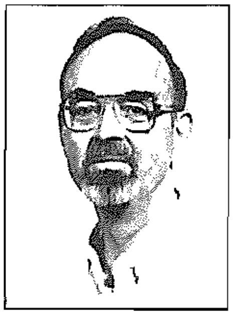
EXPLORE

The Association of Exploration Geochemists Newsletter

NUMBER 70 JANUARY 1991

PRESIDENT'S MESSAGE



If you read my Presidential Message and technical article in the last issue of **EXPLORE**, you will recall that I raised various questions about the possibility of the Association of Exploration Geochemists becoming more active in the field of environmental geochemistry. I invited comments from the membership, and people responded. A particularly significant letter arrived from Olle Selinus of the Geological Survey of Sweden. The entire letter is published in the *Letters* section of this issue. In summary, Mr. Selinus said that in Scandinavia the fields of exploration and environmental geochemistry have essentially merged into one discipline. Mr. Selinus emphasized, however, that each field still has much that can be contributed to the other, which was precisely the message that I put forth in the last **EXPLORE**. He also informed me of the forthcoming 2nd International Symposium on Environmental Geochemistry. (See *Letters* for details of the Symposium.) You may recall that I had also raised the question as to whether or not we should enter into a joint symposium with the SEGH, and now I learn from Mr. Selinus that such a symposium has already been planned.

On another, totally unrelated topic, I want to call your attention to how quickly time flies (as if you needed reminding!). I have often wondered if Einstein missed one of the fundamental laws of Relativity, that is: "The older one becomes, the faster time passes." What, you may ask, am I raving about? Obviously, I am talking about the forthcoming 15th International Geochemical Exploration Symposium in Reno, Nevada, April 29-May 1, 1991. I just sent in my Early Registration materials and I urge you to do the same; April will be here day after tomorrow! The program at the Reno Symposium will include as many as three short courses, two workshops, 17 field trips (including one to Chile), three days of technical sessions, and a full social program. The Organizing Committee, chaired by Hal Bonham, has gone beyond the call of duty in arranging this incredible array of riches for us. To avoid disappointment by being closed out of some of the events, be sure to mail your registration materials in today.

Finally, let me remind you that the categories of membership within the AEG are now being revised as part of a major rewrite of the By-Laws. If approved by a vote of the membership, the present category of Voting Member will become Fellow and the category of Affiliate Member will become Member. This is the perfect time for you to urge all of your non-member colleagues and friends to join the AEG. One of my colleagues here at the University of Colorado (Prof. Bill Atkinson) told me yesterday that he was finally going to join the AEG, and that now I could quit pestering him about it. (I think the handsome announcement brochure of the Reno Symposium helped him make the decision.) The benefits of our symposia, journal, and newsletter are certainly worth the modest membership cost. Everyone who works professionally in mineral

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TECHNICAL NOTES

The Need for Quality Control in Analytical Geochemistry

The 1990 AEG directory contains 272 entries under "Geochemical Laboratories." The quality of analyses provided by geochemical laboratories is of concern to the explorationists who rely on the services that these laboratories provide. J. Alan Coope and Owen Lavin of Newmont Exploration have evaluated the quality of analyses provided by 29 laboratories over a three-year period. They conclude that: 1) the quality of the labs is either good or bad; and 2) the frequency of outliers is unacceptably high. Doctors Coope and Lavin presented the results of their evalution at this fall's first session of the Denver area Geochemical Exploration Discussion Group, which meets regularly at the Colorado School of Mines.

As with other service-providing companies, we can expect a certain number of inferior analytical geochem labs. We can likewise expect that there are more of these inferior labs doing business today than twenty years ago when there was a mere handful of labs in total. The conclusions of Coope and Lavin, and other indicators such as the overtones in the recent Pearl Harbor File of this newsletter, suggest poor quality is pervasive. At the same time, explorationists convey a sense of frustration at not being able to do something about it.

Ignorance, Neglect, or Cost Prohibitiveness — Some Likely Causes of Poor Quality

Presuming none of the geochemical laboratories willfully generates poor quality analyses, I will address some reasons for their propagation: ignorance; neglect; and cost prohibitivity.

The principles of analytical chemistry require researchers to

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CONTENTS

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* 5¼- or 3½-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.

EXPLORE

Newsletter No. 70 JANUARY 1991

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NOTES FROM THE EDITOR

The Journal of Geochemical Exploration, Volume 38, Number 3 has been issued since the last Newsletter. Volume 38, Number 3 contains 7 research papers on a variety of exploration geochemical and analytical topics. The table of contents of the next JGE issue appears elsewhere in this newsletter. Claims for missing issues are honored free of charge for three months after the date of issue — see inside the back cover of the Journal. Back volumes are available at Dfl. 283 or US $138.00. AEG members can save over $350 a year for the 1987 through 1989 volumes by ordering through the Rexdale office.

