 0.19, 0.43, 0.11, 0.10 Tr, Nil, Nil	0.21 Nil	
0.0034/100	99.16	37.7, 33.2, 27.9, 28.4	32.5	1
Cleaner 1 Cleaner 2	69.46 69.60	0.44, 0.32, 1.02 0.06, 0.05, 0.06	0.47 0.06	
0.0069/100	98.93	72.7, 51.7, 78.0, 56.7	66.5	0.3
Cleaner 1 Cleaner 2	69.05 68.90	0.33, 0.19, 0.18 0.04, 0.04, 0.06	0.25 0.04	



## UPCOMING JGE

Volume 50, Numbers 1-3 of the Journal of Geochemical Exploration is soon to be published and distributed. An advanced copy of the contents follows.

Volume 50 Nos. 1-3

March 1994

### CONTENTS

#### Special Issue

Mineral Deposits of Indonesia - Discoveries of the Past 25 Years

T.M. van Leeuwen, J.W. Hedenquist, L.P. James and J.A.S. Dow (Editors)

#### Preface

Indonesian mineral deposits - introductory comments, comparisons and speculations

R.H. Sillitoe

25 Years of mineral exploration and discovery in Indonesia

T.M. van Leeuwen

Magmatic arcs and associated gold and copper mineralization in Indonesia

J.C. Carlile and A.H.G. Mitchell

Geologic and geochemical zoning of the Grasberg Igneous Complex, Irian Jaya, Indonesia

G.D. MacDonald and L.C. Arnold

Skarn Cu-Au orebodies of the Gunung Bijih (Ertsberg) district, Irian Jaya, Indonesia

H.J. Mertig, J.N. Rubin and J.R. Kyle

The Batu Hijau porphyry copper-gold deposit, Sumbawa Island, Indonesia

S.J. Meldrum, R.S. Aquino, R.I. Gonzales, R.J. Burke, A.

Suyadi, B. Irianto and D.S. Clarke

Geology, porphyry Cu-Au, and epithermal Cu-Au-Ag mineralization of the Tombulilato district, North

Sulawesi, Indonesia

J.A. Perello

Buligidun prospect: a copper, gold and tourmaline bearing porphyry and breccia system in northern Sulawesi,

Indonesia

Continued on Page 16

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## Upcoming JGE

Continued from Page 15

- H. Lubis, S. Prihatmoko and L.P. James  
 Porphyry molybdenum mineralization in a continental collision setting at Malala, northwest Sulawesi, Indonesia  
 T.M. van Leeuwen, R. Taylor, A. Coote, and F.J. Longstaffe
- Sediment-hosted gold mineralization in the Ratatotok District, North Sulawesi, Indonesia  
 S.J. Turner, P.A. Flindell, D. Hendri, I. Harjana, P.F. Lauricella, R.P. Lindsay, B. Marpaung and G.P. White
- Integrated exploration success for gold at Wetar, Indonesia  
 D.M. Sewell and C.J.V. Wheatley
- The Lerokis and Kali Kuning submarine exhalative gold-silver-barite deposits, Wetar Island, Maluku, Indonesia  
 D.M. Sewell and C.J.V. Wheatley
- The Gunung Pongkor gold-silver deposit, West Java, Indonesia  
 A. Basuki, D. Aditya Sumanagara and D. Sinambela
- Epithermal gold deposits in West Java, Indonesia: geology, age and crustal source  
 E. Marcoux and J.-P. Milesi
- Structural controls and genesis of epithermal gold-bearing breccias at the Lebong Tandai mine, Western Sumatra, Indonesia  
 D.H. Jobson, C.A. Boutier and R.P. Foster
- Alteration and epithermal mineralization in the Masupa Ria volcanic center, Central Kalimantan, Indonesia  
 J.F.H. Thompson, H.Z. Abidin, R. Both, S. Martosuroyo, W.J. Rafferty and A.J.B. Thompson
- Alluvial gold in Kalimantan, Indonesia: a colloidal origin?  
 J.B. Seeley and T.J. Senden
- High Au, Ag, Mo, Pb, V and W content of fumarolic deposits at Merapi volcano, central Java, Indonesia  
 I. Kavalieris
- The mercury "tromol" mill: an innovative gold recovery technique, and a possible environmental concern  
 L.P. James



## 1994 SME ANNUAL MEETING

### Geochemistry Session

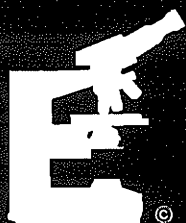
The 1994 SME Annual Meeting convened in Albuquerque, New Mexico, on February 14-17. Of the 77

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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.



