EXPLORE

Newsletter for the Association of Exploration Geochemists

NUMBER 81 OCTOBER 1993

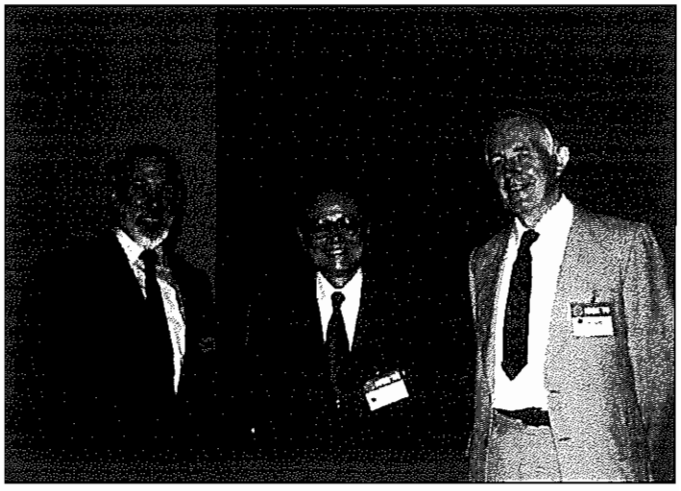
16TH IGES, BEIJING, CHINA

On September 4th, 1993, after two years of planning and preparation, Professor Xie Xuejing welcomed delegates from around the world to the 16th IGES. Professor Xie then introduced the Chinese Vice Premier, Zou Jiahua, who extended a warm welcome to the delegates on behalf of the Chinese people. The Vice Premier went on to say that China is now more open to the west and is particularly anxious to advance their scientific endeavors through cooperation and communication with the West. The Vice Premier's welcome was followed by a welcoming address on behalf of the Association of Exploration Geochemists (AEG) by the AEG president Graham Taylor. Graham reiterated the AEG's desire to strengthen its international composition, and commended Professor Xie and his colleagues on their efforts to bring about the symposia in Beijing.

In the morning plenary session an address by Graham Taylor drew attention to innovations in exploration geochemistry and encouraged delegates to continue to push back the frontiers of exploration. Following Graham's comments, Professor Qu Geping described the current status of environmental concerns in China. He pointed out the significant progress made in China to protect the environment but also drew the delegate's attention to the problems remaining for a country with an expanding population and a shrinking amount of arable land. Dr. Arthur Darnley (Canada) concluded the welcoming session by bringing delegates up-to-date on the International Geochemical Mapping project. In his remarks, Dr. Darnley drew heavily on the Chinese National Mapping Project, as this is arguably the most advanced geochemical mapping project in the world today.

Approximately 300 delegates attended the symposia from 29 different countries, making this one of the most international of all IGES. English was the official language for the Symposia, making it easy for the English-only participants; however, at any one time, one could hear private conversations in a variety of languages and accents. More than once, some very brave non- native English delegates found themselves making presentations, in English, to a primarily non-native English audience. Regardless, with ample arm waving, gesturing, sketching and help from the audience, most points were adequately communicated.

The symposia was held in the north-eastern section of Beijing, at the 21st Century Hotel and Conference Center, which included a wide range of lecture halls, conference rooms, shops, restaurants and a 25 story hotel. With all of the facilities on-site, symposia delegates could have isolated themselves in Western style; however, just a short step off the premises exposed you to the hustle and bustle of Beijing streets.



Three of the speakers at the first session of the 16th IGES. From left to right: Graham Taylor (AEG President, CSIRO Australia, Xie Xuejing (Chairman of the 16th IGES, PRC), Arthur Darnley (GSC Canada).

Workshops

Five well-attended workshops were held prior to the symposium. Because these workshops will not be reported upon elsewhere, a brief summary of several is provided on the following pages.

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Information for Contributors to EXPLORE

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

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

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

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

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EXPLORE

Newsletter No. 81 OCTOBER 1993

PRESIDENT'S MESSAGE

I have just returned from the 16th International Geochemical Exploration Symposium (IGES) held in collaboration with the 5th Chinese Geochemical Exploration Symposium (GES) in Beijing, China. Although details are noted elsewhere in this issue of EXPLORE I would to again express my thanks to Professor Xie and his colleagues for organizing the technical sessions, workshops, field trips, social functions, and above all, a marvelous introduction to Chinese culture and cuisine. We all left with many rich memories of our visit.

The symposium was attended by many present and past members of Council and committees, including four of the present Regional Councillors. This enabled many informal discussions and one semi-formal "Council" meeting. As a result three issues, each previously discussed at length in Council, emerged.

The Association has to make membership more readily available to geochemists from developing countries. We received many enquiries about membership during the symposium, but the (US)$50 dues is beyond most of the members of developing countries. One former member from Nigeria was most apologetic that he had been unable to pay his dues since 1988. The Council is now sending the Journal of Geochemical Exploration (JGE) to libraries in a limited number of countries but many geochemists seldom are able to visit them. One suggestion was to have a reduced rate subscription for members in developing countries (as defined by the World Bank) which would entitle them to receive EXPLORE.

Environmental geochemistry is assuming a greater significance throughout the world and although exploration geochemistry is still very strong in many countries, there is no doubt that the future of The Association of Exploration Geochemists is dependent upon catering for the needs of both groups. Perhaps at this time, when we are about to enter negotiations with Elsevier Publishing Company for the JGE contract, greater emphasis on environmental geochemistry may be pertinent.

Our present six Regional Councillors cannot hope to

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President's Message

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publicize the AEG properly throughout the world. Again, it is time to look at appointing additional Councillors who can act as a focus for AEG activities in smaller areas. How can one Regional Councillor adequately cover South America and another Southern Africa? At present we are looking to appoint somebody in the United Kingdom, another in Hong Kong to cover SE Asia, and a third person to represent China. These appointments together with a possible reduced subscription rate will only serve to strengthen the Association and insure it's future.

Graham Taylor,
AEG President

NOTES FROM THE EDITOR

These notes are being prepared from a hotel room in the 21st Century Hotel, Beijing, PRC. The 16th IGES is now over and delegates are clamoring in the hotel lobby heading for the four corners of China as well as their respective home countries. In my opinion, the symposia represents a significant step forward, particularly if you consider that a few short years ago Westerners knew virtually nothing about the geochemical methods and practices in China and the Eastern block countries. We do, however, have a very long way to go. Although we are now talking regularly to one another, I do not believe that we have yet achieved technical communication. The problems are language and approach. At this point, it is simply too difficult to tell which of these two represents the greatest impediment.

For whatever reason, it seems the geological community has settled on the English language for international communication. This makes it relatively easy for native English-speakers to communicate amongst themselves, but significantly hinders effective communication between geologists of different native tongues. We all know that making a presentation to an international audience in your native tongue can be a terrifying experience; therefore, I can only imagine the trepidation felt by someone about to speak in a foreign tongue. Likewise, memories are fresh in my mind of straining to understand every word and decipher unfamiliar diagrams at presentations by non-native English presenters during the symposium in Beijing. Several sessions gave me a headache without the satisfaction of having fully understood what the speaker was trying to tell the audience.

In addition, the scientific communities of East and West have, in effect, evolved separately over the past half decade. The basic concepts of science in the West, such as scientific proof, peer review, objectivity, multiple working hypothesis and others are viewed differently or not considered in the East. Surely, Eastern scientists have a separate set of basic concepts which we in the West fail to appreciate. It would seem that the two separately evolving scientific communities would have must to gain from each other. Each would be unencumbered by the other's hang-ups, conventions and traditions. If we could take the best from both, we could make a quantum step forward; however, I am not certain that we are now able to understand each other well enough to find this common ground.

The answer? Continued dialogue. Symposia such as the 16th IGES will be important to bridge the gap, but written dialogue will probably be the most effective in the short term. Written communications are easier for us all to comprehend. We can ponder a particular point, examine data in our own way and otherwise gain a more complete understanding of each other's views. In my opinion, **EXPLORE** provides an excellent format for such exchange, in that **EXPLORE**:

1) accepts a wider range of views than refereed journals,

2) is read by geochemists and geologists around the world

3) is published in a timely manner (articles are normally published within three months of receipt), and

4) allows for timely exchange of views through letters to the editor or comments on previous articles.

EXPLORE has traditionally featured information from English-speaking geochemists; however, in keeping with the AEG's desire to become a more international association, we would like to particularly invite submissions from all geochemists around the world. **EXPLORE** sees this as a good way for us all to benefit from our mutual experiences.

Owen P. Lavin
Editor

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International Geochemical Mapping

The first workshop of the 16th IGES was chaired by Arthur Darnley of Canada and attended by some 30 registrants. The announced purpose of the workshop was to provide a status report on the progress of the International Geochemical Mapping project in greater detail than could be done in the main sessions of the Symposia. This was achieved in a reasonably satisfactory fashion within the 3.5 hours available.

Dr. Darnley explained how the work accomplished through the original IGCP project, No. 259, as being summarized for publication as a report entitled "A Global Geochemical Database, Recommendations for International Geochemical Mapping", and how implementation of these recommendations, on an experimental basis, under a new IGCP project (no. 360) called Global Geochemical Baselines. Agnete Steenfelt, of Denmark, leader of the project's technical committee on field methods reviewed the recommendations on this topic; Xie Xuejing (China) presented his committee's recommendations on analytical methods; Arthur Darnley (Canada) spoke on the recommendations for gamma ray surveys for radioelements; Alf Bjorklund (Finland) summarized the approach to be taken for global sampling and Nils Gustavsson (Finland) covered the data management recommendations. Copies of the five-page executive summary of the draft report were distributed to participants. Pertinent questions and comments were made from the floor, particularly by Australian attendees. The morning concluded with a short talk by Professor Xie on the current wide-spaced

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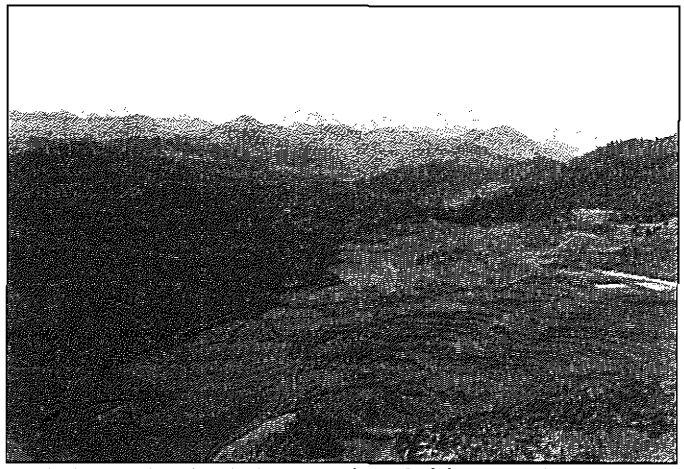
geochemical sampling program now being conducted in China by the Ministry of Geology and Mineral Reserves. This is to supplement and confirm the results of the earlier wide-spaced regolith sampling carried out by Chinese environmental agencies. It is this work which has done most to transform the concept of wide-spaced sampling from controversial speculation to reality.