EXPLORE Number 69 was distributed to 4000 professional including members of AEG, the Alaska Mining Association, the Geological Society of America, and and over 100 libraries. Bulk shipments were made to Stan Hoffman for distribution in Canada. The remainder were dispersed at the Northwest Mining Association meeting in Spokane, WA, CVG-TECMIN in Puerto Ordaz, Venezuela, and at a short course taught in Alaska. If you would be willing to distribute this newsletter to a local or regional meeting or to supply mailing labels of an association, please write to **EXPLORE.**

Owen P. Lavin
Editor

President's Message

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exploration should be a member of the AEG, and each of us should do our part to convince them to join.

In closing, may I wish each of you good health, good friends, and prosperity.

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NOTES FROM THE SECRETARY

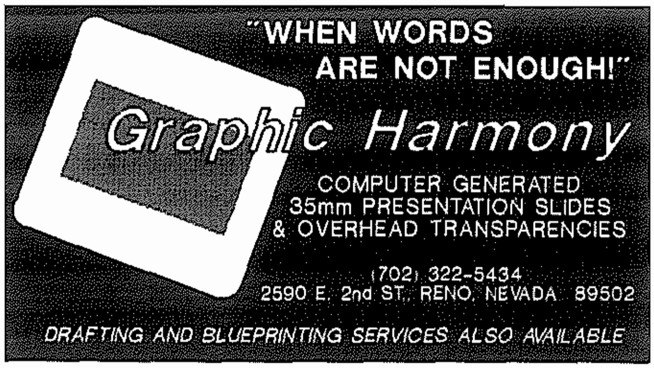
It is hard to believe but by the time you read this, ballots for the 1991 Ordinary Councillor election will have been mailed out. Your ballot must be returned to the Association office in Rexdale, Ontario, by the end of March, 1991 in order for your vote to be valid. I encourage all Voting Members to take a few minutes to read the short biographies on each candidate and then vote for five of your choice. Please exercise your right to vote; it is your chance to take an active part in the affairs of the organization. DO IT NOW, DO IT TODAY. YOUR VOTE COUNTS!!!

The timing of this election points out one of the inequities in the Association that will hopefully be changed in the upcoming revisions to the By-Laws. Our elections are tied to the Annual General Meeting, where the newly elected Councillors and Executive are announced. In recent years the AGM has been scheduled in many foreign countries at irregular times of the year. This means that the President and elected Councillors can serve terms as little as nine months or as long as 18 months, depending on when the AGM is held each year. The proposal before the By-Laws committee is to hold the AGM in the spring of each year, at some appropriate meeting, and thus give the elected Officers and Councillors a full term of office. If you have any comments or thoughts on this, please send them to me and I will forward them on to the By-Laws Committee.

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

One of the more significant changes in your Association was enacted by Council at the November, 1990 meeting. It was decided to move the headquarters for the Association from Rexdale, Ontario, Canada to Vancouver, British Columbia, Canada. This move will be gradual, over the next six months, and the Rexdale address will remain active until the move is completed. This move will consolidate many of the functions of the Association that are now scattered over much of the United States and Canada. One of our biggest difficulties has been communicating with members concerning problems with membership, the Journal of Geochemical Exploration, and other business matters. We hope this consolidation of our business activities will alleviate much of the difficulty we have had in responding to our membership. We will make every effort to keep disruption to a minimum during the transition but hope the end result will be better service to our members.

Sherman P. Marsh
Secretary, Association of Exploration Geochemists
U.S. Geological Survey
MS 973, Federal Center
Denver, Colorado 80225
USA



LETTERS

Dear Editor,

Thank you for you your letter in **EXPLORE** Number 69 by Dr. Runnells about the relationships between exploration geochemistry and environmental geochemistry.

Exploration geochemistry is certainly an interdisciplinary field, and so is environmental geochemistry. These two types of geochemistry are, in fact, related to each other. I would say that they, at least in Scandinavia but also in some other European countries, are related in that geochemists formerly working in mineral exploration are now working with environmental geochemistry. Sweden has a long history of geochemical exploration at the Geological Survey (e.g., Nils Herman Brundin). For 12 years, however, we have been working predominantly with environmental geochemistry. The methods we use are derived from exploration work, but we have found completely new fields in the environmental sciences. The geochemical mapping work we are doing is also used by the exploration companies.

Geochemists, in general, are specialists in the natural occurrences of metals (e.g., heavy metals); they are also generally experienced with statistical methods, analytical methods, and computer modeling. This knowledge can effectively be brought into the environmental sciences. In general, there has been a rather poor understanding in the environmental sciences of natural processes and the natural behaviour and contents of heavy metals in natural conditions. Geochemists can provide this baseline information. In addition, we can use our experiences in statistics and computer modeling to arrive at new approaches for the environmental sciences. We can also contribute

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Letters

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significantly to a better understanding of the impact of anthropogenic effects on the natural environment.