## TAUSON INTERNATIONAL SYMPOSIUM

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 "Geoecology 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

Continued on Page 17



## Tauson International Symposium

Continued from Page 16

### 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-Kholba, 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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## CALENDAR OF EVENTS

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 Comité Aurífero, Sociedad Nacional de Minero y Petróleo and Randol International Ltd. (Sondra Wells, Randol International Ltd., Golden, CO, USA, FAX: (303) 526-1650 or Dr. Guillermo Albareda, Comité Aurífero Sociedad Nacional de Minero y Petróleo, Las Flores 346, Lima 27, Peru. TEL: (51-14) 70-4260, FAX: (51-14) 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**, Kraków, 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, **Geoanalysis '94**, International Symposium on Analysis of Geological and Environmental Materials, UK (Doug Miles, British Geological Survey, Keyworth Nottingham NG12 5GG, UK; TEL: 44-36-602-3100; FAX: 44-36-602-3200)

■ 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)

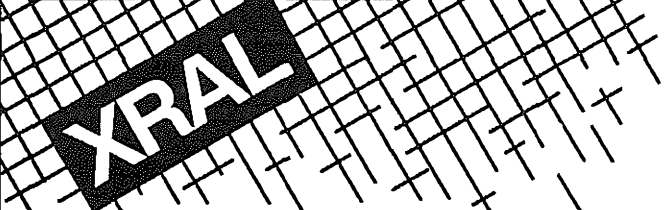
■ Sept. 19-21, '94, **Exploration and Mining Geology of World Class Deposits**, Sudbury, Ontario, Sudbury Geological Discussion Group, and Canadian Institute of Mining, Metallurgy and Petroleum (Ruth Debicki, MNDM, A3-933 Ramsey Lake Road, Sudbury, Ontario P3E 6B5 Canada; TEL: (705) 670-5627; FAX: (705) 670-5622)

■ Sept. 26-27, '94, **Manganese Mineralization: Geochemistry and Mineralogy of Terrestrial and Marine Deposits**, London, England (Dr. Keith Nicholson, School of Applied Sciences, Robert Gordon University, Aberdeen AB1 1HG, Scotland. TEL: 0224-262821/262802, FAX: 0224-262828)

■ 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)

■ Oct. 5-7, '94, **Porphyry Copper Deposits from Alaska to Chile Symposium**, Tucson, AZ, by Arizona Geological Society, Society for Mining, Metallurgy and Exploration, and U.S. Geological Survey (Jim Laukes, The University of Arizona Extended

*Continued on Page 19*




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## Calendar of Events

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. 25-27, '94, Geological Society of America, ann. mtg., Seattle, WA (Vanessa George, G.S.A., Box 9140, Boulder, CO 80301; TEL: (303) 447-2020)

■ Oct. 26-29, '94, 4th Asia Pacific Mining Conference and Exhibition, Jakarta, Indonesia (Warjono Soemodinoto or Joe Widartoyo, 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: 27 12 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 89510; 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.

### FELLOW

Cook, Stephen J.  
Geochemist  
B.C. Geological Survey  
Victoria, BC, Canada

### MEMBERS

Bloomer, Anthony G.  
Rio Tinto Exploration  
Sandton, South Africa

Bolster, Simon J.S.  
Geomorphologist  
Normandy Poseidon  
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Bolter, Ernst  
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Goldsworthy, Julian  
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Geopeko

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Ouagadougou, Burkina Faso

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Vancouver, BC, Canada



## 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.

- Appleton, J.D., Claros, J. and Rodriguez, W., 1989. Lithochemical and mineralogical indicators of Andean precious-metal and polymetallic vein mineralization. *J. Geochem. Explor.* **32**: 359-368.
- Appleton, J.D. and Ridgeway, J., 1993. Regional geochemical mapping in developing countries and its application to environmental studies. *Applied Geochem., Suppl. Issue No. 2*: 103-110.
- Ashton, T. and Lamb, T., 1993. An evaluation of groundwater at the Gay's River mine, Halifax County, Nova Scotia. *CIM Bull* **86**(975): 46-54.
- Barbier, J., 1989. L'évaluation quantitative des anomalies géochimiques en sols résiduels: une aide pour le choix des prospects. *J. Geochem. Explor.* **32**: 445-452.
- Barnes, S.J., Couture, J.F., Sawyer, E.W. and Bouchaib, C., 1993. Nickel-Copper occurrences in the Belleterre-Angliers Belt of the Pontiac Subprovince and the use of Cu-Pd ratios in interpreting platinum-group element distributions. *EG* **88**(6): 1402-1418.