Arthur Darnley
Geological Survey of Canada
Ottawa, ON, CANADA

Analytical Methods in Exploration Geochemistry

The workshop on Analytical Methods in Exploration Geochemistry was led by Gwendy Hall of the Geological Survey of Canada. She outlined the strengths and weaknesses of the major analytical techniques used in North American and Australian laboratories, focussing on ICP-MS, ICP-ES, INAA, XRF, and AAS. Particular attention was paid to sample decomposition, bearing in mind that an analysis is only as good as the preparation and dissolution procedures employed, regardless of the degree of sophistication of the measurement technique itself. The discussion on the diagnostic capabilities of selective extractions led into the presentation by J. Robert Clark of Activation Laboratories, Canada, who described the enzyme leach approach, currently



Typical terracing in drainage basins, Guizhou Province, PRC. A complication to stream and soil surveys?

creating much interest in the exploration industry. This self-limiting leach is designed to extract cations and anions scavenged by amorphous manganese dioxide coatings as distinct from those held within crystalline lattices/ minerals in the overburden. Significant anomalies in B-horizon soil samples from various deposits in Nevada were highlighted. David Garnett of Becquerel Labs in Australia demonstrated the vast amount of information to be gained from the cost-effective 'Au + 33' INAA package which developed in the 80's, particularly in the association of Au with elements such as Hf. Continuing on the gold theme, Hank Blok of Chemex Labs in Vancouver described progress made in the 'mini lead fire assay' procedure where only partial cupellation is carried out to give a lead button of only about 100 mg mass which can be dissolved easily for the determination of Au, Pt, Pd, and Rh. The retention of other PGE's, otherwise lost in complete cupellation or not collected in Ag, remains to be investigated. Finally, Lin Yunan of the Zhengzhou Institute in China described their techniques of Pb fire assay combined with emission spectrography for determination of Au, Pt, and Pd to limits as low as 0.1 -0.2 ppb. These improvements were attained largely by implementation of a procedure to 'clean-up' / purify the flux. See the next issue of **EXPLORE** for the recipe!

G.E.M. Hall
Geological Survey of Canada
Ottawa, ON, CANADA

Applied Biogeochemical Exploration

Approximately 35 people attended this half-day workshop led by Colin Dunn and Gwendy Hall from the Geological Survey of Canada (GSC). Invited speakers from China, Japan, Russia, United States, and Australia gave presentations on developments in their respective countries.

Colin Dunn set the scene with an overview of biogeochemical applications and methods under various climatic and environmental conditions, detailing procedures that are essential for conducting successful biogeochemical surveys.

Analytical methods were discussed only briefly by Gwendy Hall as she had just given a detailed presentation to many of the participants who had attended the Analytical

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Methods Workshop given earlier that day. It appeared that INAA and ICP-ES remain the preferred analytical methods. Li Guohui (China) followed with an account of some instrumentation developed for the direct XRF analysis of 3 gram pellets of powdered vegetation for 25 elements.

The "Case History and Developments" session began with an account by Yoshiyuki Kita (Japan) of investigations conducted throughout Japan over the past five years. The Japanese experience is that INAA dry tissue analyses of 10 gram samples of leaves of several species can effectively be used to outline zones of Au, As, and Sb.

Since very little information concerning developments in China has been released, an account by Gao Ping was of particular interest. It appears that the first studies, done in the 1950's, were related to the recognition of indicator plants for Cu. Systematic biogeochemical studies began in the 1970's, and over the past decade the focus has been mostly on the search for deeply buried mineralization in arid regions. Sagebrush has proved successful in outlining Ag-Pb-Zn mineralization concealed by as much as 20 meters of aeolian sand in the semi-arid grasslands of Inner Mongolia. Elsewhere Cu-Ni ore that subcrops beneath 80 meters of cover can be delineated by subtle enrichments of As, Sb, Bi, Co, Cr, Ni, and Cu. In a third study the outline of Pb-Zn stratabound deposits beneath more than 100 meters of loess and 100 meters of redbeds could be traced from the analysis of willow twigs. Factor analysis showed that P,K, and S (with As and Ba) is the element suite that best outlines the mineralization. The Chinese consider that their biogeochemical activities are still in the experimental stage.

Jim Erdman (USGS) kept his presentation short to give time for speakers from Russia and Australia. The main activities in the United States in recent years have centered upon the arid regions of the west and midwest, where sagebrush has been used extensively. However, over the past three years the main sample preparation laboratories have received a reduction in the numbers of samples submitted, commensurate with the general reduction in exploration activities.

As is the case in China, biogeochemical studies in Australia are mostly in their early stages of development because of complexities involving the many species that occur of the two most common plants — eucalypti and acacias. David Cohen (Australia) presented results of some studies done in Queensland over Au, Zn, and Cu mineralization. Anomalies are mostly subtle, but they provide a broader exploration target than that obtained from soil analyses. Some basic research on seasonal variations in plant chemistry indicate that changes are similar to those found in colder climates.

The Russian experience in biogeochemical exploration is much greater than that of anywhere else in the world. The leading proponent for many years has been Alexander Kovaleskii who has published many papers and books on the subject, including a recent text in Russian (Biogeochemistry of Plants) which has not yet been translated. In his presentation Dr. Kovaleskii gave an account of some extremely detailed surveys for Ag, using rotted pine stumps that have been found to very clearly delineate zones of Ag mineralization. He reported that investigations are now significantly detailed to be able to predict ore grade for silver. Molybdenum and PGE are other elements of current interest (with some biogeochemical success) which were briefly discussed.

Time ran out before a review of the coast-to-coast activities in Canada could be presented. There, surveys are being conducted at reconnaissance and detailed levels, by foot, road, helicopter (tree tops) , and sea (seaweed) to establish the media and techniques most appropriate for detecting a wide range of elements in differing climatic regions.

In summary, it appears that steady progress is being made, and that research and mining company experience continues to establish biogeochemical exploration as a viable option in many terranes. By the pursuit of investigations, increased insight into the problems and advantages of the methods is being gained. There was general agreement that the next stage of development should be the recognition of multi-element patterns that will assist in outlining zones of concealed mineralization.

Colin E. Dunn
Geological Survey of Canada
Ottawa, CANADA

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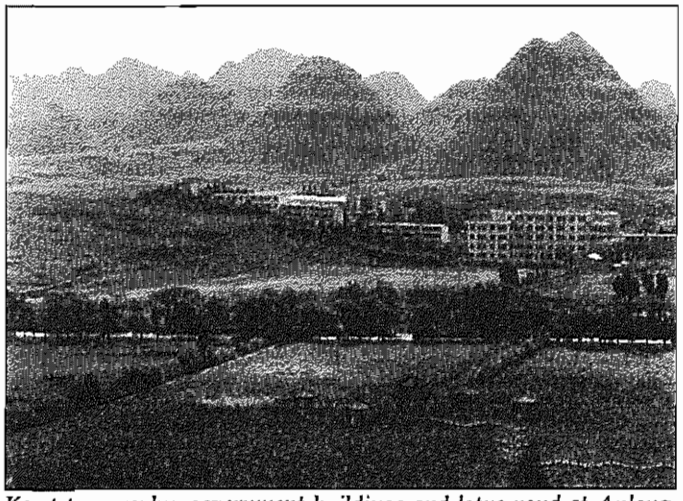

Karst topography, government buildings and lotus pond at Anlong, Guizhou Province, PRC.

Geochemical Prospecting for Gold

More than sixty individuals, including invited speakers from around the world, attended the Geochemical Prospecting for Gold workshop chaired by Ian Nichol of Canada.

In his introduction, Ian drew attention to the unique characteristics of gold that often make obtaining a representative sample difficult. Superimposed on these problems, variations in the behavior of gold in the secondary environment were cited as contributing to the development of varying gold dispersal trails.

Charles Butt of Australia reviewed the principle chemical complexes in which gold may occur in solution or as a precipitate. Charles continued by outlining the significance of regolith and landform evolution to gold exploration. The dispersion of gold has obviously varied according to past and present weathering conditions, which must be taken into account during all phases of a geochemical survey.

Richard Mazzucchelli described how geochemical techniques are now considered the most direct and cost effective methods of exploration in Australia. Richard cited two principle factors that make geochemistry particularly effective: 1) the redistribution of primary gold into very fine-grained particles during deep lateritic weathering, and 2) the high chemical mobility of gold under the present saline arid conditions, especially in the Yilgarn Block of Western Australia.

Hubert Zeegers of France emphasized the outstanding role geochemical exploration has played in the search for gold deposits in a variety of geological and surface environments, but emphasized that the best chances of success require consideration of the dispersal characteristics of each individual area. Of particular importance, Hubert described the distinction between mechanical and chemical dispersal and the quantitative relation between secondary dispersal patterns and primary mineralization.

Shigeaki Tomita described the United Nations Revolving Fund for Natural Resources Exploration activities involving the search for gold deposits in Africa and South America and the need for the adoption of appropriate search techniques.

Xie Xuejing drew attention to the Chinese experience with the detection of low-order anomalies attributable to fine-grained gold particles. The approach has involved: 1) collection of conventional-sized samples, 2) analysis of minus 80 mesh (177 μm) fraction, pulverized to 200 mesh (75 μm), 3) gold determination by an analytical method with a detection limit of 0.2 ppb, and 4) delineation of regional, low-level (4-8 ppb) anomalies rather than individual high samples. This approach was cited as having lead to the discovery of hundreds of gold occurrences.

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Owen Lavin drew attention to the wide range of exploration environments within the prospective areas of the Western United States. Rock chip sampling of altered rocks is a common practice with encouragement being drawn from anomalous gold and/or pathfinder elements. The varying role of soil, stream sediment, biological and gas samples in gold exploration was discussed with regard to weathering history, topography, present climate and sample types available.

Tawsaporn Nuchanong described the wide variation of gold particle sizes associated with gold deposits in Thailand and stressed the requirement that exploration programmes be designed and executed to detect gold grains of variable sizes.

Kay Fletcher of Canada drew attention to the marked variation of gold contents according to sedimentological environment within a stream. The accumulation of gold at high energy sites has been widely recognized, but care must be taken in the interpretation of such anomalies because gold concentrations frequently increase downstream. On this basis, although anomaly contrast is much lower, sampling at low energy sites may provide a more reliable indicator of an anomaly source.