Another field has also arisen: geomedicine or geochemistry and health. We geochemists often determine broad scale patterns of metals in nature, and this information can be used by medical authorities and researchers in studying different diseases of environmental origin. It is, however, very important that this work should be done in cooperation with medical professionals, and not in a parallel manner. The Society for Environmental Geochemistry and Health is doing important work in this field.

Dr. Runnels suggested a joint exploration-environmental symposium. In fact, an international symposium is going to be held in Uppsala, Sweden next year, entitled the **Second International Symposium on Environmental Geochemistry.** It will take place September 16-19, 1991. (See *Calender of Events* in this volume for more details.) The meeting represents a cooperative venture between the Geological Survey of Sweden and the Swedish University of Agricultural Sciences. The symposium is also in collaboration with the International Association of Geochemistry and Cosmochemistry (IAGC) and the Society for Environmental Geochemistry and Health (SEGH).

The first circular has been sent not only to environmental workers but also to many exploration geochemists and geologists. We sincerely hope that many researchers and workers of this latter category will come to the symposium because of the many papers of common interest to both exploration geochemists and environmental geochemists. The papers will be published in a special supplemental volume of **Applied Geochemistry.**

The themes of the symposium are the following:

1. Environmental geochemistry and health,
2. Anthropogenic effects on the natural environment and global changes,
3. Pollution of natural soil and water systems,
4. Methods of geochemical monitoring, modeling, and mapping
5. Geochemical aspects of waste disposal,
6. The importance of geology in environmental geochemistry,
7. Natural and man-made radiometric hazards, and
8. Biological and geochemical interactions in weathering and element translocation, and the impact of climatic changes on the geochemical environment.

In addition, two workshops are under consideration: 1) International geochemical mapping, and 2) Chemical time bombs.

There will also be a field trip to the famous ore province of Bergslagen to look at the Falun mine and the impact of mining activities on the natural environment.

We hope that the symposium will be of great interest to both exploration and environmental geochemists. Thus far, we have received almost 400 answers to our circular from 40 countries. As a matter of fact, the country with most individuals registered, apart from Sweden, is the United States.

We hope that this meeting will result in the two scientific communities (which I would say is really only one community) learning from each other.

Welcome to the "joint" meeting.

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Technical Notes

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address accuracy, precision, and the constraints on the methods they develop. It is common knowledge that all methods are not equally effective for all samples. Method developers are not able to test their procedures on an infinite variety of sample matrices. Geochemical methods are generally tested on materials broadly classified as rock, soil, sediment, water, and vegetation. The effectiveness of the method is evaluated by comparing the results obtained in testing standard samples of these materials with accepted or published values. General inferences are often drawn from specifics. For example, if a method has been successfully run on samples of granite, its effectiveness on all silicate rocks might be inferred. Inferences, though sometimes valid, do not guarantee equal effectiveness and can play havoc with quality. It is especially critical to hold as suspect, methods tested on relatively clean samples when the methods are to be used on mineralized samples. The need to match the matrices of standards with the samples is common knowledge. I suspect its importance is neglected by many labs and perhaps even ignored by others.

I can draw from my own experience examples of laboratory managers and chemists purchasing and enthusiastically taking delivery of a new, sophisticated, multi-element-capability instrument, and, with all its bells and whistles, on-lining it for production in a state of ignorant bliss. Geochemical labs are not the principal market for instrument manufacturers. Geochemical samples are inherently difficult to analyze by any instrument regardless of claims sales people may make. It would be fortuitous to have new analytical technology come off the assembly line ready as is for a geochemical sample. Without thoroughly developing and testing an instrument for our particular application, we are begging for trouble. I shudder to think how many "instrument anomalies" were produced by the newly-introduced ICP-AES some fifteen years ago and are currently being generated by ICP-MS. There is good reason to treat state-of-the-art instrumentation as if it intends on stabbing you in the back. It may.

The large demands of exploration and a plentiful supply of low cost labor has brought some unqualified people into the geochem lab. To a person, we are all for providing jobs to those that need them. However, not to hire qualified personnel or to properly train the people we hire is to denigrate the importance of quality in our analyses. Lack of training also does not bode well with regulations concerning safety in a potentially hazardous workplace or the legal aspects of geochemical data.

I suspect that the underlying reason for poor quality is one of cost. Maintaining a sound method and instrument development program requires knowledgeable, experienced people and money. Similarly, hiring qualified laboratory technicians implies increased salary obligations and potentially lower profits.

The Cure — Development and Universal Adherence to a Uniform Quality Control Plan

Quality control (QC) as it has evolved in most geochemical laboratories (presuming that a progenitor exists) encompasses only a small portion of QC as defined by such organizations as the ASTM, NITS, and the EPA. There is more to quality control than running duplicate analyses, reference materials, and inserting blind standards into a lot of submitted samples. Nevertheless, these procedures are a good start and all laboratories should initiate their implementation if they are not already using them. More importantly, they should acknowledge and act to correct the problems that following these procedures will uncover. Most assuredly there will be problems (the laws of QC prohibit perfection!).