- Barnett, T.J., Cattalani, S. and Moelean, W.H., 1993. Volcanic lithochemical and alteration at the Delbridge massive sulfide deposits, Noranda, Quebec. *J. Geochem. Explor.* **48**(2): 135-173.
- Barrie, C.T., 1993. Petrochemistry of shoshonitic rocks associated with porphyry copper-gold deposits of central Quesmellia, British Columbia, Canada. *J. Geochem. Explor.* **48**(2): 225-258.
- Barrie, C.T., Ludden, J.N. and Green, T.H., 1993. Geochemistry of volcanic rocks associated with Cu-Zn and Ni-Cu deposits in the Abitibi Subprovince. *EG* **88**(6): 1341-1358.
- Bell, K. and Franklin, J.M., 1993. Application of lead isotopes to mineral exploration in glacial terrains. *Geology* **21**(12): 1143-1146.
- Berman, Yu. S. and Khurst, A.R., 1993. Radioelements in gold-silver ores. *Geochem. Intern.* **30**(5): 64-74.
- Bernier, L.R. and MacLean, W.H., 1993. Lithochemical and alteration at a metamorphosed VMS alteration zone at Montauban, Grenville Province, Quebec. *Explor. Mining Geol.* **2**(4): 367-386.
- Birke, M. and Rauch, U., 1993. Environmental aspects of the regional geochemical survey in the southern part of East Germany. *J. Geochem. Explor.* **49**: 35-61.
- Blackburn, W.H., Metcalf, R.V. and Ragland, P.C., 1994. Geochemical evaluation of the Precambrian Old Rag Granite, Virginia, USA: Testing a U-Th exploration model. *Chem. Geol.* **111**: 177-206.
- Bonnefoy, D., Jebrak, M., Rousset, M.C. and Zeegers, H., 1989. SERGE: an expert system to recognize geochemical anomalies (Abst.). *J. Geochem. Explor.* **33**: 343-344.
- Bonnemaison, M., Bonnefoy, D. and Braux, C., 1989. Geochemical signatures of gold-bearing shear zones in the Variscan Basement, France (Abst.). *J. Geochem. Explor.* **32**: 51-52.
- Boudreau, A-E., 1993. Chlorine as an exploration guide for the platinum-group elements in layered intrusions. *J. Geochem. Explor.* **48**(1): 21-37.
- Bourman, R.P., 1993. Perennial problems in the study of laterite: A review. *Aust. J. Earth Sci.* **40**(4): 387-401.
- Bowell, R.J., 1993. Mineralogy and geochemistry of tropical rain forest soils, Ashanti, Ghana. *Chem. Geol.* **106**(3/4): 345-358.
- Braux, C., Piantone, P., Zeegers, H., Bonnemaison, M. and Prevot, J.C., 1993. Le Chatelet gold-bearing arsenopyrite deposit, Massif Central, France: mineralogy and geochemistry applied to prospecting. *Applied Geochem.* **8**(4): 339-356.

Continued on Page 21

## Recent Papers

*Continued from Page 20*

- Bulnayev, K.B., 1993. Vertical geochemical zonation of fluorite deposits in Transbaykalia. *Geochem. Intern.* **30**(6): 141-145.
- Burenkov, E.K., Mukhitdinov, G.N. and Reznikov, I.N., 1989. Procedure for the evaluation of lithochemical anomalies in large-scale mineral exploration (Extended Abst.). *J. Geochem. Explor.* **32**: 399-400.
- Busche, F.D., 1989. Using plants as an exploration tool for gold. *J. Geochem. Explor.* **32**: 199-209.
- Butt, C.R.M. and Zeegers, H., 1989. Classification of geochemical exploration models for tropically weathered terrains. *J. Geochem. Explor.* **32**: 64-74.
- Chaffee, M.A. and Hill, R.H., 1989. Soil geochemistry of Mother Lode-type gold deposits in the Hodson mining district, central California, USA (Abst.). *J. Geochem. Explor.* **32**: 53-55.
- Chork, C.Y. and Salminen, R., 1993. Interpreting exploration geochemical data from Outojumpy, Finland: A MVE-robust factor analysis. *J. Geochem. Explor.*, **48**(1): 1-20.
- Coker, W.B., Robertson, D.J. and Snow, R.J., 1989. Till geochemistry at the Great Gull scheelite prospects, Newfoundland, Canada: a case history in orientation and discovery (Extended Abst.). *J. Geochem. Explor.* **32**: 291-293.