Alf Bjorklund of Finland drew attention to the relatively recent recognition of the gold potential of Fennoscandia. In areas of supracrustal rocks, exploration focus has centered on heavy mineral counting and analyses of the fine-grained fraction of stream sediments, whereas over the Fenno-scandian Shield, till sampling has been preferred. In regional geochemistry, the analyses of the fine-grained fraction (<63 μm) of till has been undertaken with a highly sensitive analytical procedure.

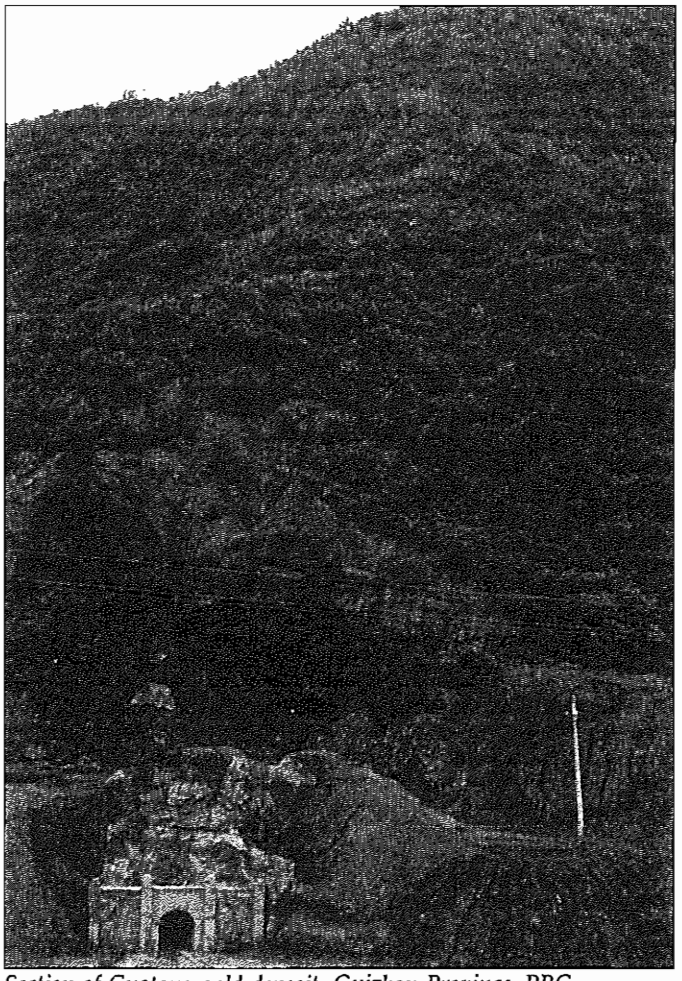
Bob Garrett, in describing Geochemical Exploration for gold using glacial till in Canada, first drew attention to the problems facing exploration in such areas due to scarcity of outcrop and variable thickness and character of glacial drift. Recently, a better understanding of glacial till and the increased use of till geochemistry has resulted in the discovery of several ore deposits.

Zhou Xiaodong described the occurrence of very fine-grained gold in till derived from mineralization in Canada and the delineation of a dispersal train of gold in the minus 177 μm fraction. These patterns only become apparent when a sensitive analytical procedure is used.

Gwendy Hall of Canada described the capabilities of a range of currently available analytical procedures for gold analysis. She also pointed out the role and performance of ultra-sensitive procedures for the determination of low-level gold in a Round Robin test.

In the final presentation, Lu Yinxiu of China described and demonstrated a rapid field method for gold and some indicator elements. The procedure involves the extraction of gold by sodium bromide, sulfuric acid and hydrogen peroxide, followed by concentration by polyurethane foam and, after desorption, estimation by spectrometer. The procedure has a detection range of 0.5 to 50 ppb and a production capacity of eighty samples per day.

The presentations covered a wide range of topics associated with geochemical exploration in the search for gold deposits in a wide variety of surface environments. Very clearly, research efforts to increase the confidence that can be placed in geochemical procedures is having marked success with respect to sampling strategies, sample processing, analytical methods and understanding the significance of the resulting data by meaningful interpretation.



Section of Guotang gold deposit, Guizhou Province, PRC.

The information presented raised some interesting

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discussion and the considerable effort put into the presentations was gratefully acknowledged by all participants.

Ian Nichol
Queen's University
Kingston, Ontario Canada

Technical Sessions

A total 10 sessions were held over the three days of the symposia:

1. Geochemical Exploration for Gold and Other Precious Metals (two half-day sessions).
2. Environmental and Agricultural Geochemistry (two half-day sessions).
3. Integrated methods in Exploration and Discovery (half-day)
4. Regional Geochemistry and International Mapping (3/4 day)
5. Data processing and interpretation of Geochemical Data (half-day).
6. Analytical techniques (half-day)
7. Geochemical exploration for blind and buried ores (half-day)
8. Geochemical exploration for oil, gas and geothermal fields (half day).

Details of the presentations can be found in the 164-page *Abstracts volume which was distributed at the beginning of* the meeting. In addition to the technical presentations, perhaps one of the most significant contribution of the technical sessions was that they provided many of the Chinese delegates, particularly the younger ones, with their first look at how western geochemists carry out their work, interpret their data and display the results for others to evaluate. Likewise, western geochemists had their first opportunity to examine and delve deeply into the practices of Chinese geochemists.

Poster Session and Commercial Area

A large room was set aside at the conference center with posters in the middle of the room and commercial booths around the perimeter. The posters were well attended and generated much discussion. The posters were particularly useful when the author(s) and/or audience were not native English-speaking. One could dwell on a particular point until satisfied, before proceeding.

A few Chinese companies maintained commercial booths and the Chinese Department of Geology and Mineral Resources displayed an impressive array of mineral specimens for sale. Rounding out the commercial area was Chemex (Canada), Actlabs (Canada) and the AEG.

Field Excursions

All but one of the field excursions was scheduled for after the symposia. At the time of this writing, eager looking groups are assembling in the lobby of the 21st Century Hotel for busses and planes to places like Tibet, Inner Mongolia, and Xian.

The only pre-symposia field trip took 12 registrants to Guizhou province in south central China were they visited some intriguing gold deposits. In addition to the geological points of interest, participants were exposed, first hand, to one of the more remote rural areas of China, thus seeing what few westerners have ever seen. Participants were also exposed to the difficulties of transportation in this area during the rainy season; however, their determined tour guides were able to overcome all but the most formidable obstacles. All-in-all, it was an experience never to be forgotten.

Social Program

With a location rich in custom and history, such as Beijing, it is not surprising that many delegates arranged to have their spouses accompany them. The local tour company arranged for trips to the world famous attractions of the area, and on a free day between the workshops and the IGES, participants scattered into the local environment. Nearly everyone visited the Great Wall, which turns out to be a significant physical feat, just to ascend. The Forbidden City and Tian'anmen Square were equally popular attractions. Many delegates also learned how to catch an inexpensive taxi to down-town Beijing for new shopping and eating experiences.

Concluding Remarks

Like any symposia the 16th IGES had its rough points; however, all should agree that courage and efforts shown by our Chinese hosts made this first-ever Chinese symposia a memorable event. Special recognition should be given to the following:

Xie, Xuejing	General Chairman
Zhu, Xun	Minister of MGRM and Honorary Chairman
Lue, Su and Xia, Guozhi	Steering committee co-chairmen
Lin, Cunshan	Organizing committee chairman
Zheng, Kangle	Technical committee chairman

Anyone attending the symposia would have noticed the special efforts extended by: Professor Xie's students, Zhu Lixin, Yan Guangsheng, Chang Hangxin, and Li Weitian, among others as well by Xu Li, William White, and Tracy Schupp. Our thanks to all.

Owen Lavin
Editor

Photos by Steve Garwin

TECHNICAL NOTES

Another Cry from the Heart

Oooo..oh! Here we go again. Still at the same desk as last time (Garrett, 1989a) reviewing yet another submission to the Journal. You may ask, "what has got under his skin now?", well two things. Firstly, people carrying out multivariate statistical procedures, which they clearly do not fully understand, with far too few samples for the number of variables/elements measured; and secondly, the failure to use even the most simple of robust procedures in order to minimize the effects of outliers or anomalies when trying to describe/estimate the geochemical background statistically.

"Grief, what is he on about — this is a geochemical newsletter." Well, the problem is that it has become too easy to misuse the statistical software we can all buy for the PC. For the most part, these packages assume that the user knows what is going on, and has a knowledge of the underpinnings and assumptions of the statistical procedures. Unfortunately this is not always so, which permits the enthusiast to quickly break "the rules" and produce results, or come to conclusions, that are meaningless. So perhaps a few reminders are in place.

How many samples do I need?

How many geochemical samples should one have for a specified number of measurements if one is going to use traditional multivariate statistical procedures? In the past this was not a problem, some 10 years ago it was unusual to have data above detection limit for more than 15 elements, and most studies were sufficiently large that problems were not encountered. However, the advent of widely-available multi-element INAA and ICP-ES packages has provided data above the detection limits for 30 to 50 elements.

For a moment, let's go back to the basics. Many of the multivariate procedures used by applied geochemists, like regression and discriminant analysis, principal components, canonical variates and some forms of cluster analysis, start from the computation of a covariance matrix. The covariance matrix is one step back mathematically from the correlation matrix we are all familiar with, and its computation is critical. If it is not a good stable estimate everything that follows is a house-of-cards. What is meant by a "good stable estimate"? Imagine an elliptical (5:1 major:minor axis) cloud of 100 points on an x-y plot; the trend and correlation are obvious. The smallest number of individuals that could be used to estimate the covariance and correlation would be 2, and the result would be meaningless. The correlation coefficient would be ± 1 and the trend could be anywhere from the true one to 90° in error. Clearly with the number of variables, p, equal 2 and the number of cases, n, equal 2, i.e., n = p, the estimate is not reliable.

This is known as the "dimensionality" problem to statisticians, who also refer to it as the "curse of dimensionality." As the number of variables, p, increase so must the data set size, n, and with it the costs of sampling and measurement/analysis, if reliable results are to be obtained.

Obviously what would be ideal would be a rule of thumb, that indicated how many times greater n should be than p. The first proposal in the geochemical literature was made by Howarth and Martin (1979). They noted, "The number of samples needed to reliably estimate the multivariate correlation matrix should preferably be at least 10 times the number of elements involved." This recommendation was derived from Trochimczyk and Chayes (1977), whose work with 9 variable subsets of various sizes from a 2086 member data set indicated a marked improvement in stability when n was increased from approximately 5p to 10p. It is worth noting that the simulated data sets were closed, i.e. had a constant sum, and that fact may well have had an influence on the result. It was not until the early 1980's that a satisfactory solution to the constant sum problem, i.e., as some correlation coefficients go positive, some must go negative, was found by Aitchison (1981; 1984a, b; 1986). In Howarth and Sinding-Larsen (1983) the recommendation was relaxed thus, "... the ratio of sample size to number of measurements should be at least three, ...", and the authors added the still important note, "Obviously, reduction of the dimensionality of the problem by using only those (elements) which are good geochemical discriminators between the classes of interest will also be helpful".