Increased efforts are needed to develop an expanded range of well characterized geologic materials for use as standards and to make them available to laboratories. Historically, this has been one of the roles of the USGS and the GSC. The two are continuing their efforts. If industry can be pursuaded to join in, albeit not without cost, so much the better. Beyond the development of standards, laboratories have to make use of them in the manner which standards are intended to be used.

More rigid quality control also requires: 1) certification and documentation of the methods used in the laboratory; 2) defining levels of uncertainty and establishing levels of rejection for analyses; 3) documentation of modifications or changes to methods as might be necessary to process certain samples; 4) maintaining a contamination-free workplace; 5) careful record keeping of instrument calibration, malfunctions, and maintenance; and 6) certification of analyses by a reviewing official. Again, fundamental to all of this is a competent, knowledgeable and conscientious staff. Finally, and most importantly, quality control requires a guarantee to the customer that the laboratory will adhere to the rules it has set for itself.

Currently, the degree of quality control practiced by individual laboratories offering analytical services to the exploration community is solely discretionary. Implementing more rigid and universally applied procedures would result in increased operating costs which would have to be borne by the users. If it is important enough, it can be done. The environmental and health sciences require their

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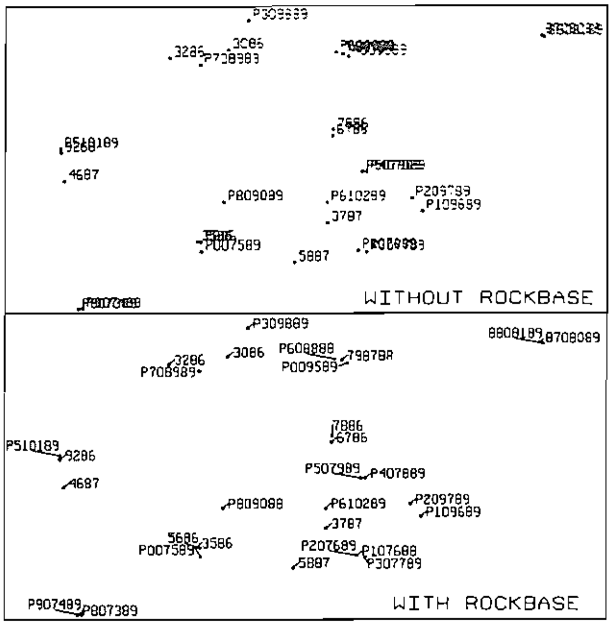

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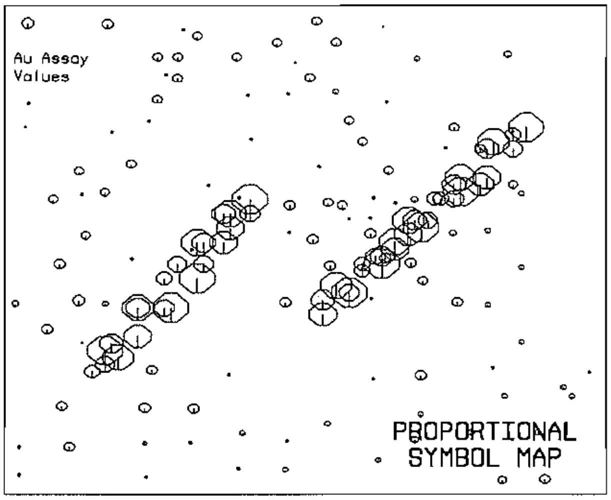

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Technical Notes

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laboratories to pass the muster of rigid quality control. That may or may not be too extreme for our purposes but with some prodding from the explorationists the analytical and assay laboratories can at least do better than they are apparently perceived to be doing now.

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Technical Notes *Continued from Page 6*

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Mount Milligan — Cat Mountain Updates

EXPLORE Number 69 presented geochemical data for both of these alkalic Au-Cu porphyry prospects. Since publication, Continental Gold Corporation has sold its 70% interest in the project via sale of the company to Placer Dome Inc. for Cdn. $182 million. BP Resources Canada Limited also sold its 30% interest to Placer Dome for Cdn. $79 million. The deposit has not, as yet, been put into production, but one can assume from the purchase price, the resource will soon be developed.

Exploration on Cat Mountain continued in 1990, with trenching and drilling of the anomaly reported on Figures 5 - 8 in **EXPLORE** Number 69. Results for Cu and Au are shown on Figure 1. A regional program of geological mapping, soil geochemistry, ground magnetics, and induced polarization has defined a large system with soil anomalies comparable to those reported for Mount Milligan (Fig. 2).