- Colin, F., Lecomte, P., Edou Minko, A. and Benedetti, M., 1993. Regional exploration strategies at Pounga, Gabon, and gold dispersion under equatorial rain forest conditions. *Chron. de la Recherche Miniere (BRGM)*, No. 510: 61-69.
- Connors, K.A., Noble, D.C., Bussey, S.D. and Weiss, S.I., 1993. Initial gold contents of silicic volcanic rocks: Bearing on the behavior of gold in magmatic systems. *Geology* **21**(10): 937-940.
- Cottard, F., Abdulhay, G.-J., Artigan, D., Gelot, J.-L., Roubiehou, P., Trinquard, R. and Vadala, P., 1993. The Al Hajar gold deposit (Kingdom of Saudi Arabia): A newly discovered example of supergene enrichment from a massive sulfide deposit of Late Proterozoic age. *Chron. de la Recherche Miniere (BRGM)*, No. 510: 13-24.
- Couture, R.A., Smith, M.S. and Dymek, R.F., 1993. X-ray fluorescence analysis of silicate rocks using fused glass discs and a side-window Rh source tube: Accuracy, precision, and reproducibility. *Chem. Geol.* **110**(4): 315-328.
- Darnley, A.G., 1993. Some notes on the importance of airborne gamma-ray spectrometry in International Geochemical Mapping. *J. Geochem. Explor.* **49**: 201-212.
- Darnley, A.G., 1993. IGCP 360: International Geochemical Baselines - New Project. *Episodes* **16**(3): 405-407.
- Darnley, A.G., 1993. IGCP 259: Workshop on Systematic Geochemical Mapping (Conference Report). *Episodes* **16**(3): 398.
- Davenport, P.H., Christopher, T.K., Vardy, S. and Nolan, L.W., 1993. Geochemical mapping in Newfoundland and Labrador: its role in establishing geochemical baselines for the measurement of environmental change. *J. Geochem. Explor.* **49**: 177-200.
- Davies, J.F. and Whitehead, R.E., 1994. Molar ratios in the study of unaltered and hydrothermally altered greywackes and shales. *Chem. Geol.* **111**: 85-100.
- Davies, T.C., Friedrich, G. and Wiechowski, A., 1989. Geochemistry and mineralogy of laterites in the Sula Mountains greenstone belt, Lake Sonfon gold district, Sierra Leone. *J. Geochem. Explor.* **32**: 75-98.
- Day, S.J. and Fletcher, W.K., 1989. Effects of valley and local channel morphology on the distribution of gold in stream sediments from Harris Creek, British Columbia, Canada. *J. Geochem. Explor.* **32**: 1-16.
- Delaney, T.A. and Fletcher, W.K., 1993. Size distribution of gold in some soils associated with selected gold mineralization in Canada and the United States of America. *J. Geochem. Explor.* **48**(3): 309-327.
- Disnar, J.R. and Gauthier, B., 1989. Contribution of organic geochemistry to regional exploration and characterization of Mississippi Valley-type mineralization in the Causses basin, France (Extended Abst.). *J. Geochem. Explor.* **32**: 401-403.
- Dudka, S., 1993. Baseline concentrations of As, Co, Cr, Cu, Ga, Mn, Ni and Se in surface soils, Poland. *Applied Geochem. Suppl. Issue No. 2*: 23-28.
- Dunn, C.E., Hall, G.E.M. and Hoffman, E., 1989. Platinum group metals in common plants of the northern forests; developments in analytical methods, and the application of biogeochemistry to exploration strategies. *J. Geochem. Explor.* **32**: 211-222.
- Dunn, C.E. and Irvine, D.G., 1993. Relevance of a lithochemical data base to epiderminological studies in central Saskatchewan, Canada. *Applied Geochem. Suppl. Issue No. 2*: 215-222.
- Erlor, A., 1989. Geochemical character of the hydrothermal alteration zones around the Madenkoy-Siirt massive sulfide deposits and implications for geochemical exploration (Extended Abst.). *J. Geochem. Explor.* **32**: 405-407.