Statisticians have worked on the dimensionality problem for many years and there is still no clear resolution. Some of the early work that influenced Howarth's studies on pattern recognition applied to exploration geochemistry was by Foley (1971; 1972). Foley showed that once n > 3p was exceeded the expected error rate in the classification problems he was studying improved only slowly. From this, one can infer that the covariance matrices underlying his procedure were reaching some useful level of stability once n exceeded 3p (Jain and Chandrasekaran, 1982). Subsequently, Mehotra (1973) studied more complex classification situations where the shape and attitude of the data clouds in the variable space were unlike each other. In such cases n should exceed 5p for the error rate to be acceptably small. It is interesting to note that Young (1978) interprets the Foley (1972) paper to indicate that n should exceed 5p. Young investigated this same problem in terms of tolerance intervals associated with classification and showed that accepting a 10 % tolerance n should exceed p by 16.5 for p = 4, by 12.4 for p = 16, and by 11.2 for p = 128. In contrast a 100% tolerance interval leads to values of n between 2p and 3p. From this we could conclude that 3p might be acceptable as a bare minimum, but that 10p would be far more prudent. Later work by Fukunaga and Hayes (1989) led to results that were generally

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similar for low dimensionality, but required a greater sample size for higher stated dimensionality. They noted, "(that their results) ... sharply contrasted with the common belief that a fixed multiple of the dimensionality such as 5 or 10 could be used to determine sample size". The situation has been summed up succinctly by Kanal and Chandrasekaran (1971) and Kanal (1974), "... the less is known about the underlying probability structure, the larger the ratio of sample size to dimensionality".

Work in robust multivariate statistics, rather than pattern recognition, has taken a somewhat different approach. Devlin et al. (1981) recognizing that desirable data set size was a function of the number of variables used n = 8p in a series of simulation experiments. Bringing us up to date, Woodruff and Rocke (1993) state, "The trade-off here is that small subsamples can lead to very unstable shape (covariance) estimates ...". They continue by noting that the problem is one of selecting a subsample size when there are outliers and suggesting for their application that subsets from a data set of size n should exceed (n+p+1)/2, within the constraint that n > p.

Thus 20 years of work by the statistical and pattern recognition community has not brought forth a simple formula for the applied geochemist to use. In applied geochemistry when financially important decisions or significant genetic conclusions may be drawn from the data analysis it is prudent to err on the conservative side. Thus, Howarth and Sinding-Larsen's recommendation still stands firm, i.e., as a bare minimum n should exceed 3p. This may be extended to note that n in excess of 5p is desirable, and once n exceeds 10p stability should be close, if not already achieved. As a postscript, it should be remembered that as the data structures become more complex, i.e., different and divergent shapes, it is prudent to increase n relative to p; which brings us back towards the original Howarth and Martin (1979) proposal that n should exceed 10p.

Finally, what this indicates is that we should not just be "throwing" all of today's multi-element data into multivariate procedures. Some multivariate procedures are predicated on the assumption that the data are drawn from a single multivariate population, e.g., regression analysis, and others are more exploratory in nature and forgiving, e.g., principal components and some forms of cluster analysis. There are benefits to be had from carefully inspecting the data sets and selecting only those variables (elements) that contain appropriate information for the subsequent analysis. In general, for regression studies the data should be approximately normal and not contain outliers (anomalies) if the objective is to model background processes. In fact, studies using regression analysis to model background variation patterns usually benefit if suspected anomalous individuals are excluded from the statistical modelling. However, they are included when residuals are computed for each individual samples. The effect of this is twofold, the background model is improved and the residuals for the anomalous sample are larger, making them easier to recognize. For exploratory and structural studies, variables

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that do not exhibit a simple bell-shaped distribution, but are polymodal or skewed, and pairs and triplets of variables that show interesting data structure when viewed graphically, will be more helpful. Thus even with sophisticated multivariate tools at our disposal there is a need for thorough preliminary exploratory data analysis.

Robust procedures, why should I be using them?

What are they? Simply stated, robust procedures are statistical methods that do not yield wildly incorrect estimates when either the statistical assumptions of the *methods, e.g., the requirements for normality and homo*geneity of variance (heteroscedasticity), are not strictly met, or a reasonable number of outliers (anomalies) are included in the data set.

What are outliers? An outlier to a statistician is an individual drawn from some other statistical population than the one being investigated. The most common statistical populations in applied geochemistry are background populations. It may be possible to combine the different background populations relating to different geochemical landscapes, i.e., different source rocks and weathering environments, in a study area and treat them as a single population. This is convenient, and can save time and effort. However, *it should be proven that they are generally similar* enough in the context of the problem being studied to warrant combination before it is carried out.

When the dominant population is background, outliers will be individuals related to other processes, e.g., anomalies related to mineral occurrences, sample preparation or analytical hiccups, etc. As geochemists we recognize anomalies, statistical outliers, in two general ways. Firstly, when plotted on a map they exhibit notably different values from other nearby samples; and secondly, when compared statistically with the remaining data they occur a notable statistical distance from the main mass of that data. You will note that I am avoiding the word "significant", it has a very specific *statistical meaning, and that is an area which I do* not wish to pursue here.

Clearly, if we wish to estimate the statistical properties (location and spread through the use of mean and standard deviation etc.) of background data sets we do not wish to permit non-background individuals, i.e., outliers or anomalies, to influence those estimates.

Most of us have at one time compared the arithmetic and geometric means and the medians of geochemical data sets (size = n). In the common case one or more high values, i.e., a reasonable number, m, of outliers (m < n/2-1), will have the effect of elevating the arithmetic mean relative to the geometric mean, and both will be high relative to the median. *Those high values can be replaced with* any value at all greater than the median and the median will not change. Both means will change, the arithmetic mean more than the geometric mean. Now which is the most stable estimator of the central location of the data and representative of background? I suggest it is the median. It can be argued from a theoretical statistics point of view that the median is less "efficient" than the mean. That is true for a perfect normal distribution, but when did you last see one of those in your applied geochemical data? In general, the data sets applied geochemists work with are both large and non-normal enough to make the median the preferred estimator of average background.

Spread is usually estimated by the standard deviation. In a perfect normal distribution the standard deviation can be computed from the Inter-Quartile Range (IQR) as IQRx0.7413. In terms of the percentiles the upper and lower quartiles are equivalent to the 75th and 25th percentiles. Again as with the mean, the estimate of standard deviation can be distorted by including outliers in the data set, if the objective is to estimate the spread of the background population, a way has to be found to diminish their effects. As with the median, they can be eliminated entirely by estimating the standard deviation from the middle 50% of the data via the Inter-Quartile Range, so long as the there are no more then n/4-1 outliers beyond either the upper or lower quartile.

Various weighting procedures have also been proposed that diminish the effects of outliers, these do not seem to have been used frequently by applied geochemists even though they have been available for several years (Garrett et al., 1980). Rocke et al. (1982) provide an excellent discussion on the merits of using robust estimators in the engineering and natural sciences. The authors conclude that there are no good reasons not to use robust estimates in areas of science similar to geochemistry. The whole matter of outliers is discussed by Beckman and Cooke (1983), and is regarded as a classic paper on the topic.

The use of the rank statistics as described above provides two very simple robust procedures that will diminish the effects of outliers in estimating summary statistics that describe the background population(s). In fact, a most useful summary is simply to quote in a table together with the data set size, n, the minimum, 5th, 25th, 50th (median), 75th, 95th percentiles, and maximum values. Location and spread is readily apparent from the table, and the skewness of the data *across the distribution can be appreciated by the amount the* value pairs, 25th-75th percentiles, 5th-95th percentiles and minimum-maximum are asymmetric about the median.

Extending to robust estimates of correlation is far more complex (Devlin et al., 1981). The problem as it occurs in applied geochemistry has been studied by Garrett (1989b, c), Chork (1990), and Chork and Rousseeuw (1992) using two

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different approaches. In connection with univariate summary statistics the phrase, "a reasonable number of outliers," has been used. Clearly there comes a point when there are so many "outliers" that the statistical procedure no longer works in the way that is desired. Statisticians refer to this as the breakdown point (Donoho and Huber, 1983). The multivariate trimming (MVT) procedure investigated by Garrett has a lower breakdown point (i.e., can tolerate fewer outliers) than the minimum volume ellipsoid (MVE) procedure studied by Chork (1992). However, while MVE is excellent for small data sets, for large data sets it becomes extremely computer intensive (Woodruff and Rocke, 1993) and is unsuitable for large data sets such as regional surveys.

Readers who are interested in this should pursue the matter through the citations noted above, and the help of a professional data analyst/statistician. However, here are some hints if you do follow-up on robust estimation of covariance and correlation.

If correlation is the point of interest, investigate the use of Spearman rank correlation coefficients. Instead of estimating the extent of any linear relationship, as does the Pearson product-moment correlation coefficient, the Spearman measures monotonic relationships. That is, value pairs that increase or decrease together sympathetically with no requirement for linearity. Most statistical packages provide both types, you just have to know which one to compute. In terms of applied geochemistry the Spearman is probably a wiser choice, as we are interested in any systematic relationships, not just linear ones. The problem is that computing Spearman coefficients for large (both n and p) data sets takes time even on today's fast computers. The reason is that the procedure is non-parametric and computationally intensive, requiring a lot of data sorting and comparison.

In estimating a robust covariance matrix, on the way to a Pearson correlation coefficient or multivariate procedure, one might be tempted to simply remove the extreme high and low values for each variable/element in a data set and then use the data that remain. This procedure is not recommended as it has two serious problems.

Firstly, the samples comprising the extreme few percent (e.g., < 5 and > 95 percentile - a 10% trim), potential outliers, will not be the same for all variables/elements. Thus far more than the stated percent will be removed from the starting data set by the time all the variables/elements have been treated. This reduces the data set size, and perhaps starts to arouse dimensionality concerns, i.e., $n < 3p$.

