

EXPLORE

The Association of Exploration Geochemists Newsletter

NUMBER 68

JUNE 1990

PRESIDENT'S MESSAGE

Although I became your President in October 1989, this is my first opportunity to address the membership. Each new President hopes to accomplish various goals during his tenure in office. My goals are straightforward — communication and efficiency — both of which require concerted effort. These goals are not dissimilar to those of my predecessors and their efforts have paved the way for whatever improvements we can experience in 1990.



Communication is a simple concept and one we've had thrown at us from many directions, however the concept is paramount in any organization and becomes more complex when personal exchanges are not possible. The very basis of communication is the exchange of thoughts, opinions, concepts, etc.

To be effective communication must flow in at least two directions. It is the desire of your Executive and Council to communicate with the membership and in turn to have the membership communicate with us. The main AEG vehicle for direct communication is our newsletter EXPLORE, which has experienced rather prolonged delays during early 1990. These delays have created a hiatus in our contact with you. Although EXPLORE has been with us only a couple of years we rapidly grasped its importance as our vehicle of communication of the activities of the Association and its members. Publication appears to be back on course at this time and every effort will be made to ensure quarterly publication.

At this point I should remind you EXPLORE is your newsletter and provides a venue for you to communicate opinions, comments, short technical papers, reports on meetings, etc. I strongly urge you to exercise your responsibility as members of AEG by communicating with your Executive and Council, either publicly in EXPLORE or by personal contact.

The Association is especially concerned with international communications. At a recent council meeting Dr. W.K. Fletcher, your Vice President, enthusiastically accepted the role as Coordinator of our Regional Councillors. This position was established to ensure closer communication with Regional Councillors and our international membership.

Additional steps have been taken to ensure the dissemination of AEG literature to those countries who have no members in our group. On our 1990 Dues Notice you were provided the opportunity to contribute to a Third World Membership Fund. The degree of response was encouraging. Your previous President, Dr. M.A. Chaffee, noted the inability of some geographic areas of the world to acquire access to AEG publications. Letters were sent to 42 libraries and organizations throughout the world to enquire as to their interest in exploration geochemistry and their desire to receive the Journal of Geochemical Exploration. Nearly half of the organizations have now expressed the desire for continuing communication with the Association. Many of these groups are actively involved in geochemical exploration although none are members of AEG. At this time we are not certain that our Third

continued on page 2

TECHNICAL NOTES

Gres and Newgres: two programs to solve Gresens' (1967) hydrothermal alteration equation

Overview

Two programs have been developed for IBM-PC compatible microcomputers to model hydrothermal alteration using Gresens' (1967) original equation and a modified version of the equation (Leitch and Day, in review). The TurboPascal programs are ready-to-run, requiring no compilation. Memory, disk and graphics requirements are minimal. Output is supplied as tables and graphs which can be readily evaluated to determine loss and gain of various components during hydrothermal alteration.

Theory

Hydrothermal alteration is typically accompanied by migration of chemical species as new minerals are formed or earlier minerals are destroyed. However, chemical typing of alteration is not possible by simply comparing percentage concentrations of components in altered and unaltered rocks. Addition of one component will result in the apparent depression of concentrations of other components even though these components may in fact be hosted by minerals unaffected by the hydrothermal alteration. This effect can be accounted for by determining the overall increase or decrease of rock volume during alteration.

Gresens (1967) recognized this problem and derived a simple equation for component loss/gain during alteration which included

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Information for Contributors to EXPLORE

Scope This Newsletter endeavors to become a forum for late 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 illustrations where possible. Meeting reports may have photographs, for example. Text is preferred on paper and 5¼-inch IBM-compatible computer diskettes with ASCII (DOS) format, which can go directly to typesetting. Please include 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 reexamination 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.

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NOTES FROM THE EDITOR

Journal of Geochemical Exploration Volume 35, no. 1-3; Volume 36, no. 1-3; and Volume 37, no. 1 have been issued since the last newsletter and received by members. Those who paid dues for 1989 will receive up through Volume 35, and those who pay dues for 1990 will start with Volume 36. The note on p. 15 explains that this reduces the Volumes for 1989 from the usual three to two and splits the excellent collection of papers on circumpacific epithermal gold mineralization. By using the form on p. 30, new members may obtain back issues for up to three years.

If your earth science library subscribes to the *Journal* but does not receive EXPLORE, it may be added without cost to our mailing list by making a request under the library's letterhead. Please write the Business Manager of the newsletter at our Reno address, *not* the AEG office in Rexdale, Ontario.

There are still some **guide-books** left from the 1984 AEG Symposium in Reno at \$30 each including postage or \$20 for one with a minor defect. Among descriptions of numerous deposits are previously unpublished material like the articles on the Northumberland gold mine, the Taylor silver district, and the Pilot

Mountain tungsten district. Titles of the field trips are: Sediment-hosted Gold Deposits, Sediment-hosted Precious Metal Deposits, Precious Metal Districts in Southern and Western Nevada, Precious Metal Districts in West-Central Nevada, Western World Massive Sulfide Deposit, Porphyry Molybdenum Deposits, Sulfur Mining District, Bedded Barite Deposits, Skarn Deposits, Virginia City Mining District, and Gooseberry Mine (vein gold). Altogether, 28 mines and districts are described. The paperbound book is 8½ by 11 inches, 220 pages, typeset in two-column format, and well illustrated. Send your order to EXPLORE or call 702-331-4223 for more information. No unpaid purchase orders please.

EXPLORE Number 67 was distributed to 4140 professionals including most of the volcanology, geochemistry, and petrology membership of the American Geophysical Union. Bulk shipments were made to **John M.A. Forman** for Brazil, **Jose Luis Fernandez-Turiel** for European members, and **Gunther Matheis** in Germany for distribution at a workshop. **Chemex** has graciously aided in air freight shipment of the last two issues.

Chet Nichols

PRESIDENT'S MESSAGE continued

World Membership Fund is adequate to supply all respondents with the Journal. Therefore, if there are members who would like to participate in this program, please forward your donations to Dave Jenkins, Treasurer.

The 14th AEG International Symposium and the 5th IAGC International Symposium on Geochemical Prospecting will be held in Prague, Czechoslovakia on August 29-31, 1990. The organizers have developed an exciting series of Sessions, Workshops, Poster Sessions and Excursions. This presents an excellent opportunity for the international community to exchange ideas and learn of methods used by our counterparts in other areas of the world. The recent and dramatic changes in politics in eastern Europe will expand the opportunity for exchange and discussion. There is still time to arrange your schedule so you can attend.

A. E. Soregaroli
President

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Support your newsletter.

NOTES FROM THE SECRETARY

By now, all Voting members should have received their ballots for the 1990 Ordinary Councillor election. Your ballot must be returned to the Association office in Rexdale, Ontario by the end of July, 1990 in order for your vote to be valid. I encourage all Voting members to take a few minutes to read the short biographies on each candidate and then vote for five of your choice. Please exercise your right to vote; it is your chance to take an active part in the affairs of the organization. **DO IT NOW, DO IT TODAY. YOUR VOTE COUNTS!!!**

For those of you who are Affiliate Members, give some serious consideration to upgrading to Voting Membership. This will require a certain amount of effort on your part, but it will allow you to take part in the affairs of your Association. Anyone wishing to do this can get an application form from any member of the Council or executive, or can receive one from the Rexdale, Ontario office. Please consider this option and become active in your Association.

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LETTERS

Public Awareness of Science

This is to draw your attention to a current major concern of the Royal Society of Canada and of many other societies and associations, and to seek your cooperation in a common cause: The Public Awareness of Science.

This Society, along with many others, has been alarmed by public opinion surveys that show that an increasing number of Canadians know and care little about science. Also, studies abroad and (on a local scale) in this country, show that the percentage of the population that is scientifically literate has been declining. This is of deep concern in a participatory democracy in which more and more decisions at all levels of government involve science and technology. It is even more alarming when we realize that progressive deterioration of our global environment can only be halted by hard decisions — decisions that can only be reached and accepted by a public that is understanding and appreciative of science, technology, and engineering.

Many of us feel that scientists themselves must play a larger role in communicating with the public. This realiza-

tion led to the organization of a conference in Ottawa, March 1988, which was attended by representatives of 32 scientific societies. The results of the conference were published in a widely distributed booklet entitled "Science and the Public". The success of the Ottawa Conference has been attested to by the increased public awareness activities of many of the societies and other organizations that were represented.

One recommendation from the 1988 Conference was that the Royal Society should set up an Advisory Committee on the Public Awareness of Science (PAS). This Committee was established and, until now, has concerned itself with monitoring progress and effecting information exchange between the original participating societies. A decision was made to formalize these exchanges through a newsletter to help societies keep abreast of government initiatives and the activities of sister societies.

The Minister has said that the scientific and technical societies must play a large part in remedying the sad state of public understanding of science. I feel sure that you agree with him and I look forward to our societies working together to tackle the enormous com-

munication gap that separates scientists and the public.

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Editor's Note: Is not a similar effort needed in other countries? The grass roots involvement of scientists in schools is a laudable fundamental objective.

Membership & Services Directory

We wish to thank all Regional Councillors and other AEG members who have taken the time to review the membership list and make necessary corrections for the 1990 Directory. Your time and efforts were greatly appreciated.

Erick Weiland and Stan Hoffman

Proportional Transfer Dots

I have developed a set of black 'rub-on' dots useful for preparing geochemical survey maps. They are correctly proportioned so that there are no gaps in the sizes of the dots in the range 1mm to 13mm (½ inch). In the past I have attempted to use commercial sheets or combinations of

such sheets which has always ended up in utter frustration because at least one critical size was missing. For interested members I am willing to supply these 8.5 x 14 inch sheets at cost. Because they are specially ordered one at a time, they currently cost \$30 each.

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L.V. Tauson Dies

It is with sadness that I report on the death of Academician, L.V. Tauson of the USSR, who passed away on November 23, 1989 in Irkutsk. Academician Tauson was a leading figure in Soviet geochemistry, and his passing will be felt by all geochemists.

Stan Hoffman

POSITION WANTED

Dr. Stephen A. Shaver of the Dept. of Forestry and Geology, University of the South in Seawee, Tennessee recommends the following student for a temporary sampling position:

Cindy McIlveen
University of the South
SPO
Seawee, TN 37375
Tel. (615) 598-0700

PERSONAL

Information on Association members is received from around the world. To keep others informed of items such as moves and promotions, send a notice, preferably with photo, to EXPLORE.

C.J. Oates, formerly Senior Geochemist for the Exploration Division of Western Mining Corporation in Kalgoorlie, Western Australia, is now Senior Geochemist for Western Mining Exploration S.A. in Santiago. His new address is Las Nives 3357, Las Condes, Santiago, Chile.



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TECHNICAL NOTES

continued from page 1

ed the specific gravity of the parent and altered rocks and a volume factor (F_v , the ratio of the volume of the altered rock to that of the parent rock):

$$X_n = W_B - W_A = w[(F_v)(X_B)(S_B/S_A) - X_A]$$

where W_A , W_B are the weight of component n in parent rock A and altered rock B ; w is the initial weight of parent rock; X_A , X_B are the weight proportions of component n in parent rock and altered rock B , used directly from chemical analyses; and S_A , S_B are the specific gravities of parent and altered rock, measured on representative rock chips.

Since F_v is fixed for all components, it can be theoretically determined by assuming that one or more components are immobile during alteration and setting X_n to zero. Leitch and Day (in review) used exactly the same principles as Gresens (1967) but derived a new equation for X_n :

$$\log(X_n) = \log(W_B/W_A) = \log(F_v) + \log[(X_B/X_A)(S_B/S_A)].$$

The advantages of this equation over the original are described fully by Leitch and Day. An important difference is that the new equation is dimensionless thereby facilitating comparison of components. Both equations produce similar trends when comparing several samples in the same series. The practical problem for both equations, therefore, becomes one of selecting which components are immobile and will be used as the reference point for components which are obviously mobile.

The Programs

The programs were written to meet the following objectives:

- Testing of different parent rock types with one suite of samples collected, for example, around a vein;
- Selection of different immobile components for one suite of samples; and
- Rapid graphical evaluation of results.

To these ends, the programs are menu based, permitting abandonment of a line of testing in favour of selecting a new test scenario. Main menu options are presented in the sequence normally chosen, that is, selection of data, selection of immobile components, and finally evaluation of results.

Option 1 of the main menu graphs component loss/gain $\log(X_n)$ versus volume factor (F_v) for each component of one sample (Fig. 1). Similar behaviour of components during alteration can be evaluated and a preliminary selection of immobile components made. Option 2 allows fine-tuning of the list of immobile components by graphing F_v versus components for every sample in a series (Fig. 2). Option 3 then graphs X_n versus position (for example, distance from a vein) for every component (Fig. 3). In the case of options 2 and 3, data are provided in tables or as graphics. Option 4 returns to the data selection menu.