*Continued on Page 22*

## Recent Papers

*Continued from Page 21*

- Esbensen, K.H. and Steinfeldt, A., 1989. Geochemical prospecting in complex sample media-multivariate data analysis of indirect observations (PLS-regression between model mineralogy and geochemistry) (Extended Abst.). *J. Geochem. Explor.* **32**: 345-347.
- Fedikow, M.A.F., 1992. Rock geochemical alteration studies at the MacLellan Au-Ag deposit, Lynn Lake, Manitoba (Canada). *Manitoba Energy and Mines Econ. Geol. Rpt. ER 92-1*, 237 p.
- Fedikow, M.A.F., 1993. Chemical variability in vegetation samples from the area of the Osborne Cu-Zn deposit, Snow Lake area. *Manitoba Mineral Resources Division Econ. Geol. Rpt. ER 93-1*, 14 p.
- Fedikow, M.A.F. and LeSavage, S., 1989. The use of black poplar (*Populus balsamifera* L.) crowns for gold vegetation geochemical surveys in burned boreal forest - preliminary results. *Manitoba Mineral Resources Division (Canada) OFR OF89-1*, 41 p.
- Ferguson, J., Etminan, H. and Ghassemi, F., 1993. Geochemistry of deep formation waters in the Canning Basin, Western Australia, and their relationship to Zn-Pb mineralization. *Aust. J. Earth Sci.* **40**(5): 471-483.
- Ferreira, K.J. and Fedikow, M.A.F., 1988. Preliminary result of a humus geochemical survey over the Rod Cu-Zn deposit, Snow Lake, Manitoba (Canada). *Manitoba Mineral Resources Division OFR OF87-12*, 35 p.
- Ferreira, K.J. and Fedikow, M.A.F., 1991. Results of a rock geochemical study in the area of the Rod Cu-Zn deposits, Snow Lake, Manitoba (Canada). *Manitoba Energy and Mines Econ. Geol. Rpt. ER 91-1*, 43 p.
- Force, E.R., 1991. *Geology of Titanium Mineral Deposits. Geol. Soc. Am. Spec. Paper 259*, 112 p.
- Ford, R.C. and Duke, N.A., 1993. Concentration of gold during retrograde metamorphism of Archean banded iron formations, Slave Province, Canada. *Can. J. Earth Sci.* **30**(8): 1566-1582.
- Fordyce, F.M., Green, P.M. and Simpson, P.R., 1993. Simulation of regional geochemical survey maps at variable sample density. *J. Geochem. Explor.* **49**: 161-175.
- Freyssinet, P., 1993. Gold distribution related to ferricrete pedogenesis in South Mali: Application to geochemical exploration. *Chron. de la Recherche Minière (BRGM)*, No. 510: 25-40.
- Friedrich, G.H.W., Nahon, D. and Smith, R.E., 1989. Report on Workshop 4: Geochemical exploration in lateritic environments (IGES). *J. Geochem. Explor.* **32**: 485-491.
- Fuge, R., Pearce, F.M., Pearce, N.J.G. and Perkins, W.T., 1993. Geochemistry of Cd in the secondary environment near abandoned metalliferous mines, Wales. *Applied Geochem. Suppl. Issue No. 2*: 29-35.
- Galley, A.G., 1993. Characteristics of semi-conformable alteration zones associated with volcanogenic massive sulphide districts. *J. Geochem. Explor.* **48**(2): 175-200.
- Garrett, R.G., 1989. The chi-square plot: a tool for multivariate outlier recognition. *J. Geochem. Explor.* **32**: 319-341.
- Garrett, R.G. and Leymarie, P., 1989. Report on Workshop 2: Data Processing (IGES). *J. Geochem. Explor.* **32**: 477-483.
- Granier, C., Hartley, J., Michaud, J.C. and Troly, G., 1989. Contribution de la géochimie tridimensionnelle à la découverte, sous couverture allochtone, d'extensions de gisement polymétallique de Thalanga, Queensland, Australia. *J. Geochem. Explor.* **32**: 467-475.
- Guedria, A., Trichet, J. and Wilhelm, E., 1989. Behavior of lead and zinc in calcrete-bearing soils around Bou Grine, Tunisia - its application to geochemical exploration. *J. Geochem. Explor.* **32**: 117-132.
- Gulson, B.L., Large, R.R. and Porritt, P.M., 1989. Gold exploration using lead isotopes at Tennant Creek, Australia (Extended Abst.). *J. Geochem. Explor.* **32**: 309-310.
- Gulson, B.L., Meier, A.L., Church, S.E. and Mizon, K.J., 1989. A comparison of lead-isotope measurements on exploration-type samples using inductively coupled plasma and thermal ionization mass spectrometry (Extended Abst.). *J. Geochem. Explor.* **32**: 311-313.
- Guthrie, G.C., Jr. and Mossman, B.T., (Eds.), 1993. *Health Effects of Mineral Dusts. Min. Assoc. Am. Rev. in Mineralogy* **28**, 584 p.
- Hall, G.E.M., 1993. Capabilities of production-oriented laboratories in water analyses using ICP-ES and ICP-MS. *J. Geochem. Explor.* **49**: 89-121.
- Herrera, P.A., Cluss, L.G. and Silberman, M.L., 1993. Alteration and geochemical zoning in Bodie Bluff, Bodie Mining district, eastern California. *J. Geochem. Explor.* **48**(2): 259-275.
- Hitchon, B. and Fuge, R. (Eds.), 1993. *Environmental Geochemistry (Selected Papers from the 2nd International Symposium, Uppsala, Sweden, 16-19 September, 1991). Applied Geochem. Suppl. Issue No. 2*, 299 p.
- Hocquard, C., Zeegers, H. and Freyssinet, P., 1993. Supergene gold: an approach to economic geology. *Chron. de la Recherche Minière (BRGM) No. 510*: 3-11.