Secondly, it has the effect of *sphericizing* the data and destroying the very structure being investigated. Figure 1 depicts a three-dimensional ellipsoidal data set with a tetragonal prism, whose sides are defined by variable percentile values, placed over the data. By trimming the extreme variable values the data cloud is cut back to lie within the prism. However, unusual off-ellipsoidal individuals that lie within the extreme-value prism will not

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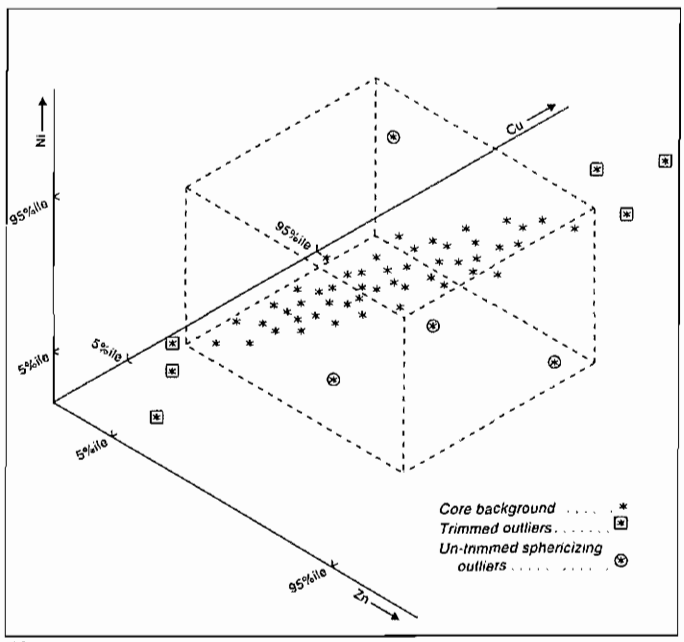

Figure 1.

be trimmed away. The result is to make the data cloud more spherical, and so destroy the linear structure/shape that we are trying to quantify.

Thus, as attractively simple as the variable/element wise trimming may seem it is not a good procedure to follow. What is required is a trimming envelope that is not parallel to the variable axes but is aligned with the data cloud. The MVT procedure used by Devlin et al. (1981) and Garrett (1989b) achieves this by computing an initial covariance matrix for all the data and trimming a stated percentage of the most extreme points (Mahalanobis distances, D^2, the multivariate analogue of univariate z-scores or Standard Normal Deviates) from the centre of the data cloud. The reduced size (trimmed) data set is then used as a basis for a more incisive graphical analysis and trimming of the initial total data set (Garrett, 1989b). The MVE procedure gets around the problem by looking at many different subsets of the data, which may or may not contain the outliers contaminating the background population(s). However, as pointed out above, as n increases in the computationally intensive MVE procedure solution times become large.

Finale

Well once again I have got this stuff off my chest. Hopefully it will be of interest to those of you who wish to use data analytical and statistical procedures to try and get the most out of your data. I am afraid I do not have any easy answers, just warnings and ideas on how to approach the problems, and things to watch for. The most important point is to be aware of the minefield one is walking through, and make others aware of the risks you are taking and assumptions you are making in your work.

Do not let me discourage you from using the computer software we now have access to. I just ask that you use it carefully, and recognize the rules of the statistical road. An excellent start is to inspect the probability plots for each variable, they contain a great deal of information that can indicate if outliers are present (high or low) and if the data are polymodal. Statisticians, and many statistical packages, prepare these in such a way that every point is plotted, not summaries based on histogram bins as many geologists have used in the past. These detailed plots are called by a variety of names in different commercial packages, e.g., normal probability plots, normal quantile plots, p-plots, etc. Outliers can be quickly identified by listing the values and sample numbers of the highest k values recognized as interesting from the probability plot. Then the geochemist can consider the significance of those individuals, plot them on maps, etc., and if there is to be a subsequent "statistical" step, whether they should be left in the data set or set aside. It should be remembered that there is no rule that says the data set being interpreted should be kept as one. The objective is to interpret the data, explain in geochemical terms why it is the way it is. Once a part of the data set is explained there is absolutely no reason why it has to be left with the remaining, as yet unexplained data. In fact, the continued inclusion of such obviously different data can make it difficult to resolve the finer more subtle features that remain. That is intelligent, thinking, geochemical data analysis.

Then maybe I, and other Journal reviewers, will not have to reject so many papers; not because of their geochemical content, but because they are terrible examples of thoughtless and mindless data analysis that should never see the light of the published page.

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STEVEN AUGUST MORENO

Steve Moreno of Conifer, Colorado died on September 13, 1993. He was 39.

Steve's professional career began in 1976 at Cities Service where his computer talents were first recognized. At Houston International Minerals (HIMCO) he developed the first-of-its-kind mainframe geochemical data retrieval system that sent data directly from the lab to the geologist in the field. Steve's original "HIMCO format" is still used today. At Barringer Research he created LIMS (Laboratory Information Management System) that continues to service Barringer's several analytical laboratories. He also developed leading edge remote sensing and geopositioning systems that were first used in Zambia and Jordan. During the past two years he worked in remote sensing for the Ministry of Defense in Saudi Arabia.

In addition to his contributions to the geosciences, Steve will be remembered for his enthusiasm and determination to excel at whatever task lay before him.

Steve is survived by his wife, Joanna, two sons, Ross and Malcolm, of Conifer, and his mother, Dorothy E. Moreno of Las Vegas, Nevada.

Shea Clark Smith

CALL FOR NOMINATIONS

The Association of Exploration Geochemists periodically awards two medals (history of the Medals and guidelines for their award are published in **EXPLORE** 75, April 1992):

The **Gold Medal** to be awarded to a person for outstanding scientific achievement in exploration geochemistry, and

The **Past President's Medal**, to be awarded to a member of the Association of Exploration Geochemists for dedicated service to the Association.

The Awards Committee is now seeking nominations for the award of these medal in 1994. Acceptable nominations shall include the following:

(a) A letter of nomination, which must be signed by a minimum of four Fellow members;

(b) A resume or curriculum vitae of the nominee;

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Call for Nominations

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(c) An itemized list of the outstanding scientific achievements (Gold Medal) or the dedicated service to the Association (Past President's Medal) of the nominee;
(d) Other pertinent documentation relevant to the achievements and/or qualifications of the nominee may include endorsements from other individuals whether or not Fellow members of the Association.

Since members of the Awards Committee may not have personal knowledge of the nominee, the completeness and quality of the nomination will be critical in evaluation and selection.

Nominations should be sent to: Jeffrey A. Jaacks, 7013 South Quince Circle, Englewood, Colorado 80112, USA
TEL: 303-220-0932 • FAX: 303-220-0932

HANDBOOK OF EXPLORATION GEOCHEMISTRY

Many members have ordered the new Handbook of Exploration Geochemistry Volumes 4 and 5 from the Association at a 40% discount and some may have received a somewhat confusing invoice from Elsevier. This is only a confirmation receipt of the order and NOT A BILL. All the orders received by the Association before the September deadline were sent to Elsevier as a group in September along with a check for full payment. You should be receiving your volumes shortly. Please accept our apologies for the delay and the confusion with the invoices.

JGE VOLUME 49

Issues number 1 and 2 of Volume 49 of the Journal of Geochemical Exploration will be published as a special issue on Geochemical Mapping, edited by Peter Davenport. This special issue is expected to be ready for distribution in December 1993.

BIOGEOCHEMICAL SHORT COURSE

29/30 NOVEMBER, 1993

The Association of Exploration Geochemists will be sponsoring a two day short course preceding and in conjunction with the upcoming 99th Annual Meeting of the **Northwest Mining Association** at the **Sheraton Hotel in Spokane, Washington State.**

APPLIED BIOGEOCHEMICAL PROSPECTING IN FORESTED TERRAIN

Instructors: *Colin E. Dunn (Geological Survey of Canada)*
Gwendy E.M. Hall (Geological Survey of Canada)
Robert K. Scagel
(Pacific Phytometric Consultants)

Course Outline

1. Introduction (30 mins.)
An introductory session will outline the scope of biogeochemistry in exploration, with a brief history of its development, and the rationale for its application in the exploration environment.

2. Trees and Shrubs (2 hrs)
a) Plant components and element uptake mechanisms will be discussed. These will include such questions as:
How does plant development affect metal uptake?
What are plants made of?
How do minerals get into plants?
What limits element uptake?
Why do different plant species accumulate different elements?
What are minerals *doing* in plants?

b) A second 'basic botany' session will focus upon those aspects of plant physiology that are relevant to biogeochemical processes (e.g. element accumulation; dose/response; active and passive uptake; translocation).

Tree identification will be discussed, limited to those species of importance to biogeochemical exploration. The concept and distribution of biogeoclimatic zones will be introduced.

3. Basic Principles and Protocols in Biogeochemical Prospecting (1 hr)
What to sample and why; when to sample; how to sample; sampling precautions; reconnaissance v. detailed sampling.

4. Sample Preparation and Analysis (2 hrs)
Washing; drying; separating tissues; macerating/pulverizing; ashing.
An outline will be given of the major analytical techniques employed in determining inorganic chemical components of vegetation. This will include a description of the analytical 'black boxes' and how they work. The principles and capabilities of ICP emission spectrometry, ICP mass spectrometry, atomic absorbtion spectrometry and

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Biogeochemical Short Course

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instrumental neutron activation analysis will be reviewed. Methods by which both dry and ashed vegetation are brought into solution for analysis by the three former techniques will be discussed and the benefits of selective leaching outlined. New directions currently being investigated in direct solid analysis, obviating the need for dissolution, will be presented.

5. 'The Real World' - Practical Application and Case History Studies (2 hrs - possibly longer to accommodate discussion and case histories of participants)
Case histories will be presented which deal with results obtained from surveys over zones of mineralization, including gold, platinum, uranium, base metals, rare metal pegmatites (Li, Rb, Cs, Ta), rare earth elements, and diamond-bearing kimberlite. Examples will be presented from the Pacific Northwest, and the northern and eastern forests of Canada. Surveys at detailed and reconnaissance levels will be discussed - both ground-based and airborne.

6. Data Interpretation (1 hr)
What do you do with all of the data, and how can you present it? This session will include a discussion of some simple statistical methods, and outline some more advanced procedures that may help in certain situations.

7. Tips, Tricks, Complications, and How to Avoid Some Pitfalls (30+ mins.)
A miscellany of odds and ends that might be encountered along the way.

The course format, supplemented by videotape to demonstrate techniques, will encourage participants to discuss their own surveys and geological problems.

Cost: US$300 (50% discount to full-time university students - the course is offered as a continuing education credit from East Washington University).

Further details can be obtained by calling:
Carla Snyder, NWMA Business Manager, at (509) 624-1158 [Fax. (509) 624-1241]

GEOANALYSIS 94

An International Symposium on the Analysis of Geological and Environmental Materials

18th - 22nd September 1994
Charlotte Mason Conference Centre Ambleside, England, UK.