Of interest to users of geochemistry, the followup documented by Figure 1 was conducted by excavating trenches and pits of source areas predicted from empirical geochemical models. Many of the areas examined would have been considered uninteresting based on examination of the limited outcrop and talus float that mantles steeper slopes of the mountain. The philosophy of completing geochemical followup despite negative prospecting evidence was rewarded by discovery.

Cost of followup using a 1.2 yard^3 (1.0 m^3) Kobelco hoe, at US $85/hour is low, considering its productivity. For example, a 220m long trench, cut 1.5 m to 3.5 m into overburden or rubbly bedrock (trench is 1.5 to 2.0m wide) took five hours to complete. A program of pitting at 25m intervals to bedrock, in overburden ranging from 1.0m to 6.0m deep, on steeply sloping terrain proceeded at a rate of 5 to 6 stations per hour. The efficiency of the backhoe necessitates that two geologists and two samplers be employed to keep pace, otherwise sampling takes precedence over mapping. All trenches and pits were filled and sites

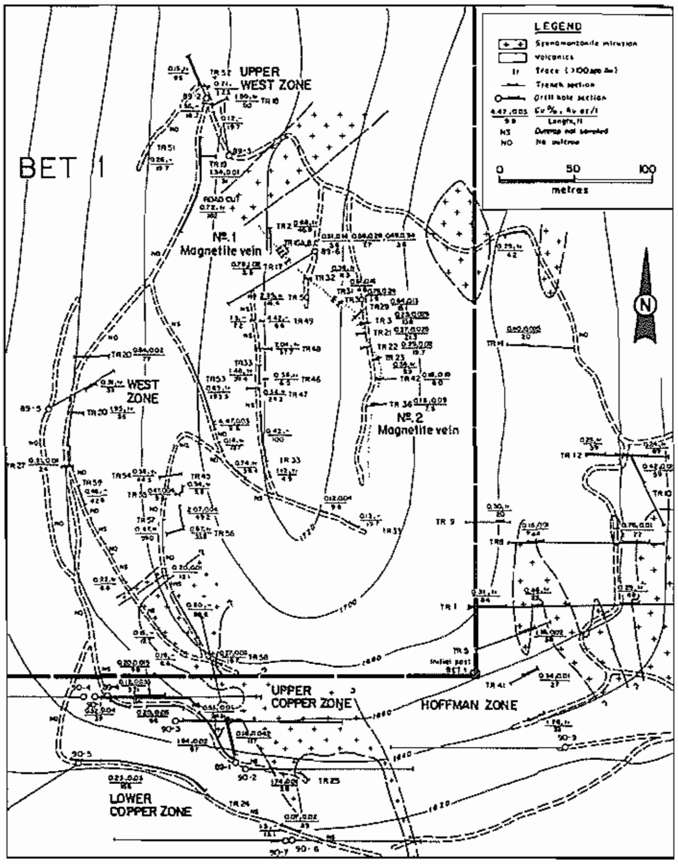

*Figure 1. Trench followup of Cat Mountain soil anomalies, see Figures 5-7 in **EXPLORE** Number 69. The solid dashed lines represent the claim outlines on Figure 8 of **EXPLORE** Number 69 (idealized).*

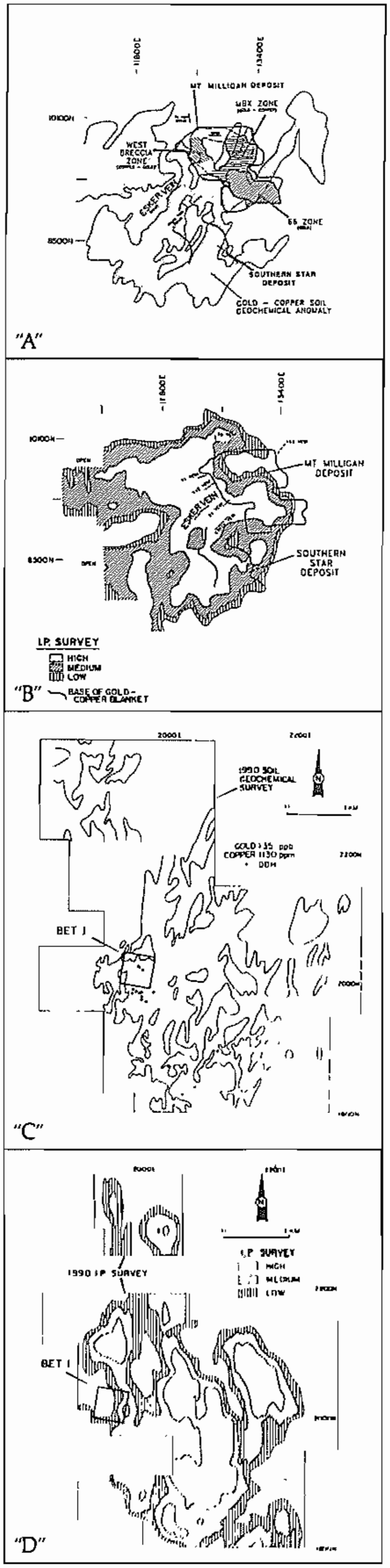

Figure 2. Comparison of soil geochemsitry (Cu >130ppm, Au >35ppb) for Mt. Milligan (A) and Cat Mountain (C) and IP survey for Mt. Milligan (B) and Cat Mountain (D). Note that the focus of initial work at Mt. Milligan centered on the Esker Vein system.

levelled to original conditions, typically within the same day, to avoid environmental hazard.