*Continued on Page 23*

## Recent Papers

*Continued from Page 22*

- Hodges, D.J. and Manojlovic, P.M., 1993. Application of lithogeochemistry to exploration for deep VMS deposits in high grade metamorphic rocks, Snow Lake, Manitoba. *J. Geochem. Explor.* **48**(2): 201-224.
- Hoffman, E.L., 1989. Instrumental neutron activation analysis as an analytical technique for gold exploration. *J. Geochem. Explor.* **32**: 301-308.
- Hornibrook, E.R.C., Broster, B.E., Gardiner, W.W. and Pronk, A-G., 1993. Glacial dispersion of garnets and other heavy minerals in tills: Miramichi Area, New Brunswick. *Explor. Mining Geol.* **2**(4): 345-353.
- Hubert, P., Beny, C. and Touray, J.C., 1989. Application of fluid-inclusion studies to exploration in gold-bearing shear zones: The Cros-Gallet deposit (France) and the Sanoukou prospect (Mali) (Abst.). *J. Geochem. Explor.* **32**: 57.
- Huston, D.L., 1993. The effect of alteration and metamorphism on wall rocks to the Balcooma and Dry River South volcanic-hosted massive sulfide deposits, Queensland, Australia. *J. Geochem. Explor.* **48**(3): 277-307.
- Hutchinson, R.W., 1993. A multi-stage, multi-process genetic hypothesis for greenstone-hosted gold lodes. *Ore Geol. Rev.* **8**(3/4): 349-382.
- Jones, B. and Manning, D.A.C., 1994. Comparison of geochemical indices used for the interpretation of paleoredox conditions in ancient mudstones. *Chem. Geol.* **111**: 111-129.
- Kabata-Pendias, A., 1993. Behavior properties of trace metals in soils. *Applied Geochem. Suppl. Issue No. 2*: 3-9.
- Kabore, J., Mathez, G., Ouedraogo, M.F. and Sattran, V., 1989. Prospection geochimique dans le centre et le nord-ouest du Burkina Faso. *J. Geochem. Explor.* **32**: 429-435.
- Koljonen, T., Gustavsson, N., Noras, P. and Tanskanen, H., 1989. Geochemical Atlas of Finland: preliminary aspects. *J. Geochem. Explor.* **32**: 231-242.
- Koval, P.V., Gotovsuren, A., Ariunbileg, S. and Libatorov, Yu. I., 1989. On prospecting for porphyry copper mineralization in intracontinental mobile zones. *J. Geochem. Explor.* **32**: 369-380.
- Kozlov, N. Ye., Ivanov, A.A., Gavrilenko, B.V. and Shelukhina, L.M., 1993. Gold prospects in the Lapland Granulite Belt, Baltic Shield. *Geochem. Intern.* **30**(9): 132-139.
- Kurzl, H., 1989. Data analysis and geochemical mapping for the regional stream sediment survey of Austria (Abst.). *J. Geochem. Explor.* **32**: 349-351.
- Lahtineu, R., 1989. Application of the zoning of ore-associated elements to exploration for volcanogenic massive sulphide deposits: a case study of the Pukkiharju Zn-Cu prospect, central Finland (Extended Abst.). *J. Geochem. Explor.* **32**: 395-398.
- Lassenre, J.L., Testard, J. and Coste, B., 1989. Multiple data-type processing as applied to the selection of areas with high gold potential in French Guyana (Abst.). *J. Geochem. Explor.* **32**: 353-354.
- Laville-Timsit, L. and Wilhelm, E., 1989. An attempt for selectively using the chemical dispersion of metals to search for hidden deposits. *J. Geochem. Explor.* **32**: 243-256.
- Laznicka, P., 1993. *Precambrian Empirical Metallogeny*. Elsevier. 1640 p.
- Li, X. and Thornton, I., 1993. Multi-element contamination of soils and plants in old mining areas, U.K. *Applied Geochem. Suppl. Issue No. 2*: 51-56.
- Lima da Costa, M., Vieira-Costa, J.A. and Angelica, R.S., 1993. Gold-bearing bauxitic laterite in a tropical rain forest climate: Cassipore, Amapa, Brazil. *Chron. de la Recherche Miniere (BRGM) No. 510*: 41-51.
- Llorea, S.M., 1993. Metallogeny of supergene cobalt mineralization, New Caledonia. *Aust. J. Earth Sci.* **40**(4): 377-385.
- Loredo, J., Iglesias, J.E. and Ruiz, F., 1989. Mineral exploration for gold-bearing levels in the central-western zone of Asturias, Spain (Abst.). *J. Geochem. Explor.* **32**: 409-410.
- MacDonald, M.A. and Boner, F.J., 1993. Multi-media geochemistry and surficial geology of the Yava Pb deposit, southeastern Cape Breton Island, Nova Scotia, Canada. *J. Geochem. Explor.* **48**(1): 39-69.
- Machesky, M.L., Rose, A.W., Androde, W.O., Bliss, L. and Kato, T., 1993. Gold speciation and mobility near the Igarape Bahia deposit, Para State, Brazil. *Chron. de la Recherche Miniere (BRGM) No. 510*: 53-60.
- MacLean, W.H. and Barrett, T.J., 1993. Lithogeochemical techniques using immobile elements. *J. Geochem. Explor.* **48**(2): 109-133.
- Marcoux, E., Cottard, F., Recoche, G., El Samani, Y., Calvez, J.Y. and Deschamps, Y., 1989. Lead isotopic signatures of the polymetallic mineralization in the Ariab District, Red Sea Hills, northeastern Sudan (Extended Abst.). *J. Geochem. Explor.* **32**: 315-317.