Technical Details

Both programs are written in TurboPascal and have been compiled as .COM files of approximately 57 kbytes. Data are input as ASCII files of which the numeric fields are free-format. Up to 25

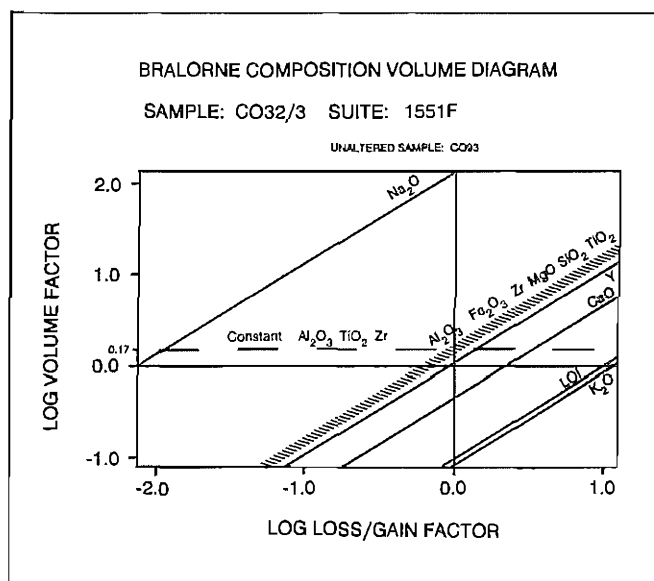


Figure 1. Plot of component loss/gain (X_n) versus volume factor (F_v).

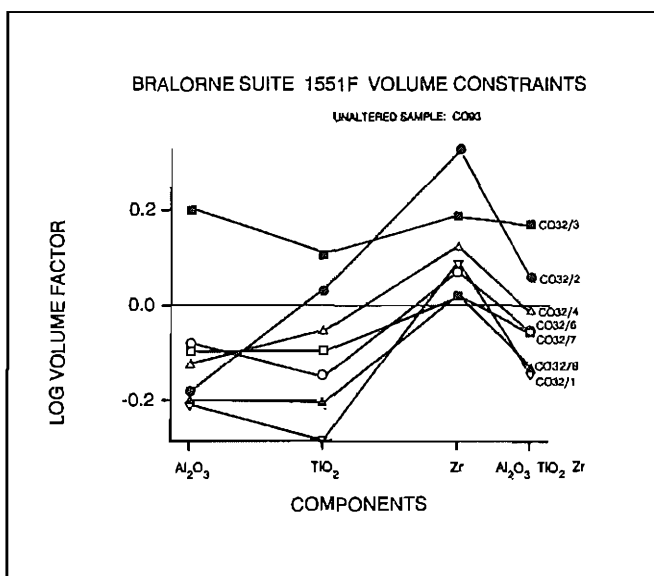


Figure 2. Plot of components (n) versus volume factor (F_v).

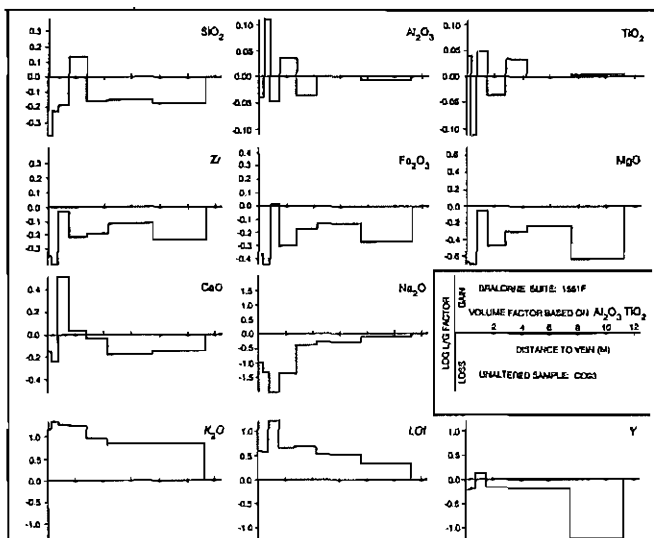


Figure 3. Plots of component loss/gain in wallrock versus distance from vein.

Lackey

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components can be evaluated (not including specific gravity and position data). The input file can contain up to 10 different parent rocks and 10 separate rock suites each consisting of 20 samples. Hercules and IBM graphics versions are available. Due to the simple form of the equations, the current versions do not depend on the presence of a math co-processor.

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References Cited:

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Gallium, a Rediscovered Pathfinder Element: Example, Sagebrush over the Betze Gold Deposit, Nevada

Several decades ago, Soviet papers began to describe the association of Ga in plants with various types of ore deposits (Burks and Mitskevich, 1960; Flerova and Flerov, 1964; Dvornikov et al., 1973; Dvornikov and Ovsyannikova, 1974).

Results from a recent study of big sagebrush (*Artemisia tridentata* Nutt.) in the Carlin Trend, show elevated levels of Ga that spatially correlate with the Betze deposit, a world class Au orebody (The Mining Record, 1989). Highlights of our results for *Artemisia* from the Betze deposit, given below, seem to agree with results reported by Dvornikov et al. (1973) where anomalous concentrations of Ga were found in species of *Artemisia* directly over Au deposits in the Donbas region of the Soviet Ukraine.

Perhaps this note will stimulate some dialogue on reasons for, and possible value of, the association of Ga with Carlin-type disseminated Au deposits, an association shown in a chart on geochemistry in gold exploration (Bondar-Clegg, and Co., Ltd 1987).

Analytical results have been obtained by inductively-coupled plasma emission spectroscopy for Ga in 62 ashed samples of sagebrush. These samples were collected by Erdman on September 26-30, 1987 from three traverses near or over the Betze deposit at Barrick's Goldstrike Mine (Bettles, 1989). Results show a high anomaly-to-background contrast, a range of 11.9-156 ppb (dry-weight basis), and distribution patterns generally consistent with the projection of the Betze high-grade sulfide orebody that occurs about 800 ft (250 m) below the surface (Fig. 1). The orebody is hosted in the Devonian Popovich Formation, which is overlain by Upper Devonian sedimentary rocks of the Rodeo Creek unit of Bettles (1989). Gold concentrations in sagebrush, analyzed by graphite furnace atomic absorption, ranged from 0.58 to 3.1 ppb (dry-weight basis) and showed no pattern that relates to the underlying deposit.

Strong positive statistical correlations were found between Sb, As, and Ga; and moderate correlations were found between Sb, As, and Au. In an extended R-mode factor analysis, a multivariate procedure that can be used to identify groups of associated elements, Sb, As, and Ga dominated the first factor in a three-factor model (Fig. 2). Samples from 62 sites were included in the analysis, and the sample with the highest factor score for factor 1 came from a site directly over the reduced ore zone. This sample contained the highest values of As and Ga (3,000 and 156 ppb, respectively) and the third highest value of Sb (146 ppb). It also

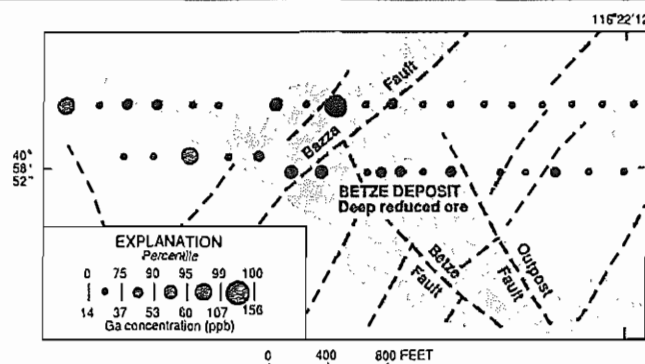


Figure 1. Distribution of Ga concentrations (ppb, dry-weight basis) in big sagebrush along two east-west traverses over the deeply buried Betze orebody at Barrick's Goldstrike Mine.

contained anomalous Au (1.9 ppb).

The Ga anomalies at Betze may result from the dominant chalcophile behavior of Ga in hydrothermal processes, as described by Vlasov (1966) and more recently by Burton and Culkin (1978). According to Burton and Culkin (1978), "The main affinity of gallium in these reactions is with zinc, and it is in sphalerite that unusually high concentrations of gallium have been widely recorded." Sphalerite is the most common base-metal sulfide in the Betze deposit, yet we found no significant correlation between Zn and Ga in the sagebrush results.

Another explanation for the Ga anomalies may relate to the lithophile properties of Ga during the hydrothermal processes in which Ga is also ubiquitous in aluminosilicates, segregating together with the sulfide minerals (Vlasov, 1966). According to Vlasov (1966), where orebodies occur in carbonate rocks some Ga may be partitioned into aluminosilicates when the surrounding host rocks are silicates and carbonaceous argillites. These conditions are similar to the host rock for the Betze deposit, the Popovich Formation. This unit is a sequence of impure limestones consisting of medium- to thick-bedded carbonaceous, silty to muddy limestones with interbedded calcareous siltstones and mudstones (Bettles, 1989).

Soil gas measurements along the traverses over the Betze deposit revealed alkane gas anomalies whose source was ascribed to organic matter associated with the Au mineralization in the unoxidized ore (McCarthy et al., 1988). These anomalies also correspond with the Ga anomalies in sagebrush.

The apparent anomalies of Ga in samples of sagebrush over the deeply buried Betze deposit are difficult to explain, if judged by similar work in the Soviet Union. In discussing biogeochemical anomalies over concealed deposits in the Soviet Union, Kovalevsky (1987) found that the "accessible depth" of biogeochem-

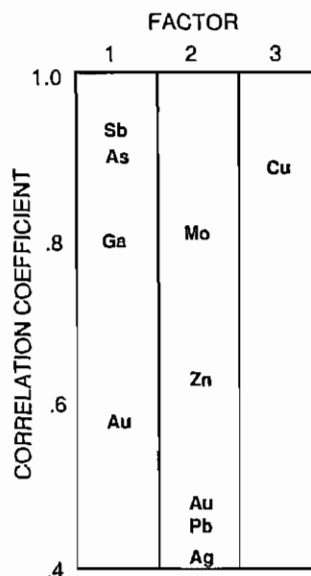


Figure 2. Associations of ore-related elements in a 3-factor model using extended R-mode factor analysis. Elements are arranged in descending order of correlation coefficient, a value which indicates relative importance of the element in the association (factor). Values below 0.4 are not considered important.

ical prospecting was 40-60 m where species of *Artemisia* were used. However, orebodies most likely are not the only sources of Ga. We have evidence of Ga-rich haloes in soils over many other Au deposits in the western U.S. (Henderson, unpublished data), so the Ga source may be much more extensive than the actual deposit.

Although biogeochemistry has become a useful tool in the search for concealed deposits, the processes by which plants respond to concealed mineral occurrences are, at best, poorly known. Only basic research, minimally funded under the present economic conditions, can throw some light on these processes.

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Box 625002, Littleton, CO 80162-5002.

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Particle Size Distribution of Gold in Geochemical Samples

Variation of Au particle size in geochemical samples has strong bearings on the reproducibility of Au analyses. This issue has been discussed by many authors (Clifton et al., 1969; Harris, 1982; Nichol, 1986); however, these discussions were based on the assumption that all Au particles in a sample are of the same size. Actually there are normally many different sizes of gold particles in any natural sample. Information about the actual distribution of particle sizes of gold in a sample is scarce and limited only to coarser particles [270 mesh (Day and Fletcher, 1986; Fletcher and Day, 1988), or 63 μ (Shelp and Nichol, 1987)]. In order to explain correctly the complicated relationship between gold particle size distribution in different samples and the precision of gold analysis, a special technique is needed to obtain detailed information about the quantity of different sized gold particles finer than 63 μ .

We are using a technique developed by Shen (1976, 1977), the basic idea of which is to separate a given sample into enough fractions so that there will be no more than one grain of gold (5 μ) in each individual fraction. According to theoretical calculation, if the number of fractions separated is five times the total number of gold grains in the bulk sample, the probability of two Au grains in any one fraction is only 1.5%. The necessary number of fractions separated could be obtained by two or three successive trials carried out by a very experienced analyst.

The size of gold grains in each fraction can be calculated from the gold mass in each fraction as determined by a special spectrographic procedure (Shen, 1976, 1977). The details of the procedure will be published in English elsewhere (Shen, in preparation). In this short note, we will only demonstrate some preliminary work comparing gold particle size distribution to precision of gold analysis using this technique.

Table 1 shows the Au content and analytical precision, based on a small number of replicate analyses, for three samples.

Table 1.

Sample no.	Gold content (ppb)	Analytical precision (%RSD)
R3	44	162
R4	21	24
R6	2920	54

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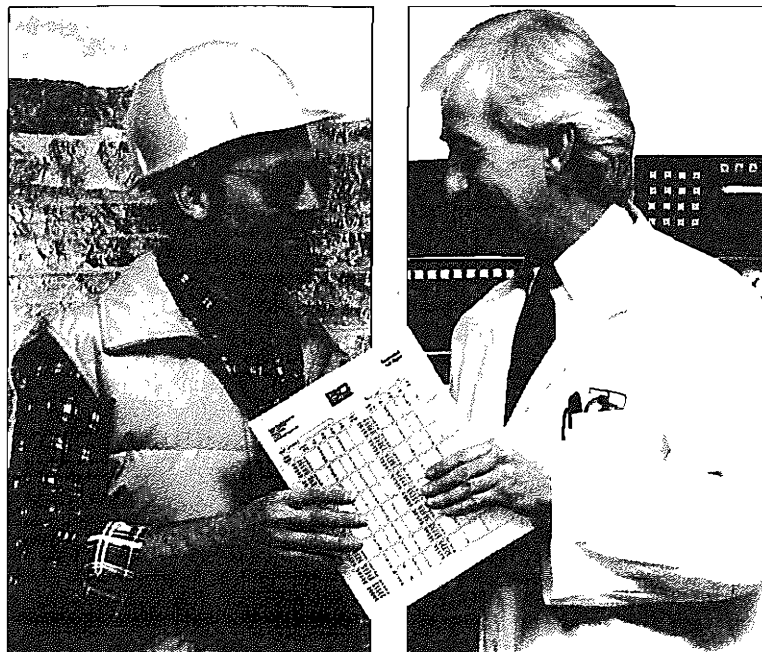
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The gold contents of R3 and R4 have similar concentration levels, yet the percent relative standard deviations (%RSD) for the two samples are quite different. Sample R6 has a high gold content, yet the analytical precision is fairly good.