A large volume of trench and drill-hole geological and geochemical data is now in hand. Continued exploration of the Cat Mountain target (Fig. 1) will rely on interpretation of lithogeochemistry. Followup efforts will be described in a future issue of **EXPLORE**.

Stan Hoffman
Prime Geochemical Methods Ltd.
630 - 1199 West Pender St.
Vancouver, BC, V6E 2RI
Canada
TEL: 604-684-0069
FAX: 604-682-7354

DISTINGUISHED LECTURER

W.K. Fletcher has completed his three-week lecture series in Australia. Graham Taylor, the Association's Regional Councillor in eastern Australia, arranged a full itinerary that maximized the Association's exposure to the Australian geoscience and exploration community. Local sponsorship for the tour was provided by the Australian Institute of Mining and Metallurgy, the Eastern Goldfields Discussion Group, CSIRO Division of Exploration Geosciences, Western Mining Corporation, CRA Exploration, Billiton Australia, and Renison Goldfields Consolidated.

In all, eleven lectures were given in Sydney, Perth, Melbourne, and Canberra, with the presentation on "Behavior of Gold and other Heavy Minerals in Streams" being most in demand. In addition one-day workshops were given at James Cook University (Townsville) and to the Eastern Goldfields Discussion Group in Kalgoorlie. The latter benefitted greatly from contributions by Russ Birrell on local exploration geochemical problems. An informal field trip, that followed the Kalgoorlie workshop, provoked lively discussion on relations between anomalies and gold mineralization and on what should (and should not) be sampled.

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University of British Columbia
Vancouver, BC, V6T 2B4
Canada
TEL: (604) 228-2392

NEWS OF MEMBERS

Dr. Raymond Smith, whilst maintaining his responsibilities as a Chief Research Scientist in CSIRO Division of Exploration Geoscience, has been appointed Adjunct Professor in Exploration Geochemistry at Curtin University of Technology. The purpose of this appointment is to enhance integration of postgraduate studies in exploration geochemistry with industry-funded research opportunities. Emphasis is on development of exploration methods for locating concealed mineral deposits in Australia's deeply-weathered terrain, a theme central to Curtin's Key Centre in Resource Exploration and Department of Applied Geology. Dr. Smith can be reached at CSIRO, Private Bag P.O., Wembley, WA 6014, Australia. TEL: (09) 387 0200, FAX: (09) 387 8642.

Rogers Watters has put his Cairns-based consultancy on hold indefinitely while he fills the position of Manager at Alice Springs for the Northern Territory Department of Mines and Energy. Mr. Watters can be reached at Northern Territory Department of Mines and Energy, Minerals House, P.O. Box 2655, Alice Springs, NT 0871, Australia. TEL: (089) 50 3658, FAX: (089) 52 7762.

LOST MEMBERS

The members listed below have recently moved and mail is being returned to AEG offices. If you have moved recently or if you know the current addresses of the "lost" individuals, please send an update of address change to:

The Association of Exploration Geochemists
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PEARL HARBOR FILE

From reader response, few of us have had much experience in applying aqua regia-leachable metal determinations to exploration problems. These partial extraction data can prove useful to the budget conscious, once their limitations are recognized. Several lithogeochemical examples are in order.

1) **Ba determination as an indicator of barite.** Barite per se should not be soluble in aqua regia, and so Ba concentrations should be low, perhaps at detection limits. An aqua regia leach will therefore not give total Ba.

Total Ba content of most silicate samples tends to be less than 2000 ppm, and I have found 500 ppm aqua regia leachable Ba to represent a normal upper limit. Values exceeding 500 ppm thus merit special attention, particularly if presence of barite is an important geological indicator.

Two case histories display the type of results to be expected. In the first, barite mineralization was intersected in drill core of the Selwyn Basin of the Yukon. Total Ba contents (XRF) ranged from 10 to 15%. Aqua regia-leachable Ba contents gave values of 1.0% to 1.5%. In this example, about 10% of the Ba was extracted. In the second example, associated with a gold deposit, aqua regia did not extract Ba (to a 2 ppm detection limit) within barite-rich drill sections; however, wallrock immediately adjacent to the barite reported 500 to 1000 ppm aqua regia-leachable Ba. Both examples illustrate how data could be used to assist interpretation. Caution is nonetheless recommended, as these examples represent empirical observations.