*Continued on Page 24*

## Recent Papers

*Continued from Page 23*

- Marroncle, J.L., La Chapelain, J.R., Perichaud, J.J., and Brevot, J.C., 1989. Geological, geochemical and metallogenetic evaluation of the Pontgi band vein swarm and its surrounding area, Massif Central, France (Abst.). *J. Geochem. Explor.* **32**:411-412.
- McCall, J., 1993. Environmental geochemistry and health in developing countries (Conference Report). *Episodes* **16**(3): 401-402.
- McConnell, J. and Davenport, P.H., 1989. Gold and associated trace elements in Newfoundland lake sediment: their application to gold exploration. *J. Geochem. Explor.* **32**: 33-50.
- McConnell, J.W., Finch, C., Hall, G.E.M. and Davenport, P.H., 1993. Geochemical mapping employing active and overbank stream-sediment, lake sediment and lake water in two areas of Newfoundland. *J. Geochem. Explor.* **49**: 123-143.
- Money, D.P., 1993. Metal zoning in the Deep Copper Zone 3700 Level, Strathcona Mine, Ontario. *Explor. Mining Geol.* **2**(4): 307-320.
- Neumayr, P., Cabri, L.J., Groves, D.I., Mikucki, E.J. and Jackman, J.A., 1993. The mineralogical distribution of gold and relative timing of gold mineralization in two Archean settings of high metamorphic grade in Australia. *Can. Min.* **31**: 711-725.
- Nivin, V.A. and Belov, N.I., 1993. Correlations between gas-geochemical and geochemical parameters of alkali rocks at ore deposits. *Geochem. Intern.* **30**(7): 34-40.
- Ottensen, R.T., Bogen, J., Bolviken, B. and Volden, T., 1989. Overbank sediment: A representative sample medium for regional geochemical mapping. *J. Geochem. Explor.* **32**: 257-277.
- Parisot, J.C., Soubies, F., Audry, P. and Espourteille, F., 1989. Some implications of lateritic weathering on geochemical prospection - two Brazilian examples. *J. Geochem. Explor.* **32**: 133-147.
- Pasava, J., 1993. Anoxic sediments - an important environment for PGE: An overview. *Ore Geol. Rev.* **8**(5): 425-445.
- Pirajno, F., 1992. *Hydrothermal Mineral Deposits: Principles and Fundamental Concepts for the Exploration Geologist.* Springer-Verlag. 709 p.
- Pirhonen, V., 1993. Beforehand estimate of mass transfer in arseniferous gold mine tailing by means of minipilot plant process water analysis and geochemical simulations. *Applied Geochem. Suppl. Issue No. 2*: 291-293.
- Pulkkinen, E., Raisanen, M.L. and Ukonmaanaho, L., 1989. Geobotanical and biogeochemical exploration for gold in the Sattasvaara volcanic complex, Finnish Lapland. *J. Geochem. Explor.* **32**: 223-230.
- Ramsey, M.H., 1993. Sampling and analytical quality control (SAX) for improved error estimation in the measurement of Pb in the environment using robust analysis of variance. *Applied Geochem. Suppl. Issue No. 2*: 149-153.
- Ridgway, J. and Dunkley, P.N., 1989. Temporal variations in the trace-element content of stream sediments: An example from the seasonally wet-dry tropics (Extended Abst.). *J. Geochem. Explor.* **32**: 295-297.
- Robinson, G.D., 1993. Major-element chemistry and micromorphology of Mn-oxide coatings on stream alluvium. *Applied Geochem.* **8**(6): 633-642.
- Rogers, P.J. and Dunn, C.E., 1993. Trace element chemistry of vegetation applied to mineral exploration in eastern Nova Scotia, Canada. *J. Geochem. Explor.* **48**(1): 71-95.
- Roquin, C., Dandjenou, T., Freyssinet, Ph. and Pion, J.C., 1989. The correlation between geochemical data and SPOT satellite imagery of lateritic terrain in southern Mali. *J. Geochem. Explor.* **32**: 149-168.
- Rubin, J.N., Henry, C.D. and Price, J.G., 1993. The mobility of zirconium and other "immobile" elements during hydrothermal alteration. *Chem. Geol.* **110**(1/3): 29-47.
- Sadeghi, A. and Steele, K.F., 1989. Use of stream sediment elemental enrichment factors in geochemical exploration for carbonatite and uranium, Arkansas, USA. *J. Geochem. Explor.* **32**: 279-286.
- Salminen, R., Hartikainen, A. and Lestinen, P., 1989. Enrichment of As and S in the finest fractions of crushed rock samples - an experimental study stimulating the formation of till. *J. Geochem. Explor.* **32**: 287-290.
- Samama, J.C., Royer, J.J. and N'Ganzi, C., 1989. Prise en compte de la surface spécifique des prélèvements en prospection géochimique: exemple de l'uranium dans les sédiments de ruisseau. *J. Geochem. Explor.* **32**: 453-466.
- Saunders, D.F., Burson, K.R., Brown, J.J. and Thompson, C.K., 1993. Combined geological and geochemical methods discovered Agaritta and Brady Creek fields, Concho County, Texas. *AAPG Bull.* **77**(7): 1219-1240.
- Schmitt, H-K., Cameron, E.M., Hall, G.E.M. and Vaive, J., 1993. Mobilization of gold into lake sediments from acid and alkaline mineralized environments in the Southern Canadian Shield: Gold in lake sediments and natural waters. *J. Geochem. Explor.* **48**(3): 329-358.