In Association with the Geochemistry Group of the Mineralogical Society; the Atomic Spectroscopy Group of the Royal Society of Chemistry; the Society for Environmental Geochemistry and Health; the Association of Exploration Geochemistry

Introduction

Geoanalysis 94 will be an International Symposium covering all aspects of the analysis of geological and environmental samples, and follows the first highly successful symposium in this series, held in Huntsville, Canada in June 1990. Geoanalysis 94 is designed to attract international participation from scientists in universities, research institutes, commercial and industrial laboratories interested in any aspect of developments in analytical geochemistry. The scope of the symposium includes advances in bulk and microprobe analytical techniques (whether elemental or isotopic, for solids or fluids), reference materials and data quality. It is planned that sessions will be organised to cover the applications of geoanalysis in both geochemical research and environmental assessment. In addition, contributions will be particularly welcome on the themes of: field sampling and measurement, quality control and laboratory accreditation, reference materials for microanalysis, developments in techniques for isotopic analysis and geoanalytical techniques used in environmental applications.

Location

The Charlotte Mason Conference Centre in Ambleside lies in the heart of the English Lake District near to the shores of Lake Windermere. The purpose-built conference facilities offer both luxury bedrooms and more economical accommodation on site, all within easy walking distance of lecture theatres, dining areas and sports facilities. The nearest International airport is at Manchester and there are excellent travel links by road (M6 motorway) or rail (West Coast Main line to Oxenholme).

Milestone Dates

Second Circular available:	October 1993
Final Circular and application forms available:	January 1994
Deadline for the submission of abstracts:	31 March 1994
Deadline for registration at the discounted rate:	30 June 1994

Workshops/Field Trips

A number of pre- and post-symposium workshops and field trips designed in part to be of a tutorial nature and to cover specific aspects of geoanalysis are being planned. These events will be organised according to demand and it would be helpful if you would indicate your preference on the reply form.

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Geoanalysis 94

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(a) **Representative sampling of the Lake District Province:** A workshop to advance ideas in sampling coupled to a field excursion to selected localities in The Lake District to apply these concepts.

(b) **Quality Assurance and Laboratory Accreditation:** A workshop to discuss concepts and issues followed by a visit to selected commercial and research geoanalytical laboratories to see how these procedures are implemented.

(c) **Reference Materials - Preparation and Analysis:** A workshop followed by a field excursion to collect and plan the characterization of a new candidate reference material.

(d) **Statistics and Reference Material Data Sets:** A workshop for logical statisticians on the one hand and pragmatic empiricalists on the other to put their cases with a view to reaching a consensus.

(e) **Environmental Effect of Mining in the Lake District:** A field trip to evaluate role of sampling and analysis in assessing the environmental impact of disused mines in a National Park, which is a designated area of outstanding beauty.

(f) **Sellafield:** A visit to the nuclear reprocessing centre.

Accompanying persons programme

It is planned that an accompanying persons programme will be available to allow visitors to view the spectacular Lake District scenery and to visit places of interest associated with some of the famous inhabitants of the area, including William Wordsworth, John Ruskin and Beatrix Potter. Multilingual tutors with expertise in these literary areas can lead these tours if the demand is sufficient.

Please add me to the mailing list for the second circular:

Name: _____

Address: _____

Telephone: _____

Fax: _____

Offer of paper for oral/poster presentation (indicate first choice)

Provisional title: _____

_____

_____

Please indicate your interest in: Please check

Workshop/Field trip:
Representative sampling of the
Lake District Province . . . . . [ ]

Workshop/lab visits:
Quality Assurance and Laboratory Accreditation . . . . . [ ]

Workshop/Field trip:
Reference Materials - Preparation and Analysis . . . . . [ ]

Workshop:
Statistics and Reference Material Data Sets . . . . . [ ]

Field Trip:
Environmental effect of mining
in the Lake District . . . . . [ ]

Visit:
Sellafield Nuclear
Reprocessing Centre . . . . . [ ]

Accompanying persons programme:
Sightseeing only . . . . . [ ]
With literary tutors . . . . . [ ]

Further Information

To receive the Second Circular, please complete the attached form and return it to:

Mr. D.L. Miles
Analytical Geochemistry Group
British Geological Survey
Kingsley Dunham Centre
Keyworth
Nottingham NG12 5GG, UK.
TEL: 0602 363100, FAX: 0602 363200

National Organizing Committee:

Chair: Doug Miles (British Geological Survey, Keyworth); Vice Chair: Phil Potts (The Open University, Milton Keynes); Mark Cave (British Geological Survey, Keyworth); Simon Chenery (British Geological Survey, Keyworth); Anthony Cohen (University of Cambridge); Jenny Cook (British Geological Survey, Keyworth); Richard Hinton (University Of Edinburgh); Chris Jackson (Anamet Services, Avonmouth); Ian Jarvis (Kingston University, Kingston-on-Thames); Kym Jarvis (Royal Holloway, University of London); Susan Parry (Imperial College, University of London); Bill Perkins (University College of Wales, Aberystwyth); Mike Ramsey (Imperial College, London); Stephen Reed (University of Cambridge); Mike Thompson (Birkbeck College, University of London); Nick Walsh (Royal Holloway, University of London).

CALENDAR OF EVENTS

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

■Oct. 25-27, '93 Dredging and **placer mining** conference, Reno (Y.S. Kim, Nevada Institute of Technology, PO BOX 8894, Campus Station, Reno NV 89507 USA; TEL: (702)673-4466; FAX: (702)673-4386)

■Oct. 25-28, '93 Geological Society of America, Annual mtg., Boston, MA (V. George, GSA, Box 9140, Boulder CO 80301 USA; TEL: (303)447-2020)

■Oct. 25-26, '93 **Latin American Mining** mtg., Acapulco, Mexico (Randol International, 21578 Mountsfield Drive, Golden CO 80401 USA; TEL: (303)526-1626; FAX: (303)526-1650)

■Nov. 1-5 '93 **Alaska Miners** Assoc, Annual mtg., and short course on Precious Metal-Bearing **Skarn Deposits** (Alaska Miners Assoc., 203-501 W. Northern Lights Blvd., Anchorage AK 99503 USA; TEL: (907)276-0347; FAX: (907)278-7997)

■Nov. 5-21, '93 **Circum-Pacific and Circum-Atlantic terrane**, International mtg., Guanajuato, Mexico (D.G. Howell, USGS, MS 902, 345 Middlefield Road, Menlo Park CA 94025 USA; FAX: (415)354-3224)

■Nov. 7-9, '93 **Underwater Mining** Institute Annual mtg., Estes Park, CO (K. Chong Morgan, UMI, 811 Olomehani St., Honolulu HI 96813-5513 USA; TEL: (808)522-5611; FAX: (808)522-5618)

■Nov. 9-13, '93 **Mineral Resources of Russia**, mtg., St. Petersburg, (Organizing Committee, PO BOX 215, 199004, St. Petersburg RUSSIA; TEL: 011-7-(812)355-7952; FAX: 011-7-(812)218-9224; in USA, TEL: (505)291-9812)

■Nov. 10-12, '93 The 15th New Zealand **Geothermal** Workshop, Auckland (Professional Courses, Centre for Continuing Education, The University of Auckland, Private Bag 92019, Auckland NEW ZEALAND; FAX: 64-9-373 7419)

■Nov. 14-20, '93 2nd Congress of **Geochemistry** of the Portuguese-Speaking Countries (II Congresso de Geoquímica de dos Países de Língua Portuguesa) and 9th "Geochemical Week - Portugal", Porto, Portugal (Dr. Fernando Noronha, Mineralogia e Geologia, Faculdade de Ciencias, 4000 Porto PORTUGAL; TEL: (351-2)310 290; FAX: (351-2)316-456)

■Nov. 28 - Dec. 3 '93 **International Mining** Pros & Cons, Northwest Mining Assoc. Annual mtg., Spokane (NWMA, N.10 Post, Suite 414, Spokane WA 99201 USA; TEL: (509)624-2524; FAX: (509)838-2838)

■Nov. 29 - Dec. 3 '93 Perspectives for **Environmental Geochemistry** in Tropical Countries, Niteroi - Rio de Janeiro, Brazil (Drs. Julio C. Wasserman/Jorge J. Abrao, Programa de Geoquímica, UFF Instituto de Química, Outeiro de Sao Joao Batista, Centro, CEP 24020-007, Niteroi RJ BRAZIL; TEL: (55 21)717 1313; FAX: (55 21)719 7025)

Feb. 14 '94 **Association of Exploration Geochemists - ANNUAL GENERAL MEETING**, in conjunction with the SME Convention, 1:00 - 2:00 pm, Doña Ana Room, Albuquerque, NM (A. Clendenan, Business Mgr. AEG, PO BOX 48270, Bentall Centre, Vancouver BC V7X 1A1 CANADA; TEL: (604)685-4767)

■Feb. 14-17, '94 **Integrating Mining and the Environment**, SME, Annual Meeting, Albuquerque, NM (Meetings Dept., SME, PO BOX 625002, Littleton CO 80162-5002 USA; TEL: (303)973-9550; FAX: (303)979-3461)

■Mar. 5-9 '94 Prospectors and Developers Assoc. of Canada, Annual mtg., Toronto (S. Lawton, PDAC, 1002-74 Victoria St., Toronto ON M5C 2A5 CANADA; TEL: (416)362-1969; FAX: (416)362-0101)

■May 1-4 '94 **CIM Toronto '94** CIM Annual mtg., Toronto (D. Harquail, General Chairman, Toronto '94, 2000-20 Eglinton Ave. W., Toronto ON M4R 1K8 CANADA; TEL: (416)480-6497; FAX: (416)488-6598)

■May 10-14, '94 **Mining Latin America**, mtg., Santiago, Chile, coincident with **EXPOMIN 94** (IMM, 44 Portland Place, London W1N 4BR UK; TEL: 44 71 580 3802; FAX: 44 71 436 5388)

■May 13-18 '94 **GAC-MAC** Annual mtg., and **MDD-GAC** short course on **alteration processes**, Waterloo (G. Roberts, Waterloo'94, Dept of Earth Sci., Univ of Waterloo, Waterloo ON N2L 3G1 CANADA; TEL: (519)885-1211; FAX: (519)746-7484; Shortcourse info see advert this issue or contact D.R. Lentz, GSC, PO BOX 50, Bathurst NB E2A 3Z1 CANADA; TEL: (506)546-2070; FAX: (506)546-3994)

■May 17-19, '94 **GAC-MAC**, Annual mtg., Edmonton (J.W. Kramers, Alberta Geological Survey, Box 8330, Station F, Edmonton AB T6H 5X2 CANADA; TEL: (403)438-7644; FAX: (403)438-3364)

■Sept. 18-22 '94, **Geoanalysis '94**, International symposium on analysis of geological and environmental materials, UK (D.L. Miles, British Geological Survey, Keyworth, Nottingham NG 12 5GG UK; TEL: 44 602 363100; FAX: 44 602 363200)