Tables 2 and 3 show the gold particle size distribution obtained by using Shen's technique. Most of the grains in samples R3 and R4 are within the 5-10 μ range; however, the gold grain sizes are much more uniformly distributed in R4 than in R3 (Table 3).

Table 4 shows the gold contents attributed to the dispersed gold in R3, R4, and R6, which are obtained by subtracting the gold contents attributed to the discrete particulate gold (5 μ) from the total contents of gold in the samples.

Table 2.

R3		R4		R6	
Particle size range(μ)	Number of particles	Particle size range(μ)	Number of particles	Particle size range(μ)	Number of particles
5-10	443	5-10	130	5-10	12
10-20	2	>10	0	10-20	26
20-24	0			20-30	17
40-60	1			30-40	5
>60	0			40-60	3
				60-80	1
				>80	
(Total 446 gold grains in 100 gm sample)		(Total 130 gold grains in 123 gm sample)		(Total 64 gold grains in 24 gm sample)	

Table 3.

R3		R4	
Particle size range (μ)	Number of particles	Particle size range (μ)	Number of particles
5-6	77	5-6	127
6-7	207	6-7	3
7-8	139	7-8	—
8-9	16	8-9	—
9-10	4	9-10	—
10-20	2		
50-60	1		

Table 4.

Sample no.	Total gold (ppb)	Gold (ppb) attributed to particulate gold (>5 μ)	Gold (ppb) attributed to dispersed gold (<5 μ)	Percent contribution of dispersed gold
R3	44	31	14	31
R4	21	1	20	93
R6	2920	428	2492	85

Tables 2, 3, and 4 indicate that: (1) a very large portion of dispersed gold is found in sample R4 (93.4%) with a smaller portion in sample R3 (31.3%); (2) although most gold grains in R3 and R4 are in the 5-10 μ range, the variation in grain size within this range is much greater for R3; and (3) the high gold value of sample R6 does not result from a few coarse grains, but is distributed evenly throughout a number of fine grain size fractions. Of the 64 grains in the 24 g sample of R6, 55 grains are in the range of 5-30 μ , even though the 5 μ fraction is only 14.7% of the total gold content in the sample.

The above observations show the reason why there is better analytical precision for R4 and R6 and poorer for R3. To explain this conclusion in a more quantitative way, the calculation of *effective particle diameter* of a sample (Shelp and Nichol, 1987) was carried out, using the equation:

$$d_e = \sqrt{\frac{\sum M_j d_j^3}{M}}$$

where, d_e is the effective diameter of gold grains in that sample, M_j is the mass of gold in size grade j , d_j is the midpoint of size grade j , and M is the total mass of gold.

The result for the three samples is given in Table 5.

Table 5.

Sample no.	Effective diameter(μ)	
	Dispersed gold not considered	Dispersed gold considered
R3	33.	29.
R4	7.5	3.2
R6	56.	30.

The theoretical analytical precision of the three samples can be calculated by substituting the effective diameters into the equation derived by Wang (1989):

$$C = \sqrt{\frac{\pi a^3}{6} \cdot d \cdot B / (A \cdot W)}$$

where, C is relative standard deviation, a is particle diameter, d is density of gold, B is percentage of gold in a single mineral, A is gold content, and W is subsample weight.

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Table 6.

Sample no.	Theoretical precision (%RSD)		
	Dispersed gold not considered (1)	Dispersed gold considered (2)	Dispersed gold considered (3)
R3	110	60	67.
R4	55	30	3.5
R6	64	36	8.7

Note: (1) and (3): gold grains are assumed to be spherical.
(2): gold grains are assumed to be platy with thickness: diameter = 1:5.

From Table 6, it is evident that the precision for sample R3 will be quantitatively poorer than for R4 and R6. Some deviation exists between the %RSD obtained by theoretical calculation (Table 6) and that obtained by replicate analysis (Table 1). We are unable to explain this disagreement further because the samples were exhausted. Further work will be carried out using this approach on other samples.

Our technique for counting the number of grains for various sizes of gold particles in geochemical samples will be very useful in understanding the complicated and confusing relationship between the particle size distribution of gold and precision of gold analyses for samples collected from different geological and geographical settings. The technique will also be useful in studying the mode of occurrence and migration characteristics of gold in surficial environments.

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New Rhenium-mineral Microlites in a Porphyry Copper Deposit

Recognition of discrete rhenium oxide(?) microlites in the Island Copper porphyry copper deposit of BHP-Utah International, Inc., Vancouver Is., B.C., is believed to be significant because naturally occurring rhenium minerals are virtually unknown. Between 1978 and 1982, W.M. Hanusiak and I investigated Island Copper primarily to characterize the occurrence of gold which is present at an abundance level of less than one ppm. Milling and smelting results had suggested that gold occurs as lattice substitutions in chalcopyrite, molybdenite, and pyrite, and only half was being recovered during smelting. Microlite gold was found and reported on earlier (Gabelman and Hanusiak, 1986). The mine also produced byproduct rhenium from molybdenite concentrate in which it commonly exceeded 10,000 ppm. Rhenium originally became known from its occurrence in the products of European copper smelters, and is now mainly produced from porphyry-copper molybdenite concentrates. Minor amounts come from porphyry-molybdenum concentrates.

Rhenium is a naturally rare Series 6 transition element occupying Group VIIB of the periodic table along with manganese and technetium which should behave similarly. However, rhenium has not been reported in manganese or its minerals (Hamm, 1969). Technetium has no stable isotopes and occurs only as a short-lived decay daughter of molybdenum or lutetium.

According to Blossom (1985), rhenium does not occur in the

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native state and rarely is a major constituent of minerals. It is known only as lattice substitutions, mostly in sulfides, with molybdenite being the most common host. Prevalent rhenium valence states are 3+, 4+, and 7+. In man-made products, the most common forms of rhenium are the oxides ReO_2 and Re_2O_7 , and the perrhenate (ReO_4^{1-}), rhenate (ReO_4^{2-}), hyporhenate (ReO_3^{1-}), and rhenite (ReO_3^{2-}) ions. It forms complexes with halogens and thus is carried as volatiles in hydrothermal fluids.

Hamm (1969) emphasized the kinship of horizontally adjacent elements in the periodic table (i.e., chromium, manganese, and iron). However, natural associations of tungsten, rhenium, and osmium are unknown.

Molybdenum is diagonally adjacent to rhenium. The chemical similarities indicated by vertical and horizontal adjacency in the table should stimulate close mineral associations and intergrowths, but similar ionic radii are required for substitutions of trace elements in major-element minerals. The crystal ionic radii of Mo^{+1} , Re^{+4} , and Re^{+7} are 0.93, 0.72, and 0.56 angstroms respectively (Weast, 1977). The radius of Mo^{+4} in molybdenite is 1.27 angstroms. Although the sizes of these ions are significantly different, Blossom (1985) invokes them to explain the apparent preference of rhenium for molybdenite. How similar radii must be to allow substitution is problematic. If similarity in ionic radius is important in elemental substitution, rhenium should occur in many manganese minerals because Re^{+4} is closer in size to Mn^{+4} which is 0.68 angstroms.

During studies of gold occurrence to guide recovery improvements, we serendipitously discovered that gold and rhenium, as well as many other trace metals, occur dominantly as discrete microlites of high purity in altered rock, ore, and rarely in magmatic minerals at Island Copper. Particulate native gold is common in all types of gold deposits and was expected, but the occurrences of other microlites were unexpected.

The consistent failure to identify gold or rhenium in the lattices of ore or gangue minerals by energy dispersive X-ray fluorescence (EDAX) analyses using a scanning electron microscope (SEM) was equally surprising. Among hundreds of mineral analyses, rhenium substitution was found in only one of 40 molybdenite grains analyzed, as well as in two pyrite grains and one TiO_2 grain.

Because the only source of rhenium produced worldwide is from molybdenite concentrates, it is possible that our SEM/EDAX was simply not sensitive enough to detect it at extremely low abundances. However, the common observation of essentially pure rhenium microlites up to about one micron diameter in a variety of minerals other than molybdenite suggests a previously unrecognized mineral type and occurrence mode, as well as another supply source.

It also casts some doubt on the importance of substitution of rhenium in molybdenite. Rhenium liberated from other minerals by grinding might simply report with molybdenite during flotation. This new source will remain economically insignificant as long as the production of rhenium depends on molybdenite production because other host minerals are not sufficiently valuable.

Among hundreds of high-Z-element microlites recognized by their brightness in the SEM backscatter mode and analyzed by EDAX, 24 were nearly pure rhenium (barring the possibility of combinations with elements of Z numbers lower than six (H, O, C, N, etc., the peaks of which are not easily analyzed using EDAX spectra). In order of decreasing frequency, the host minerals for rhenium microlites were: quartz, siderite, sericite, andesine, calcite, K-feldspar, pyrite, dumortierite, and asphaltite.

Most of the rhenium microlites are anhedral, but four appear to have crude rhombohedral terminations, one seems to be a complete rhombohedron with truncated corners, and another is an aggregate of hexagonal(?) plates (Figure 1). All these microlites, and most of those of other compositions, occur in cavities of less than 2 microns in diameter and some are held so loosely that they are dislodged upon excitation by the electron beam.

The cavities are interpreted as original multiphase fluid inclusions, probably formed during hydrothermal alteration or metallization, and opened by subsequent deformation or during

thin-section preparation. The microlites thus would be samples of the metal content of ore fluid. The elements occurring in trace amounts in the rhenium microlites seem to vary systematically with the composition of the mineral hosting the microlite. However, the volume of analytical influence is large relative to the microlites, and these trace elements may occur in the host rather than the microlite.

Most of the microlites contain iron regardless of host. Those in quartz, siderite, and calcite also contain traces of copper which is less abundant than iron. One of these also contains sulfur, and another lutetium and platinum but no sulfur. Those in andesine and dumortierite contain iron, copper, and nickel. One in asphaltite contains iron, nickel, copper, and mercury. None of these trace elements is aligned with or adjacent to rhenium in the periodic table. Only nickel has an ionic radius approximately similar to that of rhenium.

During our study rhenium oxide (ReO_2) black powder and ammonium perrhenate (NH_4ReO_4) white powder were produced for sale by Utah International. Samples of both of these were photographed and analyzed using the SEM for comparison with the microlites. White perrhenate appears as irregular rods, some with hexagonal pyramids, and as crudely hexagonal plates. Black oxide occurs as spherical aggregates composed of tiny anhedral (less than 0.1 micron) from which some hexagonal pyramids project (Figure 2).

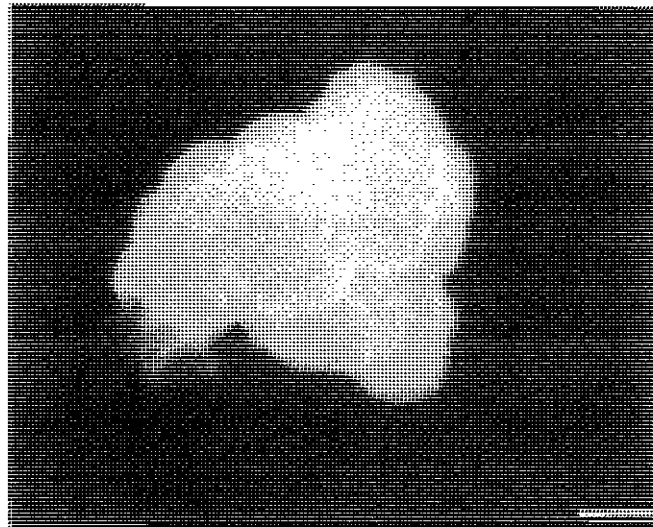


Figure 1. SEM image of an aggregate of hexagonal(?) plates of rhenium oxide in quartz. Scale is 5μ in length.

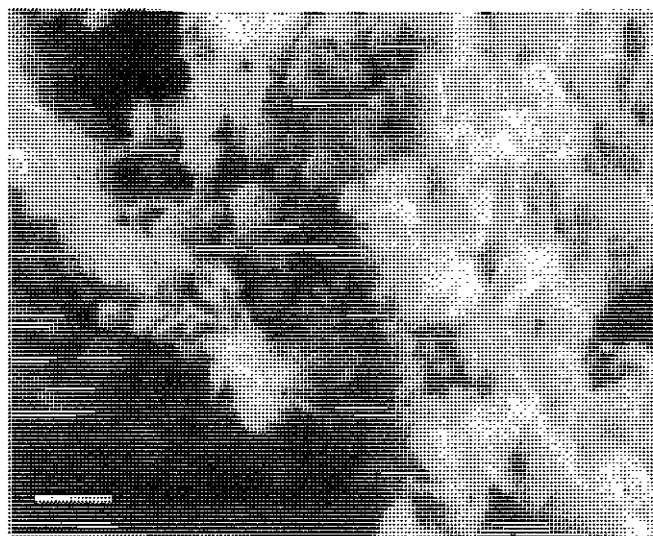


Figure 2. SEM image of rhenium oxide (ReO_2) black powder produced by Utah International. Scale bar is 0.5μ in length.

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The natural microlites most resemble the rhenium oxide. The platy microlites (both natural and in perrhenate powder) conform morphologically with platy hexagonal Re_2O_7 (Weast, 1977). Both powders contain approximately the same proportions of trace aluminum, francium(?), lutetium, and technetium (recall the chemical similarity of technetium) in decreasing order. In addition the oxide also contains copper and iridium, and the perrhenate contains potassium and calcium.