2) **The search for volcanogenic massive sulphides.** Routine exploration involves determination of total Na and total Mg values in rock samples, with an empirical determination that total Na_2O contents below 2% and/or total MgO contents above 6% are favourable indicators of alteration. (Note that alkali indices can also be constructed to chart alkali leaching versus chlorite (Fe + Mg) formation as a guide to ore.)

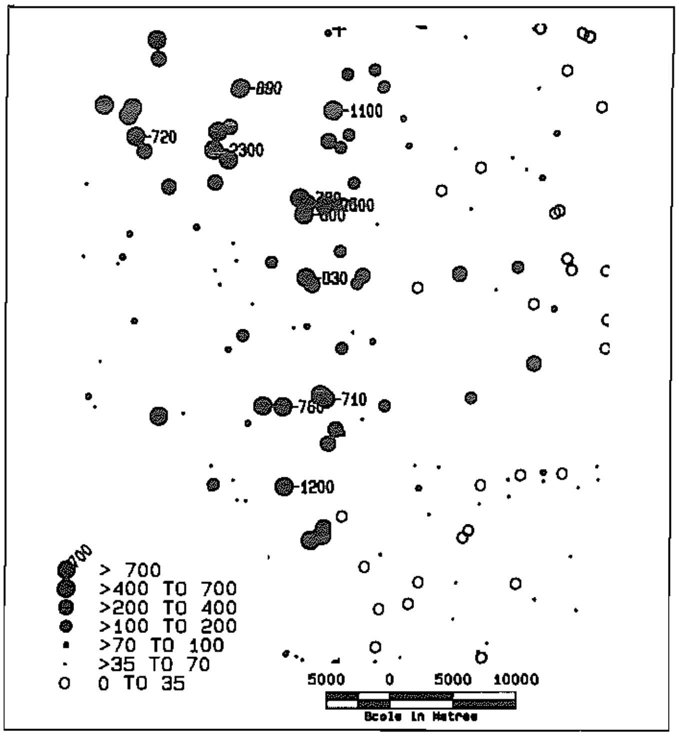

Figure 1: Distribution of Hg (ppb) in stream sediments, Central British Columbia.

The aqua regia leach unfortunately does not provide useful Na data. About 50% of the Mg is typically extracted, and so trends in Mg data can suggest enrichment. Many of the "whole rock" suite of elements are also extracted in proportion to their total content (Ca, Fe, Mn, P). Some elements are leached to a greater extent in altered rocks (Al), whereas others leach in response to minerals present (K in biotite or muscovite may be soluble whereas K content of orthoclase may be relatively insoluble). Although an alkali index cannot be constructed using aqua regia data, I have found the multielement distribution patterns adequately fill the void and in fact can be more specific for exploration applications.

3) **Ti and P.** Geologic arguments suggest Ti and Zr are relatively insoluble elements whose distribution and concentrations can be used to indicate original rock composition in cases where subsequent alteration is extreme. Phosphorus, often being held in the resistate mineral apatite, would likely be controlled by similar factors.

Aqua regia tends to leach Ti and P in proportion to their total content in many examples, although Ti is sometimes insoluble in aqua regia. Both of these elements proved invaluable in unravelling stratigraphy in a volcanogenic massive sulphide environment where alteration was extreme and extensive. In another case, they documented major changes in volcanic stratigraphy which were not appreciated geologically following logging of drill core. Clearly, making use of available data can develop its applications.

Many more lithogeochemical examples can be given. All are very dependent on sample preparation, a laboratory procedure rarely investigated in detail by users of lithogeochemical analysis. Leachability of metals by aqua regia depends on fineness of grind of the pulverizing process. How many readers have investigated the size fraction distribution of their pulps or appreciate the jaw crushing: splitting ratio routinely conducted to prepare pulps prior to analysis? Results might astound you. If sufficient interest is indicated, I can expound on this subject in a future issue of **EXPLORE**.

Figure 1 displays the Hg distribution from a regional stream sediment survey conducted in central British Columbia. Can you detect anything peculiar about the map? More next issue.

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QUESTIONS AND ANSWERS

Correlation of Rock Units by Lithogeochemistry

I am writing about information for the application of lithogeochemical analysis in exploration for vein-hosted epithermal gold systems in arid climates and also the application of whole-rock geochemistry as a method of correlating parent lithologies on a regional basis.

At this time our primary objective is to use lithogeochemical whole rock analysis in combination with petrological studies as a means of correlating the Pajingo Deposit host rocks to regional lithologies. Later a program using lithogeochemical analysis as an exploration tool for epithermal-style mineralization will be initiated.

In order to convince the "powers that be" that such methods will work, if indeed they will, I require answers to a number of questions, as well as the support of documented case studies in which these methods were successful.