*Continued on Page 25*



## Recent Papers

*Continued from Page 24*

- Sea, F., Tanguay, M.G., Trudel, P. and Bergeron, M., 1993. Solubilité de l'or dans les eaux interstitielles de la laterite coiffant le gîte oursifère de Misseni, au Mali. *Can. J. Earth Sci.* **30**(8): 1553-1565.
- Simpson, P.R., Edmunds, W.M., Breward, N., Cook, J.M., Flight, D., Hall, G.E.M., and Lister, T.R., 1993. Geochemical mapping of stream water for environmental studies and mineral exploration in the U.K. *J. Geochem. Explor.* **49**: 63-88.
- Singh, V., Moon, W.M. and Fedikow, M.A.F., 1988. An integrated remote sensing study of mineralized zones associated with the Agassiz Metaltect, Lynn Lake, Manitoba (I) (MEIS-II and biogeochemical study). Manitoba Energy and Mines (Canada) OFR OF88-3, 99 p.
- Singh, V., Moon, W.M. and Fedikow, M., 1989. Agassiz Metaltect: application of MEIS-II for biogeochemical remote sensing and geochemical exploration, Lynn Lake area, Manitoba. *Geol. Surv. Can. OFR 1994*, 74 p.
- Smith, R.E., Birrell, R.D. and Bridgen, J.F., 1989. The implications to exploration of chalcophile corridors in the Archean Yilgarn Block, Western Australia, as revealed by laterite geochemistry. *J. Geochem. Explor.* **32**: 169-184.
- Stanley, C.R. and Sinclair, A.J., 1989. Comparison of 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 Greenland. *J. Geochem. Explor.* **49**: 5-13.
- Steenfelt, A., 1993. Comparison of geochemical patterns obtained from stream sediment, stream organics and till in the Nordkalott project in Fennoscandia. *J. Geochem. Explor.* **49**: 145-159.
- Taner, M.F., 1993. Gold abundance and an aluminosilicate-rock alteration zone in the Val d'Or mining district, Abitibi, Quebec: Examples of the fossil geothermal fields. *Ore Geol. Rev.* **8**: 451-475.
- Tarkhanov, A.V., Leonenko, M.P. and Prozorova, M.V., 1993. A REE geochemical anomaly at the Zhelta Reka uranium deposit. *Geochem. Intern.* **30**(5): 84-94.
- Taufen, P.M. and Marchetto, C.M.L., 1989. Tropical weathering control of Ni, Cu, Co and platinum group element distributions at the O'Toole Ni-Cu sulphide deposit; Minas Gerais, Brazil. *J. Geochem. Explor.* **32**: 185-197.
- Taylor, G.H., Coste, B., Lambert, A. and Zeegers, H., 1989. Geochemical signature (bedrock and saprolite) of gold mineralization and associated hydrothermal alteration at Dorlin, French Guyana (Abst.). *J. Geochem. Explor.* **32**: 59-60.
- Teigler, B. and Eales, H.V., 1993. Correlation between chromite composition and PGE mineralization in the Critical Zone of the western Bushveld Complex. *Min. Deposita* **28**(5): 291-302.
- Thornton, I., 1993. Environmental geochemistry and health in the 1990s: A global perspective. *Applied Geochem. Suppl. Issue No. 2*: 203-310.
- Toverad, O., 1989. Geochemical prospecting for gold in the county of Jamtland, upper central Sweden (Abst.). *J. Geochem. Explor.* **32**: 61-63.
- Trudel, P., Methot, Y. and Perrault, G., 1989. Géochimie de la minéralisation aurifère à la Mine Eldrich, région de Rouyn-Noranda, Québec, Canada. *J. Geochem. Explor.* **32**: 415-428.
- Van Baalen, M.R., 1993. Titanium mobility in metamorphic systems: A review. *Chem. Geol.* **110**(1/3): 233-149.
- Velikoslavinsky, S.D., Tolmacheva, E.V., Dook, V.L., Milkevich, R.I. and Rudnik, 1993. Geochemical mapping of basic complexes in the early Precambrian Aldan Stanovoy shield of Siberia. *Precambrian Research* **62**(4): 503-510.
- Xie, X., and Ren, T., 1993. National geochemical mapping and environmental geochemistry - progress in China. *J. Geochem. Explor.* **49**: 15-34.
- Wackernagel, H. and Butenuth, C., 1989. Caractérisation d'anomalies géochimiques par la géostatistique multivariée. *J. Geochem. Explor.* **32**: 437-444.
- Watts, K.C., Jr. and Hassemer, J.R., 1989. Geochemical signatures of possible deep-seated ore deposits in Tertiary volcanic centers, Arizona and New Mexico, USA (Extended Abst.). *J. Geochem. Explor.* **32**: 413-414.
- Yang, W. and Siegal, F.K., 1989. Geochemical exploration for chromite deposits, Piedmont Upland Province, Maryland, USA (Extended Abst.). *J. Geochem. Explor.* **32**: 299-300.
- Zientek, M.L., Fries, T.L. and Vian, R.W., 1990. As, Bi, Hg, S, Sb, Sn, and Te geochemistry of the J-M Reef, Stillwater Complex, Montana: Constraints on the origin of PGE-enriched sulfides in layered intrusions. *J. Geochem. 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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