The occurrence of rhenium in Island Copper ore differs so greatly from the lattice substitutions described in literature, that further characterization with more sophisticated equipment is invited. It is possible that one or more new minerals could be described from the rhenium and the other microlites. An additional feature worthy of more investigation is the grouping of elements into distinct microlite and substitution families.



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NEWS & COMMENT

Quebec Profile

Introduction

Mining in the province of Quebec in Canada is of major economic importance. In 1988, mineral production was valued at over 2.5 billion Canadian dollars. About 900 million dollars were invested in exploration.

Many mining camps are internationally well known, including the Noranda, Val-d'Or and Chibougamau camps which have been amongst the most productive. Beside numerous base metal mines, the province has over 20 operating gold mines. The Quebec government has long recognized the importance of mining exploration and has given it great support through a strong mineral exploration department in Quebec City and seven regional offices located throughout the province.

A two day exploration seminar is held at the end of November each year in Quebec City. The meeting attracts hundreds of scientists, permitting a review of exploration and mapping projects completed by government geologists, geophysicists and geochemists, and enabling contacts to be made between companies and with government representatives. Technical sessions are accompanied by displays of each project.

The Geochemistry and Geophysics Service of the Quebec Department of Energy and Resources is headed by Francois Dompierre. Working under his leadership are: Marc Beaumier and Jean Choiniere, geochemists; Pierre LaSalle, quaternary geologist; and Francois Kirouac and Michel Leduc, technicians.

An annual budget of about 1 million dollars is approximately divided 85% for regional geochemical surveys and 15% for research and development in the field of analytical methods, geochemical interpretation techniques, and software development for data processing.

History Of The Geochemistry Division

The first geochemical surveys conducted by the Provincial Department of Energy and Resources in the early fifties were under the direction of J. E. Riddell. The Ministry of Energy and Resources (MER) in 1962 mandated that its geologists routinely collect stream sediment samples while conducting geological traverses on regional and detailed mapping programs. This approach prevailed for 20 years and led to definition of exploration targets based on anomalous geochemistry. Geochemical background was established in many districts throughout the province at relatively low cost. The Geochemistry Division of the MER was officially created in 1968, coinciding with the initiation of the first regional geochemical surveys by the province.

Regional Geochemical Surveys

Regional geochemical survey types (Fig. 1) are selected based on the nature of the local terrain. Among the most important are: (1) stream sediment surveys using a 500 m sample interval, (2) groundwater surveys from domestic wells using a 500 m sample spacing, (3) till and soil surveys on a square grid pattern at a density of 1

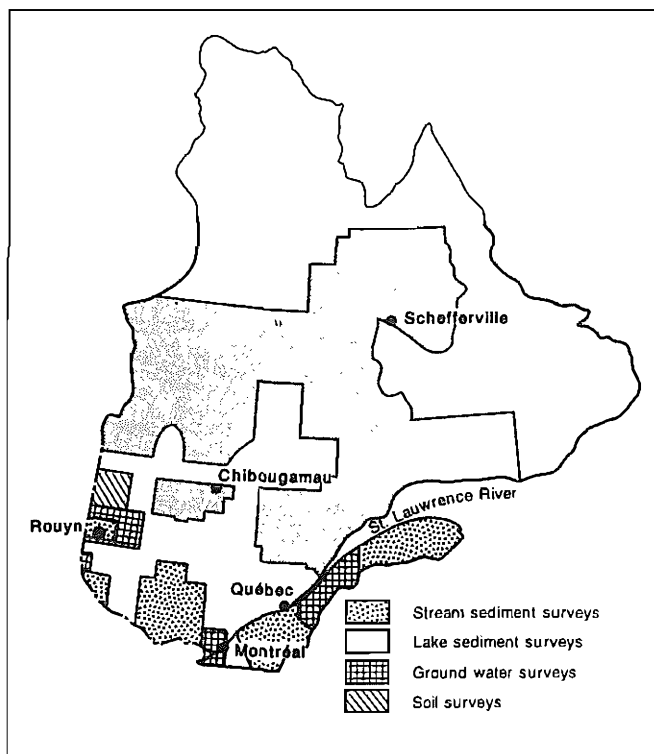


Figure 1. Location of major reconnaissance geochemical surveys in the province of Quebec, Canada. A major basal till survey of more than 6,000 samples covers approximately the same area as the groundwater survey in the Abitibi area which surrounds Rouyn. Detailed and orientation surveys are not shown.

sample per km²,

(4) heavy mineral surveys at a density of 1 sample per 10 km², and

(5) centre lake bottom sediment surveys at a density of either 1 sample per 13 km² or 1 sample per 2.5 km² depending on local lithology and structure.

A geochemical data base for the province was created by combining results from the geochemical surveys described above and the 450 stream sediment surveys carried out by MER geologists on regular geological mapping assignment. Stream, lake, and heavy mineral surveys conducted on behalf of corporations owned by the provincial government (SOQUEM and SDBJ), and by the federal government (GSC), were also included in the geochemical data base which contains information for over 500,000 samples.

Major objectives of the geochemical division of MER have been to:

- (1) Define exploration targets based on anomalous geochemistry,
- (2) Determine regional backgrounds for a variety of sample media types against which the exploration industry could compare results,
- (3) Produce a geochemical data base which could be easily accessed for other metals or commodities currently not in fashion but having potential for future interest, and
- (4) Develop methods for relating regional geochemical data collected on one type of survey (i.e., stream sediments) with data from a second type of survey (i.e., groundwater) to enable all available geochemical data to play a role in geochemical mapping of the province and assist in regional geological mapping projects.

Geochemical Analysis

From 1968 to 1980, geochemical analysis for approximately 12 elements was performed routinely by atomic absorption spectrometry. Between 1980 and 1986 most analytical determinations were done by plasma emission spectroscopy (ICP). Since 1986, geochemical samples are analyzed by both neutron activation and plasma emission methods to provide the best possible detection limits for most elements at reasonable cost.

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A catalogue of these publications is available at no cost under the following title: *Repertoire des publications et des donnees de geochimie du Gouvernement du Quebec*, Publication # DV 88-02. It can be obtained at the following address:

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Recent Developments of Exploration Geochemistry in China

Exploration geochemistry in China is conducted on a national level by the Ministry of Geology and Mineral Resources, the Ministry of Metallurgical Industry, the Corporation for Non-ferrous Metals, and the Ministry of Nuclear Industry. In addition, there are provincial and local geological and geophysical organizations that are involved with geochemical exploration.

In the past, geologists in China did not consider geochemical exploration as a useful method in prospecting for mineral resources. Today it is commonly acknowledged that geochemical exploration plays an important role in mineral resource investigations. Some of the main developments in exploration geochemistry in China are described below.

After several years of exhaustive research on analytical methods and standards preparation and field orientation studies, a major program called the Regional Geochemistry-National Reconnaissance (RGNR) Project began in 1981. Since that time samples—mainly of stream sediment—have been collected at a density of 1 /km² in an area of 3,200,000 km². This represents about half of the area of China that can be effectively sampled.

The samples were analyzed quantitatively for many elements. To date these data have been compiled into geochemical atlases at 1:200,000 scale for an area of 1,000,000 km². The data and maps have been used for prospecting for different types of mineral deposits, interpreting basic geology, mapping geology, identifying and evaluating environmental problems, and predicting local human and animal health problems.

Geochemical prospecting for gold is of particular interest in

China. Many areas with potential gold resources, as well as economic gold deposits, have been discovered since more sensitive analytical methods were adopted. In the past, the detection limit for gold analysis was about 10-50 ppb and the threshold for anomalies was thought to be about 50 ppb. Because of these high limits of determination, few significant gold anomalies were found. That period was described by the exploration geochemists as the period of "stars everywhere but no moons."

Since that time, the detection limit for gold has been lowered to 0.3-1.0 ppb and regional gold anomalies are delineated using a threshold of 1-3 ppb. This lower detection limit has produced many more anomalies than were found with the previous analytical methods. Many of these anomalies have been found to be related to identifiable gold mineralization; however, some anomalies cannot yet be explained. In order to resolve these problems and correctly interpret the unexplained gold anomalies, the secondary weathering environment of gold is being studied.

Analytical laboratories in China have developed and now use several rapid, quantitative, multi-element analytical techniques using conventional chemical instruments that are available in most Chinese geochemical laboratories. These analytical methods are of great assistance to the RGNR Project. Recently the laboratories have been making a set of standard reference samples for quality control and assurance purposes. Twelve reference samples for drainage sediments (standard series GSD), eight for soils (GSS), and six for rocks (GSK) have been released to date.

These reference materials have been used by the international geochemical community for calibration of new and improved chemical methods and for monitoring of results between laboratories. A set of seven gold reference standards with gold contents ranging from 0.8 to 87 ppb have also been prepared and certified. Geochemical standard reference samples for vegetation are presently being prepared and will be released in the near future.

Gas geochemical methods are also being used in China. Multi-component (Hg, CO₂, SO₂, He, C, and light hydrocarbon) surveys have been carried out, mainly in desert areas with residual soil, alluvium, and/or loess. These methods have been applied over a wide variety of deposit types, including those of copper, lead-zinc, tungsten, molybdenum, mercury, antimony, gold, silver, uranium, iron, and niobium-tantalum, as well as over geothermal fields, and oil and gas fields.

Surveys using hydrogeochemical methods and biogeochemical methods have been carried out in arid and semi-arid areas of China, including areas covered by eolian sand deposits. Hydrogeochemical methods have been successfully applied to prospecting for concealed lead-zinc deposits in northeastern China.

Experiments using a combination of geochemical and non-seismic geophysical prospecting techniques have been conducted on a large scale in major oil and gas fields in China. Other on-going geochemical programs use primary haloes in the search for blind and concealed metallic deposits, kimberlite bodies, and non-metallic mineral deposits.

Computers, particularly microcomputers, are being used extensively in solving geochemical exploration investigations in China. Computers are used to establish geochemical data bases, process geochemical data, and produce geochemical maps. A Chinese language system has been developed for use with these geochemical investigations. Most of the data from the RGNR Project have been processed using computer techniques. These techniques use a combination of geological, geochemical, and geophysical data, remote-sensing images, and data on geological and geochemical models of mineral deposits. Thus, computers help to interpret and evaluate results for final mineral resource reports.

Some of these research activities are described in the Chinese Special Issue of the *Journal of Geochemical Exploration*, Volume 33, no. 1-3, 1989.

Hou Zhihui

Institute of Geophysical and Geochemical Exploration

Langfang, Hebei 102849

P. R. CHINA

Exploration '87

Proceedings of Exploration '87, an international symposium reported in EXPLORE NO. 62, p. 10 has been published as Ontario Geological Survey Special Volume 3. The volume contains 960 pages, including many full colour maps.

Exploration '87 reviews the state of the art and the outlook of geophysical and geochemical methods in exploration for minerals, groundwater, and other non-petroleum resources. Cost for the volume is CDN \$60.00 for orders from Canada and the USA. Customers in countries outside of North America should enquire first for the appropriate postal charge for this 2 kg volume. Checks or money orders must be in Canadian dollars.

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Overburden Data for NE Ontario

Data are now available from the Black River-Matheson (BRiM) project of the Ontario Geological Survey, a five year reconnaissance-scale overburden drilling project in the Matheson area of northeastern Ontario. The project was designed to aid overburden exploration in the area through the documentation of the regional Quaternary stratigraphy and setting up a database of till geochemistry. The data should be of great interest to exploration companies.

Data for overburden samples collected in the BRiM area from the 1984, 1985, 1987, 1988 sonic drilling and backhoe trenching programs have been published as Ontario Geological Survey Geophysical/Geochemical Series Maps 80759 to 80796, 80838 to 80893, 81099 to 81137, and 81146 to 81170. These data are also available as a series of either dBase IV or ASCII text files on 5.25 inch or 3.5 inch PC-DOS/MS-DOS-compatible floppy diskettes. Sample locations and material types, and results of mineralogical, geochemical and lithological analyses are provided. Requests for data must be accompanied by the required diskettes: 1) six double sided, double density, 5.25 inch disks, or 2) two double sided, high density 5.25 or 3.5 inch disks. There is no charge to copy the data onto diskettes. For more information contact:

Beth McClenaghan

Engineering and Terrain Section

Ontario Geological Survey

77 Grenville Street

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Alaska Miners Association (AMA) Convention - November 5 - 9, 1990

This year's convention begins with an Exploration Geochemistry short course led by Dr. Stan Hoffman of Prime Geochemical Methods Ltd. of Vancouver, B.C. The two day course will discuss the principles and designs of geochemical sampling. Topics covered will be: general geochemical principles; relationships between bedrock and overburden geochemistry; preparation for conducting a geochemical survey; geochemical sampling of soil, sediments and rocks; defining an anomaly; interpretation of geochemical anomalies; case histories; formulation of models; and use of multi-element analysis.

A one day course on mining agreements and conveyances, designed for persons involved or interested in the negotiation and preparation of mining agreements and conveyances, is led by Joseph J. Perkins Jr., of Guess and Rudd, Anchorage, Alaska. Topics to be covered include choosing a structure for the transaction, negotiating and drafting the key economic provisions, acquiring the rights you need and identifying and getting the protection you need. Mining claimants, Native corporations, mining companies,

land managers, and lawyers all will benefit from the program.

Technical sessions will be accompanied by a trade show. Following the convention, a three day field trip is tentatively scheduled to cover selected mines in the Juneau Mining District.

For more information and a registration package, please contact: **Alaska Miners Association, Inc.**, 501 W. Northern Lights Blvd., Suite 203, Anchorage, AK 99503, Tel: (907) 276-0347, Fax: (907) 278-7997.