■Aug. 28-Sept. 3, '94 European Association of Geochemistry Meeting and **4th Goldschmidt** Conference, Edinburgh (Dr. B. Harte, Department of Geology and Geophysics, Grant Institute, University of Edinburgh, West Mains Road, Edinburgh EH9 3JW UK)

■Sept. 12-15, '94, 3rd Symposium on **Environmental Geochemistry**, Kraków, Poland (Dr hab. Edeltrauda Helios Rybicka, Faculty of Geology, Geophysics and Environmental Protection, University of Mining and Metallurgy, Al. Mickiewicza 30, 30-059, POLAND; TEL: (48)12-333290; FAX: (48)12-332936)

Sept. 6-10, '94 Joint International Symposium on **Exploration Geochemistry**, Irkutsk: a tribute to Academician L.V. Tauson (Pavel Koval, Institute of Geochemistry, PO BOX 4019, 664033 Irkutsk-33 RUSSIA; TELEX: 133 163 Taiga SU; TEL: 395(2)46-59-78)

Continued on Page 19

Calendar of Events

Continued from Page 18

■Oct. 25-27, '94 Geological Society of America, Annual mtg., Seattle, WA (V. George, GSA, Box 9140, Boulder CO 80301 USA; TEL: (303)447-2020)

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

■Apr. 3-7 '95 **Centennial Geocongress 1995** Johannesburg, The Geological Society of South Africa (The Congress Secretariat, Centennial Geocongress, PO BOX 36815, Menlo Park 0102 SOUTH AFRICA; TEL/FAX: +27 12 47 3398)

■Apr. 10-13, '95 Geology and **Ore Deposits of the American Cordillera**, Geological Society of Nevada Symposium III, Reno (B. Hatch, GSN, PO BOX 12021, Reno NV 89510 USA; TEL: (702)323-4569; FAX: (702)323-3599)

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

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

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

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

Fred Siegel
The George Washington University
Department of Geology
Washington DC 20052
USA
TEL: (202)994-6194
FAX: (202)994-0458

1994 SME ANNUAL MEETING

The Geochemistry session of the 1994 SME Annual Meeting will be held on Monday, February 14th, from 9:00 AM to 12:00 PM in the Doña Ana room of the Albuquerque Convention Center. The session includes presentations of interest to all explorationists: exploration geochemistry/geology case histories, deposit scale geochemical studies, effective new geochemical prospecting techniques, analytical geochemistry, and environmental geochemistry. Please make a strong effort to attend: the 1994 SME Geochemistry session promises to be the best geochemistry program of the year. A list of scheduled presentations is shown below:

1. Surficial Geochemistry and Geology of the Meikle Deposit, Carlin Trend, Nevada. D.E. Wells, Barrick Gold Exploration.

2. Relationship of Soil Anomaly Magnitude to Depth of Mineralization, Jerritt Canyon District, Nevada. M. Jones, Independence Mining.

3. Precambrian Precious Metals Exploration Targets in East-Central Minnesota Using Ground Water Chemistry and Aqueous Speciation Models. P.F. O'Hara, Katterskill Exploration, and D.L. Shettle, GeoData Systems.

4. Spontaneous Potential - Passive Electrogeochemistry. J.A. Roberts, Geochemical Consultant.

5. Gold Analyses - Can You Trust Them? E.F. Weiland, SHB AGRA Inc.

6. Mineral Paragenesis and Characteristics of Fluids Associated With Mineralization in the Getchell, Rabbit Creek, and Carlin Mines. J. Groff, FirstMiss Gold Inc., and D.I. Norman, New Mexico Tech.

7. Twin Creeks Gold Mine - Synthesis of Geology of Rabbit Creek and Chimney Creek Mines, Humboldt County, Nevada. C.J. Tapper, W.F. Thompson, and G.L. Massengill, Santa Fe Pacific Mining Inc.

8. Gas Analysis of Fluid Inclusions: Application Toward Precious Metal Exploration at the Steeple Rock Mining District, Grant County, New Mexico. R.K. Ruff and D.I. Norman, New Mexico Tech.

9. Impact of Lead-Zinc Mining on Distribution of Major and Trace Elements in Water, Sediment, and Soil. J. Routh and M. Ikramuddin, Eastern Washington University.

The Geochemistry session will be followed (after a 1 hour break for lunch) by the **Annual General Meeting of the Association of Exploration Geochemists** from 1:00 to 2:00 PM, also in the Dona Ana room. All AEG members at the 1994 SME Annual Meeting should plan to attend.

1994 SME Annual Meeting Registration Form

First Name | Middle Initial | Last Name | AM

Badge to Read

Nickname

Job Title

Employer

Address

City, State

Country

Zip/Postal Code

Employer's Phone

Fax #

SME Member, #

INSTRUCTIONS:
- **Photocopy this form if additional forms are needed.**
- **No refunds issued after January 28, 1994.**
- **Registration may be sent via FAX only if payment is by credit card. FAX 303-979-3461.**
- **Questions should be directed to: Meetings Dept., 303-973-9550.**
- **Mail form and payment by January 28, 1994 to: Meetings Dept., SME, P.O. Box 625002, Littleton, CO 80162-5002**

▼ ▼ ▼ ▼ ▼ ▼ ▼ ***AFTER JANUARY 28, 1994 ON-SITE REGISTRATION FEES APPLY**** ▼ ▼ ▼ ▼ ▼ ▼ ▼

▶ *PLEASE CHECK THE FOLLOWING:*

JOB DESCRIPTION

- ❑ Executive/General Manager (12)
- ❑ Mine/Plant Manager (13)
- ❑ Supervisor/Foreman (14)
- ❑ Engineer (15)
- ❑ Scientist/Researcher (16)
- ❑ Marketing/Sales (17)
- ❑ Educator (18)
- ❑ Consultant (19)

FIELD

- ❑ Geology/Exploration (20)
- ❑ Coal Mining (21)
- ❑ Coal Processing (22)
- ❑ Industrial Minerals Mining (23)
- ❑ Industrial Minerals Processing (24)
- ❑ Metals Mining (25)
- ❑ Metals Processing (26)
- ❑ Metallurgy (27)

▶ ❑ **CHECK HERE IF YOU ARE A FIRST TIME ATTENDEE**

▶ *REGISTRATION FEES*

Member:				
____ SME	M	$250	$300	$ ____
____ TMS	T	$250	$300	$ ____
____ ISS	I	$250	$300	$ ____
____ SPE	S	$250	$300	$ ____
____ Student Member	SM	$ 25	$ 30	$ ____
____ Retired Senior Member	RM	$125	$150	$ ____
____ Legion of Honor Member	LH	$125	$150	$ ____
____ Member, Founder Society	MFS	$250	$300	$ ____
____ CIM Member	CIM	$250	$300	$ ____
____ SEG Member	SEG	$250	$300	$ ____
____ Nonmember Author	NMA	$250	$300	$ ____
____ Nonmember	NM	$375	$425	$ ____
____ Student Nonmember	SNM	$ 40	$ 45	$ ____

** THESE FEES APPLY AFTER JANUARY 28, 1994*

▶ *3-DAY SHORT COURSES: Feb. 11-13*

$495 MEMBER • $675 NONMEMBER • $322 STUDENT MEMBER

- ____ Copper Heap Leach — CL — $ ____
- ____ Evaluation, Design, and Operation of Precious Metal Heap Leaching Projects — ED — $ ____
- ____ Mine Data Analysis with Computers — MD — $ ____
- ____ Risk Assessment Principles & Practice for Evaluating Environmental Aspects of Mining Projects — RA — $ ____

❑ Check if you have any special needs. If so, please identify them. (1992 ADA)

▶ *2-DAY SHORT COURSES: Feb. 12-13*

$350 MEMBER • $475 NONMEMBER • $228 STUDENT MEMBER

- ____ Mine Equipment Maintenance — EM — $ ____
- ____ Planning and Design Concepts for Mine/Mill Closure — PD — $ ____
- ____ Safe and Cost Efficient Blasting in Surface Mines — SC — $ ____
- ____ TQC and JIT: Innovative Techniques for Process Management — TJ — $ ____

A late processing fee of $20 is charged on short course registration after January 28, 1994

▶ *SOCIAL FUNCTIONS*

 # Tickets

SUNDAY, Feb. 13

- ____ Reagents for Better Metallurgy Symposium Reception, Hyatt, $25 — SR — $ ____

MONDAY, Feb.14

- ____ Welcoming Luncheon, CC, $30 — WL — $ ____

TUESDAY, Feb. 15

- ____ Scotch Breakfast, Hyatt, $30 — SB — $ ____
- ____ Coal Div. Luncheon, CC, $25 — CD — $ ____
- ____ Industrial Minerals Div. Luncheon, CC, $25 — IM — $ ____
- ____ SEG Luncheon, La Posada, $25 — SE — $ ____
- ____ M&MSA Luncheon, Hyatt, $25 — MM — $ ____

WEDNESDAY, Feb. 16

- ____ Mining & Exploration Div. Luncheon, CC, $25 — ME — $ ____
- ____ Mineral & Metallurgical Processing Div. Luncheon, CC, $25 — MP — $ ____

SME Dinner, Hyatt

- ____ Individual Tickets, $45 — SD — $ ____
- ____ Table of 10, $450 — SMT — $ ____

▶ *FIELD TRIPS*

FRIDAY, Feb. 18

- ____ Industrial Minerals of Central New Mexico, $45 — IC — $ ____
- ____ Lee Ranch Coal, $30 — LR — $ ____
- ____ Quivira Uranium Mill/Homestake Mine, $35 — QH — $ ____

▶ *SYMPOSIUM PROCEEDINGS (available at the meeting)*

- ____ Reagents for Better Metallurgy –$45 AIME Member, $60 Nonmember, $36 Student Member — PR — $ ____

❑ American Express ❑ Discover ❑ MasterCard ❑ Visa ❑ Check or Money Order Enclosed

Card No. _____ Exp. Date _____

Signature _____

REGISTRATION TOTAL AND PAYMENT

Registration Fee Total	$ ____
Short Course Total	$ ____
Social Functions Total	$ ____
Field Trip Total	$ ____
Proceedings Total	$ ____
GRAND TOTAL	$ ____

REVIEW OF THE GSC

"Report of the Canadian Geoscience Council Advisory Committee on Mineral Exploration Geochemical Activities at the Geological Survey of Canada" GSC Paper 91-13

This report was commissioned by the Assistant Deputy Minister of the GSC in July 1988. At that time there were a number of questions concerning exploration geochemical activities at the GSC that needed to be addressed by an independent peer review body.