1989 a Two-volume Year for JGE

Elsevier has recently informed us that only two volumes of the *Journal of Geochemical Exploration* (JGE) were issued for the 1989 membership year (Volumes 34 and 35). Four volumes are scheduled for 1990. Your AEG representative is currently reviewing this matter with Elsevier and will report on discussions in a subsequent issue. This unanticipated arrangement affects the distribution of the *Epithermal Gold Volume*. Part 1 (v. 35) has been included in the 1989 subscription rights while Part 2 (v. 36) will be received only if 1990 dues have been paid. If you have not received Part 2 (Hedenquist, ed), verify the address label indicates *PAID-90* on this issue of *EXPLORE*. If you do not have the volume, and you paid your 1990 dues over two months ago, now is the time to inquire at the AEG Rexdale office.

The following table summarizes planned publications of JGE.

Volume/Issue	Pages	Cover Date	Special Issue Edition
37.1	180	Mar., 1990	C.E. Dunn
37.2	132	May, 1990	
37.3	?	July, 1990	
38.1/2	?	Aug., 1990	S. Kesler
38.3	?	Oct., 1990	
38.1/2	?	Nov., 1990	A. Darnley

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Gold Analysis and Other Factors - Part 2

Figure 10 in *EXPLORE* no. 67 summarized exploration information available for a property having outstanding geochemical and geophysical anomalies associated with major structures, favourable geology, and a prominent gossan zone, all above treeline without extensive glacial overburden. Twelve drill holes tested a variety of geochemical and geophysical parameters, but grades in bedrock were not encouraging. Is the property worth maintaining?

Well drafted summary maps belie true conditions on the ground. Early work positioned drainages as these were encountered along idealized grid lines (a procedure still in common use today). Later work involved preparation of an orthophotograph topography map with drainage features highlighted. The two versions of topography were not the same; the geochemical anomaly, outlined on the first topography map, was transferred to the second topographic base as best as possible, with a note as to the uncertain location appearing in the map legend.

The old grid could not be recovered in the field. A new metric grid was supposed to coincide with the old grid, and was used to


control geophysical surveying, mapping, rock chip sampling and diamond drill siting. The soil survey was not undertaken on the new grid. Drill holes appear to have moved, from Figure 10 to Figure 11, a consequence of comparing the old idealized grid to the new grid corrected by tie lines. The geology has also "changed" to reflect recent mapping of restricted areas, controlled by reference to drill core, compared to historical property wide outcrop mapping which was not drilled when the map was prepared.

The validity and exact location of the historical Cu-Au soil anomalies were never verified. In this case orientation soil sampling conducted late in the program indicated that the soil anomalies of Figure 10 are actually 50 m south of where they are plotted. Coincidence of geochemical anomalies with geophysical anomalies, a factor important to selecting drill locations, could more aptly be described as geophysical anomalies correlating with geochemical lows. Not surprisingly, drill results testing geophysical anomalies reflected grades seen in outcrop.

The 200 ppm Cu anomaly was selected by a "feel" for the data and not with reference to histograms or probability plots. This arbitrary level has defined 30% of the grid as anomalous. Figure 11 highlights only 5 to 10% of the area, using exactly the same data. Most drill holes now appear to test areas not obviously anomalous in Cu or Au.

The existing soil data was contoured but not interpreted. The two procedures are not equivalent. For example, the prominent

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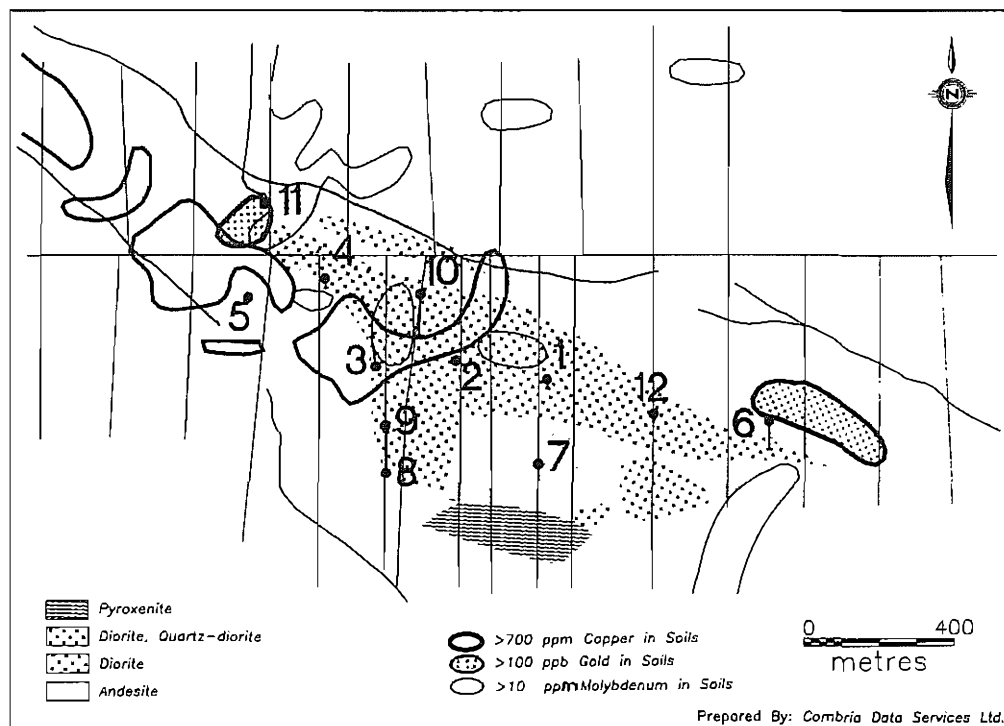


Fig. 11. Same area as presented in Figure 10 (*EXPLORE* no. 67). Differences in geology are due to updated mapping. Drill hole locations, grid irregularities, and geochemical anomalies have moved due to threshold and anomaly selection criteria.

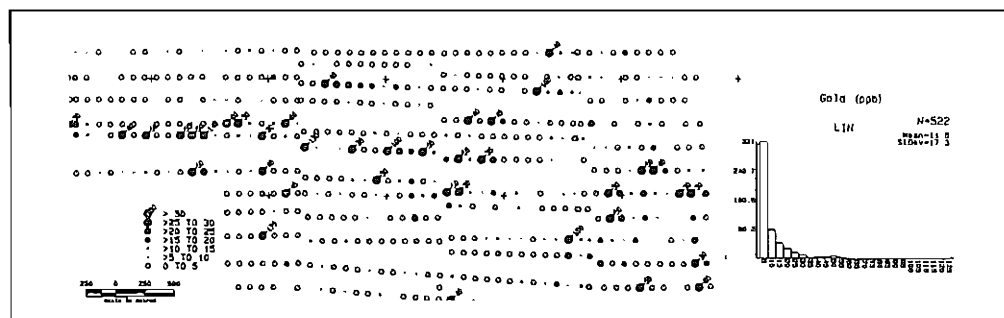


Fig. 12. Au content (ppb) in soils. Histogram plots number of samples (vertical) versus Au concentration (ppb).

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gossan accompanied by high Cu suggests hydromorphic dispersion in an acidic environment. Association of highest Cu values, in the 1% to 2% range, with a solifluction lobe was ignored, and absence of Au correlating with the very high Cu values was taken as negative finding. The possibility that upward water pressure promotes sinking of the Au to levels deeper than would be accessed by soil sampling was not investigated.

Underlying geology is highly variable and the orientation multi-element soil survey indicates complexity which might assist in documenting dispersion types and distances. Repeating the soil survey and ensuring wooden pickets are present on site to mark anomalous locations should not be considered an expensive luxury but rather a prudent investment which for this property is still required.

Assaying core for Cu and Au at U.S. \$11.50 per sample showed grades to be sub-economic (Table 3, first and second columns). The use of assays, particularly for Au and one or two other elements is commonplace in the industry. Too often I have heard that, once the drilling begins and Au is the element of interest (with perhaps one or two other elements of interest), Au is the best pathfinder for Au; therefore Au is the only element to be determined. This is really too bad for the exploration effort!

Table 3 summarizes portions of orientation multi-element geochemical analysis plus geochemical Au determined following an aqua regia digestion, on pulps originally assayed for Cu and Au only. Cost was US \$9.75 or US \$1.75 less than assaying. Elements such as Mn and Fe suggest zonation with Au and Cu, as do several other elements. Comparison of assay versus geochemical values for Cu and Au reveal differences which reflect the different detection limits (which are much higher for assays) and aqua regia versus fire assay fusion dissolution procedures for Au (see Hall, et al. in *EXPLORE* no. 65 for comments on methods of gold analysis). The concentration differences are really not significant to evaluating the merits of this property. The lower-priced procedure should have been chosen on a cost and technical merits basis. Absence of multi-element data to fingerprint geology and chemical zonation from one hole to the next is a severe impediment to geological interpretation. Re-analysis of all core would be my first recommendation, should interest in the property be renewed, a likely possibility now that Cu exploration is topical.

Multi-element analysis was used to see if anomalous quantities of elements, such as Ag, were present in the core. Money was saved by requesting the laboratory prepare composites of 5 contiguous samples, representing 15 m of core (selected at the discretion of the laboratory) prior to analysis, at a \$US 1.50 per sample additional preparation cost. Results are summarized at the bottom of Table 3. No silver was detected. The efficacy of this ap-

Table 3


Cu and Au assays, as well as a representative suite of concentrations of Cu, Au and other elements determined on aqua regia digests. Note the loss of information accompanying compositing of core by the laboratory.

Sample Number	Assay		Geochem									
	Cu %	Au gm/T	Cu ppm	Au ppb	Zn ppm	Co ppm	Mn ppm	Fe %	Sr ppm	V ppm	Mg %	
42	.05	.05	176	15	26	3	230	6.4	32	67	1.3	
43	.02	.10	200	50	38	1	309	6.6	27	109	2.0	
44	.04	.25	369	150	32	2	261	7.2	23	83	1.1	
45	.01	.15	73	55	15	1	101	3.0	18	25	1.0	
46	.01	.05	82	75	12	1	64	3.0	72	17	0.7	
47	.01	.05	91	35	11	3	86	3.2	52	21	0.9	
48	.13	.20	1103	105	13	9	84	3.2	20	20	1.0	
49	.21	.25	2253	105	10	16	60	3.1	32	11	0.9	
50	.20	.25	2077	75	10	11	63	3.0	18	12	0.9	
51	.25	.20	2613	115	11	18	87	3.4	15	22	1.0	
52	.27	.20	2887	125	23	20	227	6.8	10	65	2.0	
53	.17	.20	1711	85	21	26	226	5.7	12	66	2.0	
54	.17	.15	1748	90	22	28	239	7.3	18	79	2.0	
D.L.	.01	.05	1	5	1	11	1	0.01	1	1	0.01	
Composite Sample Analysis												
42-46	NA	NA	268	NA	27	2	209	5.8	41	70	1.4	
47-51	NA	NA	1522	NA	13	11	72	3.4	30	18	1.0	
52-54	NA	NA	2013	NA	23	23	226	6.7	11	72	2.1	

proach can be gauged by examining the Cu data. Compositing masks the geological contribution to the local geochemistry!

Assaying for Cu and Au and compositing core cost 40% more than routinely analyzing all samples for 30 elements, plus performing a separate aqua regia Au determination. Monies saved by the latter approach could then be allocated to assaying core exceeding 500 to 1000 ppb Au and/or 5000 to 10,000 ppm Cu. The fund represented by that 40% would not be expended unless great success was encountered, whereupon management probably would not be upset with expenditures beyond the 40%.

What impact does failure to routinely analyze the core for the multi-element suite have on this property evaluation? The assay grades are not encouraging and future exploration could depend on defining new targets or reassessing old targets based on reinterpretation of the geology for zones of favourability. The latter possibility is not easily accomplished without returning to the field to examine the core (which may be disrupted as the core boxes deteriorate with time). This costs money! It is likely that interest will wane or a joint venture agreement will be reached based on an underevaluation of the ground. The ground might ac-



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tually be dropped!

The cost to cover all bases (i.e., perform the multi-element analysis plus determine geochemical gold) was actually less in direct terms, although it would require additional expense to plot and interpret the data. I believe the additional efforts would add minimal cost for the potential rewards.

Our next example is also from central British Columbia. As this example focuses on analysis, details of local property conditions are not described. Soil sample Au data reported on Figure 12 represent fire assay preconcentration of Au, followed by atomic absorption determination, to a 5 ppb detection limit. Can you recognize any artifacts in the data and what remedial action would you recommend?

Editors note: Please send your comments or observations on these case histories to my attention. I would appreciate case histories from other parts of the world, submitted for publication in this column.

Stan Hoffman

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ANALYST'S COUCH

Are your REE Results Total?

Introduction

During a recent study of trace element discrimination diagrams for the tectonic interpretation of igneous rocks (Hall and Plant, in press), it was discovered that results for the rare earth elements (REEs) in some samples were dependent upon the method of analysis employed. Rocks from a gold mineralized zone on the Joburke Mine property, Timmins, Ontario gave a light REE-enriched pattern when analyzed by inductively coupled plasma mass spectrometry (ICP-MS). A mixed acid (HF/HClO₄/HNO₃/HCl) digestion was employed to bring the elements into solution for analysis. When other mafic rocks from the same property were analyzed for the REEs by instrumental neutron activation (INAA) a 'flat' chondrite-normalized pattern was obtained.

In order to verify the suspicion that this was an artifact of analytical methodology, a suite of five samples was chosen and analyzed by both methods. Two radically different patterns emerged, as seen in Figs. 1 (ICP-MS) and 2 (INAA). The light REE enrichment indicated in all cases by the ICP-MS data is not shown by the INAA results, and two samples now show a positive Eu anomaly. The agreement between methods for the elements La, Ce, Nd, Sm, Eu and Tb is satisfactory, however, the results for Yb and Lu by INAA are significantly higher than those by acid digestion/ICP-MS. The magnitude of the difference in values for either Yb or Lu is significantly greater than the limits set by the standard deviations of both methods. These differences become more pronounced when the values are normalized to chondrite, as in Figs. 1 and 2. It is apparent that this effect is matrix-dependent, as the agreement between methods for some of the samples is good for all 8 REEs.

Analysis

Each method was further examined to ascertain which set of data, INAA or acid digestion/ICP-MS, was indeed correct for the heavy REEs. Eleven samples were sent to another commercial laboratory for the determination of the REEs by INAA. Comparison of the results from two laboratories, both employing INAA, but differing in calibration strategies, is excellent, particularly for the REEs of particular concern, Yb and Lu. Therefore, it is highly improbable that the bias in Yb and Lu values by INAA is due to errors in calibration. Uranium is known to create a positive interference on Lu by INAA, but this has been ruled out since all these mafic rocks contain less than 0.5 ppm U.

Five standard reference materials, well defined at low levels of the heavy REEs (Govindaraju, 1989), were submitted for analysis by acid digestion/ICP-MS. All REEs were determined this time, as

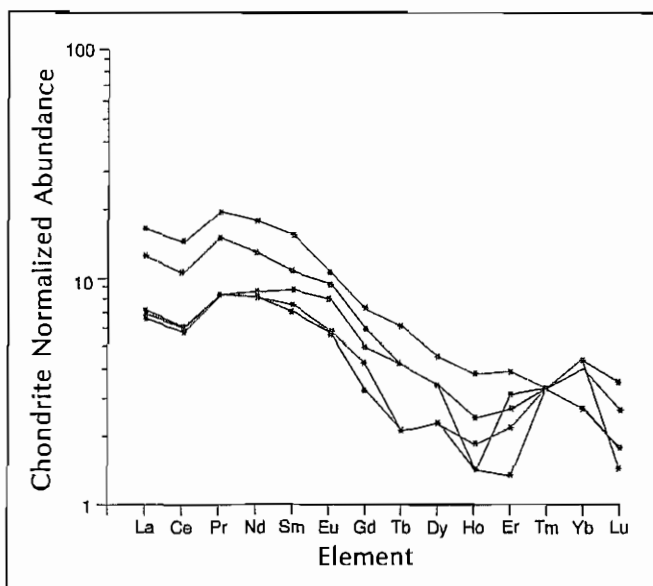


Figure 1. Chondrite-normalized abundance patterns for mafic rocks, analysis by ICP-MS following acid digestion.

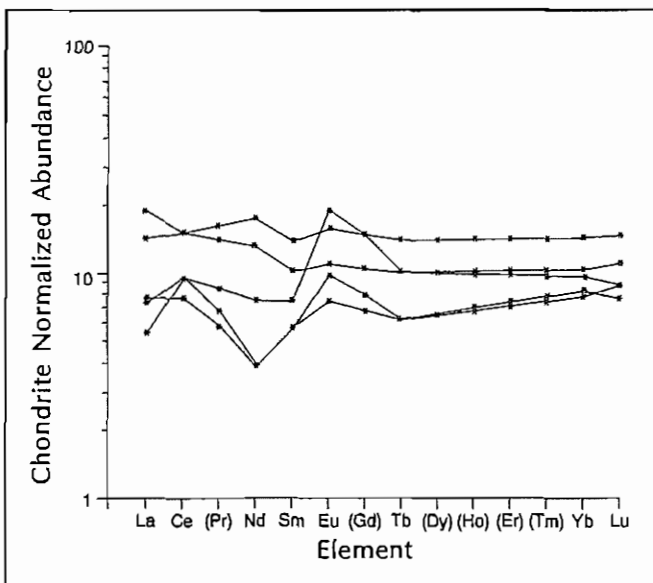


Figure 2. Chondrite-normalized abundance patterns for mafic rocks, analysis by INAA.

opposed to only those forming part of a 'geo-exploration package', and the accuracy of results proved to be excellent throughout, as shown by comparison to 'recommended' values in Table I.

At this point in the investigation, no obvious errors had emerged in the application of either analytical technique to the determination of the REEs. Bearing in mind that the bias appeared to be matrix-dependent, a small suite of samples was analyzed at the Ontario Geological Survey (Will Doherty, pers. comm.) by ICP-MS following different decomposition procedures. A mixed acid attack (HF/HClO₄/HNO₃/HCl), similar to that employed by the commercial laboratory, was compared to the more efficient fusion with lithium metaborate, LiBO₂. Standard reference materials were also analyzed to estimate accuracy; results for two of these, GSP-1 and BCR-1, are shown in Table II together with the suite of rocks from the Joburke property. While results obtained by both decompositions agree, within the established precision limits and in order of increasing atomic weight from La to Eu, the LiBO₂ fusion yields significantly higher values in Gd through Lu in three of the five rocks. In fact, the results for Yb and Lu in samples 66901, 66907 and 8-31 by LiBO₂/ICP-MS now are identical to those obtained earlier by INAA. It is interesting to note that the acid digestion is adequate for all REEs in the basalt, BCR-1, as it was

for the five standards listed in Table I. Hence, the bias initially observed between INAA and acid digestion/ICP-MS was not related to either analytical technique, but to an inefficiency in solubilizing some of the REEs in some samples. In fact, it is a bias reflecting the natural fractionation of the heavier REEs into the more resistant mineral phases such as zircon, sphene and garnet. There have been numerous reports (Date and Hutchison, 1987; Lichte et al., 1987; Jarvis, 1988; Doherty, 1989) demonstrating successful application of ICP-MS to the determination of the REEs, but all have been based upon similar acid digestions and, as in this work, the standard materials chosen to monitor accuracy have not indicated the inadequacy of the decomposition.

Conclusions

It is extremely rare that individual mineralogies of samples submitted for REE determination would be known and, hence it is virtually impossible to predict which samples would be subject to partial digestion by mixed acid attack. Thus, if ICP-MS is to be employed, total decomposition by LiBO_2 fusion should be used. This procedure is already widely employed for the determination of other trace and major elements by various analytical techniques such as ICP-ES, ICP-MS and AAS. Thus, a cost-effective 'package' based upon this fusion could be designed to benefit the exploration community. Other elements which should be included in the ICP-MS portion of the 'package' are Zr, Nb, Hf and Ta, where the host minerals also demand decomposition by fusion.

Acknowledgements

The authors wish to thank the commercial laboratories for the analyses and special gratitude goes to Will Doherty of the Ontario

Table I (Cont'd)

Er		Tm		Yb		Lu	
ICP-MS	Lit. ^a	ICP-MS	Lit. ^a	ICP-MS	Lit. ^a	ICP-MS	Lit. ^a
2.7, 2.9	<u>2.4</u>	0.3, 0.3	<u>0.33</u>	2.2, 2.1	<u>2.02</u>	0.27, 0.27	<u>0.291</u>
2.2, 2.7	<u>2.3</u>	0.3, 0.3	<u>0.37</u>	2.7, 2.6	<u>2.32</u>	0.35, 0.35	<u>0.37</u>
2.1, 2.0	<u>2</u>	0.3, 0.2	0.1?	2.2, 2.1	<u>2.01</u>	0.28, 0.28	<u>0.32</u>
1.3, 1.3	2	0.1, 0.1	0.11	1.1, 1.0	0.6?	0.10, 0.10	0.12
2.4, 2.4	2	0.3, 0.3	0.42	2.3, 2.1	<u>2.24</u>	0.24, 0.25	<u>0.31</u>

Geological Survey for the decomposition study. Geochemical interpretation was carried out by J.A.P. on sabbatical working as a consultant for T.S. Middleton Exploration Services, Inc., Timmins. The computer plots were prepared by C. David. The paper is published with the permission of the Director of the British Geological Survey (NERC).

NB: This study forms part of a larger investigation described in a paper submitted to *Chemical Geology*.

Gwendy E.M. Hall

Head, Analytical Method Development

Geological Survey of Canada

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Table I

Comparison with literature values of the results obtained for the REEs by ICP-MS and acid digestion of 5 Standard Reference Materials; all values in ppm.

Sample	La		Ce		Pr		Nd		Sm		Eu		Gd		Tb		Dy		Ho	
	ICP-MS	Lit. ^a	ICP-MS	Lit. ^a	ICP-MS	Lit. ^a	ICP-MS	Lit. ^a	ICP-MS	Lit. ^a	ICP-MS	Lit. ^a	ICP-MS	Lit. ^a	ICP-MS	Lit. ^a	ICP-MS	Lit. ^a	ICP-MS	Lit. ^a
BHVO-1 (basalt)	16.4, 16.8	<u>15.8</u>	37.1, 38.3	<u>39</u>	5.4, 5.4	<u>5.7</u>	25.8, 25.5	<u>25.2</u>	5.7, 6.2	<u>6.2</u>	2.28, 2.30	<u>2.06</u>	5.8, 6.4	<u>6.4</u>	0.9, 0.9	<u>0.86</u>	5.4, 5.4	<u>5.2</u>	0.99, 0.86	0.99
QLO-1 (quartz latite)	26.1, 25.7	<u>27</u>	47.2, 48.2	<u>54.6</u>	5.7, 5.7	<u>6.0</u>	22.9, 23.4	<u>26</u>	4.3, 4.3	<u>4.88</u>	1.38, 1.33	<u>1.43</u>	3.9, 4.2	4.7	0.6, 0.6	<u>0.71</u>	3.9, 3.5	<u>3.8</u>	0.67, 0.71	0.86
DNC-1 (diabase)	4.1, 4.0	<u>3.8</u>	8.4, 7.8	10.6	1.3, 1.1	<u>1.3</u>	6.1, 4.6	<u>4.9</u>	1.5, 1.5	<u>1.38</u>	0.87, 0.81	<u>0.59</u>	2.0, 2.0	2	0.4, 0.3	<u>0.41</u>	3.4, 2.7	2.7	0.57, 0.54	0.62
MRC-1 (granite)	9.6, 8.6	<u>9.8</u>	23.2, 25.1	<u>26</u>	4.0, 3.6	<u>3.4</u>	19.8, 17.8	<u>19.2</u>	4.4, 4.6	<u>4.6</u>	1.63, 1.53	<u>1.39</u>	4.1, 3.8	4	0.5, 0.5	<u>0.51</u>	3.3, 2.7	2.9	0.45, 0.39	<u>0.49</u>
SO-1 (soil)	53.5, 54.3	<u>54</u>	104, 103	<u>102</u>	12.4, 12.1	<u>11.8</u>	48.1, 47.5	<u>44</u>	7.9, 7.9	<u>7.9</u>	1.77, 1.90	<u>1.67</u>	5.6, 5.4	<u>6.1</u>	0.8, 0.8	<u>0.88</u>	4.7, 4.1	<u>4.5</u>	0.72, 0.75	1.1

^a Taken from Govindaraju (1989); underlined indicates a 'recommended' as opposed to 'proposed' value and a question mark reflects lack of data points.

Table II

Analysis of rocks from the Joburke property, GSP-1 and BCR-1 by ICP-MS following either an acid digestion ($\text{HF}/\text{HClO}_4/\text{HNO}_3/\text{HCl}$) or LiBO_2 fusion, all values in ppm.

Sample	La		Ce		Pr		Nd		Sm		Eu		Gd		Tb		Dy	
	acid	fusion	acid	fusion	acid	fusion	acid	fusion	acid	fusion	acid	fusion	acid	fusion	acid	fusion	acid	fusion
G6901	2.24	2.44	6.2	5.8	0.94	0.85	4.84	4.55	1.42	1.66	0.40	0.58	1.07	2.35	0.19	0.43	0.78	3.07
G6907	2.04	2.03	5.8	5.2	0.87	0.80	4.63	4.50	1.35	1.43	0.42	0.56	0.93	2.21	0.09	0.40	0.67	2.77
8-11	4.19	3.41	11.7	11.2	1.71	1.63	8.96	9.12	2.48	2.96	0.71	1.08	1.81	4.14	0.21	0.76	1.43	5.10
13-100	89.8	61.7	148	142	17.2	15.3	83.7	59.1	9.69	9.05	2.34	2.20	5.54	5.46	0.55	0.63	2.74	2.79
13-100	67.0	61.7	153	138	17.0	15.5	64.7	59.1	9.91	8.74	2.35	2.16	5.29	5.31	0.54	0.56	2.76	2.72
21-59	14.5	13.9	29.5	30.3	3.12	3.17	11.4	11.8	2.04	2.11	0.46	0.44	1.36	1.49	0.16	0.21	0.89	0.99
GSP-1 (granodiorite)	161		398		47.1		181		24.1		1.98		10.7		1.18		5.70	
	(184)		(399)		(52)		(190)		(26.3)		(1.95)		(12.1)		(1.34)		(5.5)	
BCR-1 (basalt)	25.2		55.9		6.72		28.2		6.64		2.01		6.41		1.00		6.54	
	(24.9)		(53.7)		(6.8)		(28.8)		(6.59)		(2.33)		(6.68)		(1.05)		(6.34)	

Values in parentheses are from the compilation by Govindaraju (1989), underlined indicates 'recommended' rather than 'proposed'.

Jane A. Plant

Head, Applied Geochemistry
British Geological Survey
Keyworth, U.K.