The committee, consisting of J.A. Coope (chairman), M.A. Bouchard, P. Davenport, I.L. Elliot, K. Fletcher, and A.H. Green, examined geochemical activities within the GSC, under specified "Terms of Reference". Over a two year period, the committee visited and interviewed a large cross section of GSC personnel, met with personnel from other federal departments, and circulated an extensive questionnaire to 163 earth scientists in industry, provincial governments and academia. Committee members also drew on their own experiences with other federal geological surveys to compare with the GSC.

The body of the report provides a very good and comprehensive description of the functions and breadth of the exploration geochemical activities of the GSC. The committee tabulated 38 conclusions and made 34 specific recommendations with supporting discussion. Many of these recommendations have been implemented. In summary, this report provides a very good overview of the geochemical work of the GSC and provides a clear direction for the future.

Copies can be obtained from:
GSC Publications Office
601 Booth Street
Ottawa, Ontario, CANADA K1A 0E8

Peter M.D. Bradshaw
Orvana Minerals Corp.
Vancouver, BC CANADA

NEW AEG SHORT COURSE

APPLIED BIOGEOCHEMICAL PROSPECTING IN FORESTED TERRAIN

Sheraton Hotel, Spokane, Washington, 29/30 November, 1993

Preceding and in conjunction with the Northwest Mining Association's (NWMA) 99th Annual Meeting, Dec. 1 - 3

INSTRUCTORS: *Colin E. Dunn* - Geologist/biogeochemist, Geological Survey of Canada
Gwendy E.M. Hall - Analytical Chemist, Geological Survey of Canada
Robert K. Scagel - Botanist/forester, Pacific Phytometric Consultants, Surrey, B.C.

This course will discuss basic principles of biogeochemical prospecting and lead participants through to 'state-of-the-art' knowledge, leaning heavily upon the instructors' experience in the Pacific Northwest, British Columbia, and the boreal forests of Canada.
Topics to be included will be:

- plant components and element uptake (requirements, tolerances and toxicity -what to look for); what are elements *doing* in plants?; plant physiology; biogeoclimatic zones; identification of trees and shrubs of value in biogeochemical prospecting;
- methods of sample collection, preparation, and analysis; analytical instrumentation; special procedures required for vegetation;
- case history studies of results obtained for precious metals, base metals, kimberlite, uranium, and rare metal pegmatites - examples will be mostly from British Columbia, Saskatchewan and the Maritime Provinces of Canada.
- data interpretation;

The course format, supplemented by videotape to demonstrate techniques, will encourage participants to discuss their own biogeochemical surveys and problems.

Cost: US$300 (50% discount to full-time university students - the course is offered as a continuing education credit from East Washington University).

Further details and registration forms can be obtained by calling:

Carla Snyder, NWMA Business Manager, at (509) 624-1158 [Fax. (509) 624-1241]

NEW MEMBERS

To all Fellows:
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, USA.

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

FELLOW

Cohen, David R.
Lecturer
University of New South Wales
Kensington, NSW, Australia

MEMBERS

Brewster, Douglas C.
Project Geologist
CRA Exploration
Broken Hill, NSW, Australia

de Souza, Hugh A.F.
Acting Section Chief
Geoscience Labs - MNDM
Sudbury, ON, Canada

Dupree, Paul
Chief Engineer
CDE-Chilean Mining Corp.
Santiago, Chile

Espinoza, Jorge I.
Geologist
Santiago, Chile

Howard, William R.
Calgary, AB, Canada

Novajas, Roberto A.
Research Geologist
Mineral El Salvador, Chile

Petersen, Erich U.
University of Utah, UT , U.S.A.

Reeves, Wade C.
Cavendish Analytical
Burnaby, BC, Canada

Stegman, Craig L.
CRA Exploration
Mt. Isa, QLD, Australia

Watkins, John J.
Senior Geologist
Lac Minerals
Vancouver, BC, Canada

STUDENT MEMBERS

Khan, Tazeem
University of Peshawar
Peshawar, Pakistan

Lzszklewicz, Leon
Queens University
Kingston, ON, Canada

RECENT PAPERS

This list comprises titles that have appeared in major publications since the compilation in EXPLORE Number 80. Journals routinely covered and abbreviations used are as follows: Economic Geology (EG); Geochimica et Cosmochimica Acta (GCA); the USGS Circular (USGS Cir); and Open File Report (USGS OFR); Geological Survey of Canada Papers (GSC Paper) and Open File Report (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, CO 80401-1887, Chairman AEG Bibliography Committee. Please send new references to Dr. Closs, not to EXPLORE.

Aleksandrov, S.M., 1992. Quantitative compositional relations between marginal magmatic rocks and the

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Recent Papers

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magnesian skarn zones adjoining them. Geochem. Intern. 29(12): 31-41.

Alldrick, D.J., Godwin, C.I. and Sinclair, A.J., 1993. An exploration application for lead isotope ratios, Stewart Mining Camp, Northwestern British Columbia. Explor. Mining Geol. 2(2): 121-128.

Bliss, J.D., 1992. Grade-tonnage and other models for diamond kimberlite pipes. Nonrenewable Resources 1(3): 214-230.

Boudreau, A.E., 1993. Chlorine as an exploration guide for the platinum-group elements in layered intrusions. J. Geochem. Explor. 48(1): 21-37.

Braux, C., Piantone, P., Zeegers, H., Bonnemaison, M. and Prevot, J-C., 1993. Le Chatelet gold-bearing arsenopyrite deposit, Massif Central, France: mineralogy and geochemistry applied to prospecting. Applied Geochem. 8(4): 339-356.

Cabri, L.J., Hulbert, L.J., Laflamme, J.H.G., Lastra, R., Sie, S.H., Ryan, C.G. and Campbell, J.L., 1993. Process mineralogy of samples from the Wellgreen Cu-Ni-Pt-Pd deposits, Yukon. Explor. Mining Geol. 2(2): 105-119.

Cagatay, M.N., 1993. Hydrothermal alteration associated with volcanogenic massive sulfide deposits: Examples from Turkey. EG 88(3): 606-621.

Cawthorn, R.G. and Meyer, F.M., 1993. Petrochemistry of the Okiep Copper District basic intrusive bodies, northwestern Cape Province, South Africa. EG 88(3): 590-605.

Chork, C.Y. and Salminen, R., 1993. Interpreting exploration geochemical data from Outokumpu, Finland: a MVE-robust factor analysis. J. Geochem. Explor. 48(1): 1-20.

Darnley, A.G., 1993. International geochemical mapping. J. Geochem. Explor. 48(1): 97-104.

Fedoseyeva, V.I. and Fedoseyev, N.F., 1992. Quantitative estimate of gold migration in snow cover. Geochem Intern. 29(6): 146-

Francois-Bongarcon, D.. 1993. The practice of the sampling theory of broken ores. CIM Bull. 86(970): 75-81.

Good, D.J. and Naldrett, A.J., 1993. Geology and distribution of platinum-group elements, Bucko Lake Intrusion, Thompson Belt, Manitoba. Can. Min. 31(1): 45-60.

Grabezhev, A.I., 1992. Zonality of metasomatic halos of the porphyry-copper deposits of the Urals. Geologiia

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Recent Papers

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Rudnykh. Mestorozhdenii (Geology of Ore Deposits) 34(4): 57-66.

Griffin, W.L., Sobolev, N.V., Ryan, C.G., Pokhilenko, N.P., Win, T.T. and Yefimove, E.S., 1993. Trace elements in garnets and chromites: Diamond formation in the Siberian lithosphere. Lithos 29(3/4): 235-

Headley, J.V. and Rae, W.E., 1992. Sampling and analytical strategies for delineating petroleum contaminated soils and groundwater. Bull. Can. Petrol. Geol. 40(4): 295-302.

Ilton, E.A. and Veblen, D.R., 1993. Origin and mode of copper enrichment in biotite from rocks associated with porphyry copper deposits: A transmission electron microscopy investigation. EG 88(4): 885-900.

Ivanov, V.N., 1992. Tungsten geochemistry in supergene zone of central Kazakhstan tungsten deposits. Geochem. Intern. 29(6): 99-105.

Janet, P., Hooker, P.J., Schmitt, J.M., Ledoux, E. and Escalier Des Orres, P., 1993. Hydrogeochemical modeling of an active system of uranium fixation by organic soils and sediments (Neddle's Eye, Scotland). Min. Deposita. 28(1): 66-

Kejian, J., Lieben, W., Fengxiang, L., Wuyi, W., Jianhau, D. and Jianhau, Z., 1992. The negative haloes and geochemical field system of hydrothermal deposits. Acta Geologica Sinica. 66(4): 361-369.

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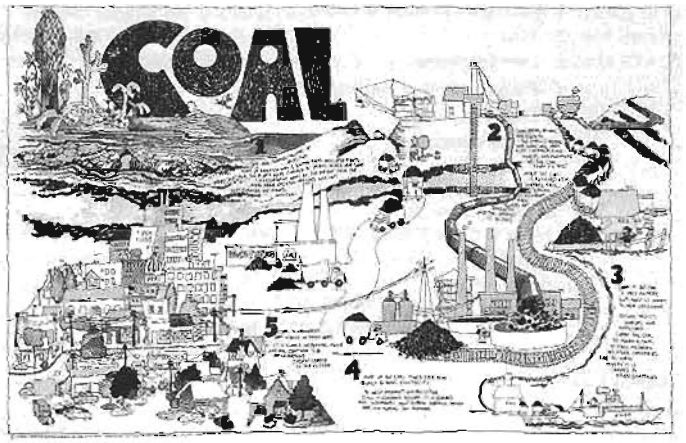

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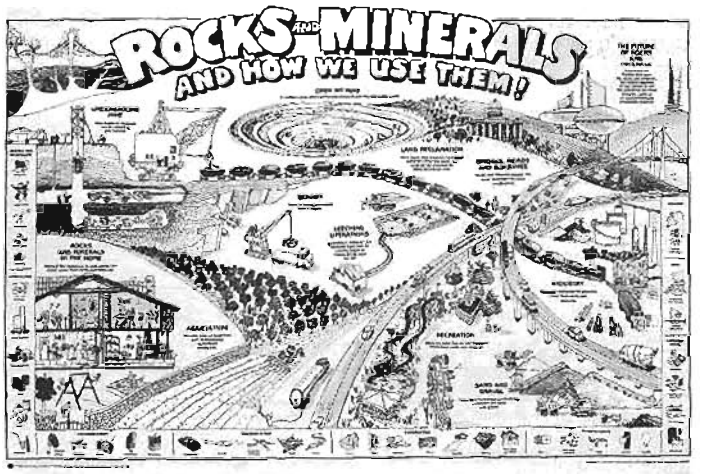

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