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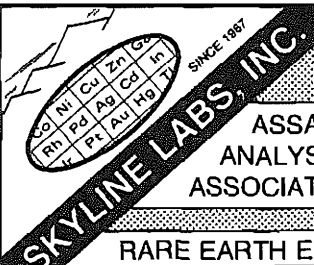
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MEETING REPORTS

New Model for Hot Spring Gold Deposits in Intraformational Arkoses of Basalt Fields

A new gold play is underway in the northwestern part of the Basin and Range province, an area long regarded as unfavorable for large precious-metal deposits. It began with the discovery of the Grassy Mountain deposit by Atlas Gold in the Lake Owyhee Volcanic Field of eastern Oregon and is now spreading westward across southern Oregon. The search may be expected to reach into northern California and Nevada west of the Black Rock Structural Boundary. Research on the regional stratigraphic and structural controls is being done by Mark Ferns and Howard Brooks of the Oregon Department of Geology and Minerals Industries, Michael Cummings at Portland State University, and James

AEG ANNUAL GENERAL MEETING

15TH INTERNATIONAL GEOCHEMICAL EXPLORATION SYMPOSIUM

Reno, Nevada • April 29, 30, May 1, 1991

Symposium Topics:

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3. Integrated geophysical and geochemical exploration
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2. Exploration using soil-gas geochemistry and other techniques
3. Biologically related geochemical exploration
4. Statistical handling of geochemical data

Field trips:

1. Base- and precious-metal deposits of the Great Basin
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3. Gold deposits of the California Mother Lode
4. Gold deposits of the Hemlo area, Canada
5. Precious-metal deposits in the Andes, North and Central Chile

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Official Language: English**Abstract Deadline:** December 15, 1990

The symposium committee invites you to submit papers for presentation at the plenary sessions or the general poster session. Completed papers or extended abstracts up to 500 words, in English, will be accepted. Visas are required from a number of countries. Please check with the U.S. Consulate or Embassy before attempting to enter the United States. All members of the AEG received the first circular in the last issue of Explore. For more details contact: **Mrs. Keryl Fleming**, Symposium Secretary, Nevada Bureau of Mines and Geology, #178, University of Nevada, Reno, Nevada 89557-0088, USA.

Rytuba, Dean Vander Mulen, and Vincent Barlock of the U.S. Geological Survey in Menlo Park, California.

Six hot spring precious metal systems have been found in the Lake Owyhee Volcanic Field including Katie, Mahogany, Red Butte, Quartz Mountain, and Grassy Mountain which are the largest. Small-volume basalt and rhyolite volcanism associated with regional caldera subsidence allowed large fluvial systems to enter the field from western Idaho and provided the ground water for geothermal cells along extensional fault zones. An excellent paper on this subject was given by James Rytuba at the Great Basin Symposium at Reno in April 1990. He described the relationship between the volcanism and the subtle features which mark the center of mineralization when the fluvial system dominates sedimentation. One of these is a small sinter pool at the hot spring vent in the river sediments.

Dr. Rytuba was also the central figure in leading the Owyhee field trip which followed the symposium. The Grassy Mountain Deposit would easily have been the highlight of the tour but Atlas would not allow participants in the area of the deposit. It is reported to contain about 1.2 million ounces of gold at a grade of approximately 0.06 ounces per ton based on extensive drilling during the summer of 1989. The discovery was announced in 1988.

An excellent guidebook with numerous full-color illustrations and maps was assembled by the tour leaders and will be part of a compendium offered by the Geological Society of Nevada, P.O. Box 12021, Reno, Nevada 89510. The Society's telephone number is (702) 323-3500.

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SPECIAL NOTES

Robert W. Boyle - Honorary Member

Dr. M.A. Chaffee, outgoing President of the Association of Explorations Geochemists, has announced that Dr. Robert W. Boyle of Ottawa, Canada has been elected an Honorary Member of the Association. The announcement was made during the 13th International Geochemical Exploration Symposium held recently in Rio de Janeiro, Brazil.

Dr. Boyle, a highly respected and internationally known scientist, is one of the pioneers of geochemical exploration development in Canada and has played an important and significant role in the establishment and advancement of geochemical methods in mineral exploration worldwide. Dr. Boyle, who retired from the Geological Survey of Canada (GSC) in 1985, is still active in the profession he has served for almost 40 years.

In 1955, he was named Head of the newly created exploration geochemistry department within the GSC

and, to a large degree from his scientific leadership and example, the GSC has become one of the world's leading institutions for geochemical exploration research. His fine reputation as a scientist led to a succession of invitations to present lectures and short courses in both developed and less developed countries which have, in turn, stimulated global application and growth of exploration geochemistry.

Dr. Boyle has authored over 160 publications including well known textbooks on gold, silver, and uranium and thorium which are outstanding standard references.

He served as President of the Association of Exploration Geochemists in 1976-77 and was a principal organizer behind both the first (Ottawa, 1966) and the third (Toronto, 1970) International Geochemical Exploration Symposia. He has been honored twice by the Canadian Institute of Mining and Metallurgy as a Barlow Medalist, awarded the

prestigious Miller Medal by the Royal Society of Canada, and has received special recognition among government scientists through a Public Service of Canada Merit Award.

In addition, he has served as Councillor of the Society of Economic Geologists and is currently Vice President of the International Association on the Genesis of Ore Deposits and is the Chairman of the

IAGOD International Conference on Mineral Deposit Modelling, to be held in Ottawa, Canada in August 1990. His commitment to education is reflected in his 20 years as a lecturer and adjunct professor at Carleton University, during which he instilled a sound background in geochemistry into a grateful stream of undergraduate and graduate students.

Wilderness in America: Should There Be Limits?

Introduction

Today, over one acre out of every three in the United States is owned by the federal government. Traditionally, this land was open to all Americans for a wide variety of uses hiking, cattle ranching, bird watching, mining, hunting, oil and gas, tourism, camping, logging, and wildlife.

But since 1964 an ever-increasing amount of land has been closed off to most of these uses, and most people are no longer able to enter these public lands for their use and enjoyment. It was in 1964 that Congress passed the Wilderness Act, which at first set aside relatively few acres as a land "untrammelled by man, where man himself is a visitor who does not remain".

Today there are over 90 million acres of federal land set aside as wilderness areas. There are proposals to set aside an additional 150 million acres into wilderness areas. This would represent 34% of the public lands, not including non-wilderness portions of national parks, wildlife refuges, and other special conservation areas. (see EXPLORE no. 61, p.12)

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The Hidden Impacts of Wilderness

What is most surprising to many is that once an area is designated as wilderness, those people who earned a living from the land and who enjoyed it for recreation and various other uses are no longer able to enter those areas. For example, one of the principal impacts of wilderness is a denial of access. Many ranchers claim that under current regulations, profitable cattle ranching is impossible.

Exploration for energy resources and strategic minerals is forbidden, eliminating the opportunity to discover new fuel supplies and rare mineral deposits. Hikers and hunters have found dirt roads used for decades are now blocked off, and there are stiff fines for anyone who drives a vehicle in wilderness areas.

Responsible off-road vehicle users are losing recreational access. The economics of rural counties surrounded by wilderness have declined due to the inability to use the public lands for many productive purposes. When land is put into wilderness and removed from productive use, the tax base of rural communities can be drastically reduced.

Wildlife may suffer the most under wilderness management. Unlike federal lands set aside for multiple use, wilderness laws make it impossible to adequately manage wildlife. The science of game management cannot be practiced in wilderness areas and diseases, pests, and fires cannot be controlled even when those problems come from areas outside the wilderness areas.

Water rights are also threatened by new wilderness proposals. New federal reserved water rights may be created if some proposed wilderness bills are passed in their present form, jeopardizing private and state water users.

Most troubling of all, however, is not that America has set aside vast acreage as wilderness, or that 150 million acres more are currently being considered for wilderness, but that so very little is known about the actual economic, social and ecological impacts of these massive single use land withdrawals.

It is time Americans found out. We need to know if past wilderness decisions were made properly before millions of acres of additional lands are set aside as new wilderness.

We don't know exactly how many head of cattle have been driven off the public lands due to wilderness. We don't know how many mineral deposits or oil and gas reserves have been lost from America's economy. We don't know precisely how much wildlife already has been lost to wilderness designations, and we certainly don't know how much could be lost through new wilderness proposals. In addition, we don't know how many millions of dollars will be lost to the recreation industry as a result of roads and campsites being made unavailable to tourists. What we do know is that the cumulative impacts of wilderness are being increasingly felt throughout the West. Every state has been affected by economic impacts from wilderness designations, and each day brings additional proposals for even more wilderness.

The Wilderness Impact Research Foundation

The Wilderness Impact Research Foundation, often called WIRF, was formed in 1986 by a group of Nevadans. At first they noted the troubling impacts of proposals to set aside large portions of Nevada as wilderness. But as they studied the effects that the new wilderness designations would have on mining, skiing, wildlife,

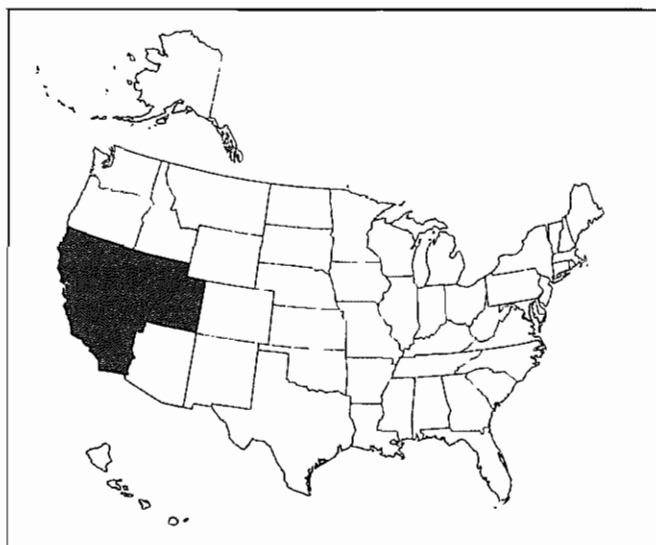


Figure 1. Proposed and existing wilderness set-aside areas are equivalent to these blacked-out states.

hunting, and ranching, it became apparent that the problem was much bigger than Nevada, that in fact it was of national significance.

Under the guidance of WIRF a national coalition has been formed to address problems that new wilderness additions would create all across America. Already, groups from as far away as Alaska, Florida, California, Montana, Louisiana, North Carolina and Canada have contacted WIRF for help.

National Wilderness Conference

In June of 1988, the tide began to turn for those disturbed by proposed wilderness legislation when WIRF, joined by the Pacific and Mountain States Legal Foundations, sponsored a national symposium on wilderness. For the first time, groups of such disparate users as miners and the handicapped, from cattle ranchers to sportsmen, and from loggers to motorcyclists gathered together in Las Vegas to form a coalition for research, education, and communication that would work to combat the exponential growth of wilderness lockups.

At that conference, and at the second conference in 1989, representatives of a wide variety of groups formed a steering committee to advise WIRF. Today, WIRF is embarked on a public information campaign about wilderness.

Wilderness Videos

WIRF sponsored and created five nationally syndicated television programs on wilderness. The first tackled the national scope of wilderness laws and the second focused on the California desert. WIRF is now working to fund future videos on wilderness and water conservation, wilderness and access, wilderness and the economy, to name just a few.

Wilderness Economics

Economic studies on the impacts of wilderness were not available until WIRF took the lead. The results of the few existing studies are startling. It is estimated that the recreation industry in Idaho will lose \$730 million annually if 1.4 million acres of new proposed wilderness is created. According to another study, Greenlee County in Arizona could lose \$19.3 million a year from wilderness designations. And wilderness proposals in Elko County, Nevada, could cost that state over \$50 million a year.

If these studies accurately represent the impacts of wilderness throughout the nation, the American economy could be losing billions from new wilderness additions. WIRF is now working to sponsor additional studies covering larger geographic areas in order to discover the full scope of the national economic impacts from wilderness.

WIRF and the Future

WIRF represents a unique approach to public land policy. It is the only organization dedicated to studying wilderness from the

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human perspective. In the past few years, much has been accomplished. But with new proposals for more and more wilderness continuing unabated, WIRF needs to do more, much more. The economic realities of wilderness distribution to publicize the impacts must be released for national distribution to publicize the impacts of wilderness. All Americans who use the public lands for work and recreation, or depend on products from the public lands, have a vital stake in making wise policy decisions today and must be informed of the true costs of wilderness before new wilderness decisions are made.

How You Can Help

WIRF has much work to accomplish before even more land is locked away as wilderness. WIRF is a non-profit foundation. You can be a part of the WIRF team by sponsoring its public information campaign through a contribution of services, pledges, or equipment. Your generous support is vital to our work.

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Please make your check payable to WIRF. The Wilderness Impact Research Foundation is incorporated in the State of Nevada and registered with the Internal Revenue Service under Section 501 (c) (4) of the Internal Revenue Code. Business contributions may be tax deductible — ask your accountant.

Wilderness Impact Research Foundation

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Members Found

The following "lost members" have been found: David Bending, Alex Bronowski, Michael Cartwright, Yehuda Diner, F. Felder, Chris Graf, Mark Griswold, Calvin Herron, John Lowdry, John McConnell, Michael McInnis, Jamnadas Patel, Peter Ronning, Sharon Roth, Thomas Salzer, Andrew Schumacher, R.W. Shewman, John Stephenson, Bruce Veek, Donald Carpenter, Hubert Zeegers. *Editor's Note: Erick Weiland and Stan Hoffman spent several hours locating members who were listed in the "Lost Members" list published in EXPLORE, Number 65, April 1989. Follow-up letters are being mailed to them to encourage their continued association with the AEG. Good work, Erick and Stan.*

COUNCIL MINUTES

Actions of November 29, 1989

1. M. Chaffee (President) reported on the successful 13th International Geochemical Exploration Symposium, the first held in a developing country. The success of this symposium leads the way for additional symposia in developing countries.
2. Council expressed concern about increasing the number of Voting Members and ways to encourage Affiliate Members to upgrade to Voting Membership.
3. D. Jenkins (Chairman, Distinguished Lecture Committee) solicited nominations for the 1990 series of lectures.
4. A committee was formed (D. Runnells, Chairman) to study By-Law revision. Suggestions are actively being solicited.
5. Nominations for European Regional Councillor were solicited for an upcoming election in early 1990.
6. An Award Committee was formed to study appropriate awards for members who have performed outstanding service.
8. The proposed telephone-telefax communications to Rexdale, Ontario were established. The number for both is (416) 740-6633.
7. Council approved 10 Affiliate and 1 Student Members.

Actions of February 21, 1990

1. Council passed a motion that all public representation and advertising of the AEG be approved by the President and Secretary, or by the entire Council prior to publication.
2. A committee was formed (J. Jaacks, Chairman) to study ways to increase the number of voting members.
3. Council passed a motion to create a new Vice Presidential duty of Regional Councillor Coordinator. K. Fletcher (Vice President) is the first to accept this new duty.
4. Council approved John M.A. Forman as Acting Regional Councillor for Brazil (1990-1992).
5. Council passed a motion to change the Name Affiliate Member to Member and the name Voting Member to Fellow. These changes will be incorporated into the By-Law revisions.
6. Council passed a motion that all new members be provided a copy of the Association Code of Ethics and be required to sign on their application form that they have read and agree to abide by the Code of Ethics.
7. Council approved 29 Affiliate and 4 Student Members.

Sherman P. Marsh, Secretary

U.S. Geological Survey
MS 973, Federal Center
Denver, Colorado 80225 USA

INFORMATION REQUESTED

Lost Members

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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 Toronto office, recommendation by the Admissions Committee, review by the council, and publication of applicant's names in the newsletter remains unchanged.

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RECENT PAPERS

Exploration Geochemistry

This list comprises titles that have appeared in major publications since the compilation in Newsletter No. 67. 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 (GCS Paper) and Open File Report (GCS 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, Colorado 80401. Chairman AEG Bibliography Committee. Please send new references to Dr. Closs, *not* to EXPLORE.

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- Rao, K.S.P., Sastry, R.S.N., and Raju, S.V.** 1989 *Results of a geochemical soil survey in Ramagiri goldfield, Andhra Pradesh, India*. IMM Trans. B24-33
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Analytical Geochemistry

This column highlights analytical papers of geochemical interest published in major international journals. These include: Analytical Chemistry (Anal. Chem.), Analyst, Journal of Analytical Atomic Spectrometry (J. Anal. At. Spectrom.), Analytica Chimica Acta (Anal. Chim. Acta), Talanta, Applied Spectroscopy (Appl. Spectrosc.), Spectrochimica Acta Part B (Spectrochim. Acta), Atomic Spectroscopy (At. Spectrosc.) and Analytical Proceedings (Anal. Proc.).

Pertinent papers from Geostandards Newsletter, published in April and October yearly, are too numerous to cite. This journal is a "must" for the geochemist. Where the number of authors on one paper is greater than four, "et al." is used. This list covers those issues received by the author since those listed in EXPLORE no. 67. Compiled by **Gwendy E.M. Hall**, Head of Analytical Methods Development, Geological Survey of Canada, 601 Booth Street, Ottawa, Canada K1A 0E8. Please send new references to Dr. Hall, not to EXPLORE.

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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

■ June 24-29 '90 **GeolInfo IV**, 4th International Conference on **Geoscience Information**, Ottawa, Canada (David Reade, GeolInfo IV Secretariat, 601 Booth Street, Ottawa, K1A 0E8, Canada)

■ July 2-6, '90 **Geology and mineral resources** of continental margins: ancient and modern (23rd Earth Science Conference, Geological Society of South Africa), Cape Town, South Africa (Dr. P.G. Gresse, Geological Survey, P.O. Box 1739, Bellville, 7530, South Africa)

■ July 2-8, '90 **Second International Symposium on Geochemistry of the Earth's Surface and of Mineral Formation**, Aix-en-Provence, France (Prof. Daniel Nahon, Secretary General GWDSP-2, University of Marseille, 13397 Marseille Cedex 13, France)

■ July 29-Aug. 3, '90 **Circum-Pacific energy and minerals resources** (Conference), Honolulu, Hawaii (Mary Stewart, Circum-Pacific Council on Energy and Mineral Resources, 5100 Westheimer Road, Houston, TX 77056)

■ Aug. 12-18, '90 8th Symp. of Intl. Assoc. on the **Genesis of Ore Deposits**, Ottawa, Canada (L.M. Cumming, Secretary, 8th IAGOD Symposium, Geological Survey of Canada, 601 Booth St., Ottawa, Ontario, Canada K1A 0E8)

■ Aug. 12-18, '90 **Mineral deposit modelling** (International Conference), Ottawa, Canada. Held with 8th IAGOD Symposium. Sponsored by IUGS and UNESCO (R.V. Kirdham, Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario, Canada K1A 0E8)

■ Aug. 15-17, '90 **Arctic geology & petroleum potential**, mtg., Tromsø, Norway (Norwegian Petroleum Society, Box 1897, Vika, 1024 Oslo 1)

■ Aug. 29-31, '90 14th International **Geochemical Exploration** Symposium, Prague, Czechoslovakia (Frantisek Mma, General Chairman, Geological Survey of Prague, 118 21 Praha 1, Malostranské nám. 19, Czechoslovakia)



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■Sept. 9-17, '90 **Geochemistry of Clay-Pore Fluid Interactions**, Burlington House, Piccadilly, London, United Kingdom (Dr. D. Savage, British Geological Survey, Keyworth, Notts, United Kingdom, Tel: 06077, 6111)

■Sept. 10-12, '90 **Goldtech 4**, mtg., Reno, Nev. (Meetings Department, Society for Mining, Metallurgy and Exploration, Box 625002, Littleton, Colo., 80162-5002, Tel: 303-973-9550; Fax: 303-973-3845)

■Sept. 17-20, '90 **Computers and minerals research**, intl. symposium, Berlin, West Germany (F.L. Wilke, Technische Universität Berlin, Institut für Bergbauwissenschaften, Sekr. EB 11, Strasse des 17. Juni 136, 1000 Berlin 12, West Germany)

■Sept. 29 - Oct. 7, '90 **European Geological Societies**, mtg., Lisbon, Portugal, by Geological Society of Portugal (Sociedade Geologica de Portugal, Apartado 2361, P 1109 Lisboa Codex)

■Oct. 8-10, '90 **Remote Sensing**: technology for mining and petroleum industries, intl conference and exhibit, London (The Institute of Mining & Metallurgy, 44 Portland Place, London, England W1N 4BR, Tel: 01-580-3802, Telex: 261410 IMM G, Fax: 01-436-5388)

■Oct. 22, '90 **Modelling geological data** consisting of multiple variable, short course, Houston (American Association of Petroleum Geologists, Box 979, Tulsa, Okla. 74101-0979, Tel: 918-584-2555; Fax: 918-584-0469)

■Oct. 29-Nov. 1, '90 **Geological Society of America**, ann. mtg., Dallas (Vanessa George, GSA, Box 9140, Boulder, Colorado 80301, Tel: 303-447-2020)

■Nov. 15-17, '90 **International Gold Expo**, (Porta Hoffman, American Mining Congress, 1920 N Street N.W., Suite 300, Washington, D.C. 20036, Tel: (202) 861-2850, or (202) 861-7535)

■Jan. 7-11, '91 Short course on **Hydrothermal alteration**: its relationships to mineralization, (Mining, Division of Continuing Education, University of Nevada, Reno; Reno, NV 89557, Tel: (702) 784-4046)

■Feb. 25-28, '91 **SME** ann. mtg., Denver, Colorado (Geochemistry: J. Stevens Zuker, Westmont Mining Inc., 4949 S. Syracuse St., Suite 4200, Denver, Colorado 80237, Tel: (303) 694-4936; Geochemistry & Geology: Kenneth A. Lovstrom, Lovstrom & Associates, 1628 S. Lee St., Lakewood, Colorado 80226, Tel: (303) 988-2854)

■March, '91 International Conference on Economic **Evaluation of Mineral Resources** (Intergeoekonomika 1991 CSSR, GEOFOND Bratislava branch Kosice, Eng. St. Richter, Ph.D., Garbanova 1, 040 11 Kosice, Czechoslovakia. Tel: 437 649)

■Apr. 21-28, '91 2nd AusIMM-SME **World Gold '91**, Cairns, Australia (Meetings Dept., SME, Tel: (303) 973-9550, Fax: (303) 979-3461, Telex: 881988, or Mrs. J.M. Webber, CEO, AusIMM, P.O. Box 122, Parkville, Vic 3052, Australia, Tel: 613-347-3166, Fax: 613-347-8525, Telex: AA 33552)

■Apr. 26-May 1, '91 Assoc. of **Exploration Geochemists**, intl. mtg., Reno, Nev. (Keryl Fleming and Mario Desilets, Nevada Bureau of Mines & Geology, Univ. of Nevada, Reno, 89557-0088. Tel: 702-784-6691)

■May 13-17, '91 **Brazil Gold '91** (USA-Charles Thorman, USGS (Denver), Fax: (303) 236-5448; Canada-C.Jay Hodgson, Queens U., Fax: (613) 545-6592; UK-Robert Foster, U. Southampton, Fax: 59-3052; Australia-David Groves, U. Western Australia, Fax: 9386-6577)

■May 27-29, '91 **GAC-MAC** (Annual mtg.), Toronto, Canada (J. Fawcett, Department of Geology, University of Toronto, Toronto, Canada M5S 1A1)

■Aug. 11-24, '91 **XX General Assembly IUGG**, Vienna, Austria (IUGG Organizing Committee, c/o ZAMG Hohe Warte 38, A-1190 Vienna, Austria, EUROPE, Tel: 43-222-36 4453 ext. 2001)

■Oct. 21-24, '91 **Geological Society of America**, ann. mtg., San Diego, California (Vanessa George, GSA, Box 9140, Boulder, CO 80301, USA, Tel: 303-447-2020)

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

Fred Siegel

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3. Bonham, H.F. Jr. *Gold 89 in Europe international symposium.* no. 67, p. 14, January, 1990

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4. Cooksley, James W., and Kendrick, Peter H. *Use of seismic geophysics in the detection of epithermal precious metal deposits in the western U.S.* no. 67, p. 1, January, 1990

5. Darnley, A.G. *International geochemical mapping.* no. 65, p. 20, April, 1989

6. Fletcher, K., and Wolcott, J. *Seasonal variation in transport of gold in Harris Creek: Implications for exploration.* no. 66, p. 1, June, 1989

7. Garrett, Robert G. *A cry from the heart.* no. 66, p. 18, June, 1989

8. Gravel, John L. *Gold exploration - Northern California: Pearl Harbor File.* no. 66, p. 14, June, 1989

9. Hall, Gwendy E.M., Coope, J. Alan, Weiland, Erick F. *Bias in analyses for gold.* no. 65, p. 17, April, 1989

10. Hoffman, Stanley J. *Volcanic massive sulphide in Newfoundland - Conclusion: Pearl Harbor File.* no. 65, p. 16, April, 1989

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16. McCarthy, Howard. *Gases as geochemical indicators of concealed mineral deposits.* no. 65, p. 6, April, 1989

Geologist's Nightmare



All summer you've been drilling
But you still ain't hit a lick,
When you hit rock it's just hard as hell
And the overburden's thick.

When there finally is some color
You are feeling quite elated,
Until you find out from the lab
The sample's contaminated.

A tire blows out on your pickup.
Then a track falls off the Cat,
OSHA's hot breath on the back of your neck
The driller won't wear his hard hat.

The Forest Service holds up your permit
A whole lot longer than they should,
They're so ornery about it that they make
The BLM look good!

The driller breaks a cable
He's two hundred miles from parts,
Sample catcher got his numbers wrong
That's where more trouble starts.

When the drill rig's running once again
He twists his pipe in two,
Spends your next month's budget fishing
Cause there's nothing else to do.

You get a message from your wife
Your marriage is destroyed,
She has found herself a better deal
Even though he's unemployed.

But then you drill a good hole
Samples running hot as sin,
Now the home office is calling
And there's big wheels coming in.

The President is calling you
He starts out "Howdy, Jim".
Last week you were just a number
And you'd only heard of him.

Now every hole is running
There's a mine here sure as pie,
There are lots of news releases
Stock's going through the sky.

You start talking 'bout construction
Of an office, shop and mill,
Tailings pond goes in the canyon
Put the dump behind the hill.

The company gives you a raise
Newspapers give you fame,
Cause right there on the front page
Is your picture and your name!

Then you get the news you're fired
Bad mistake made, you're to blame,
Cause every good hole that you drilled
Is on someone else's claim!!

Lew Eklund
Box 666
Carlin, NV 89222

17. Naldrett, A.J., and von Gruenewaldt, G. *The association of PGEs with chromitite in layered intrusions and ophiolite complexes.* no. 66, p. 10, June, 1989

18. Ottesen, Rolf Tore, and Volden, Tore. *Overbank sediment as a sampling medium in geochemical mapping.* no. 65, p. 1, April, 1989

19. Schwarz, Frederick P., Jr. *A check for error in drill hole sampling using paired assays.* no. 67, p. 4, January, 1990

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