- ***What sampling and analytical procedures should be utilised for a program of lithological correlation?***

You do not specify what type of samples are available (i.e., core versus cuttings). Generally, split core provides the most representative samples, but often they cannot be taken because the splitting process ruins geologic use of remaining core material. Also, intensive sampling might be too costly. Optimally, I prefer to take at least 3 samples from each distinctive lithology (core), or at 3 m intervals (cuttings) if distinctive lithologies are not recognized. Collect lots of samples for a lithogeochemical interpretation!

- ***Should the sampling method for use as an exploration tool differ from above?***

I do not believe differences should exist between programs of lithological correlation versus exploration methods. The normal constraints on the former involve the need for very careful (and expensive) sample collection or high analytical costs. I believe both can be mitigated by the way I analyze samples from lithogeochemical programs (as indicated below).

- ***Will such a method (both as a means of correlation of lithologies, and as an exploration tool) work in the north Queensland area? Can the method see through intense alteration?***

I cannot be specific about north Queensland, but in general the answer to your question is unequivocally "yes". I recently reviewed lithogeochemical data at our Selbaie Al Zn-Cu deposit (see Whyte and Nichol, 1987, JGE v. 8, p. 165-182) with which, despite warnings by local geologists about "extreme alteration" and "complex geology" and despite the findings in the above paper, the problem could be resolved lithogeochemically in a relatively direct fashion. In all cases, the data speak for themselves.

- ***What is the best approach to both problems?***

Use an aqua regia digestion ICP analysis, then plot the data graphically for all elements. No fancy statistics, factor analysis, etc. Use of whole-rock analysis (lithium metaborate fusion, ICP determination, plus total Ba and total Cr) can cost Cdn. $9.00 per sample, but with the exception of Na and Ti (and Si and total Ba), will not yield much additional information beyond the first procedure which costs about Cdn. $6.50 per sample (prep cost extra).

- ***As an exploration tool for epithermal style gold mineralisation, what trace elements should be included in the analysis?***

The above aqua regia ICP determination will provide As and Sb to 2 ppm detection limits. A hydride generation ICP determination (Cdn. $5.50/sample) can determine these elements to 0.1 ppm, plus

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Questions and Answers

Continued from Page 11

provide Bi to 0.1 ppm, Se to 0.2 ppm, and Te and Ge to 0.3 ppm. These elements are generally sufficient, although you undoubtedly have heard of using Hg and Tl.

Several ideas surround use of Hg. Normal rock preparation techniques involving pulverizing liberates Hg as the sample heats and ruins the analysis, but other procedures are available such as those suggested for looking for radon anomalies in cover rocks over the Jabiluka uranium deposit or at the Delbridge VMS deposit in Ontario. Tl determination costs $3 to $4 per sample and I regard the costs as unnecessary except on special orientation studies (which may document a need for routine application).

• What are some of the basic threshold values both for trace element analysis, and more particularly at this point, for whole-rock values (i.e. how do I know if rock is actually a rhyolite and not a silicified andesite?)?

Threshold values should always be determined locally as a relative value amongst available data, with due regard taken to how high the values exceed analytical detection limits. You would be wise to forget the concept of "key numbers" for one or more elements, but let the data speak for themselves.

As far as whole-rock analysis is concerned, patterns determined after plotting data in section should tell you what you want to know. In looking for epithermal Au deposits which are structurally controlled, considerations such as rhyolite versus silicified andesite should not normally pose a problem. If you really need to know this information, the whole-rock data will have to be synthesized with findings from petrological examinations.

• Are there case studies available that would support the use of whole rock geochemistry in Australia?

I have not followed this question. I can suggest you review the AEG bibliography, but if this does not help perhaps one of the AEG councillors in Australia or CSIRO can help.

• Are there any work-ready, user-friendly computer programs currently available for statistical analysis and interpretation of results?

I made some relatively negative comments on statistical analysis (of the type I think you mean) in a previous answer. The AEG has some computer programs available (PROBPLOT) which are useful, as well as some whole rock programs which are available at nominal cost. I refer you to Eric Grunsky at CSIRO who can tell you what they do and how easy they are to use. The most important computer programs you will need are ones that can plot your data in a "one hole/many element" format, or as plans or sections (see Hoffman and Mitchell, 1984, JGE, V. 21 p. 437-454). What is available will depend on what type of computer you have and how much you would like to spend. I have no recommendations, as the ones I use personally are not available for sale.

I hope these answers are a beginning for your project. Consultations with others are appropriate.

On another thought train, your letter suggests a column for **EXPLORE** where those of the AEG membership willing to assist others with questions such as yours should be given the chance. Unfortunately, this approach will not give you the immediate response you require, but might assist you long term. If you are interested, send to me a maximum 2 page description of Pajingo, including a "cartoon" geologic section which is suitable for publication. Future contributions may or may not include the name of the person asking the questions depending on whether anonymity is preferred.

Questions from:

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Townsville Office
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Australia

Answers by:

Stanley J. Hoffman
Prime Geochemical Methods
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Canada

Editor's Note: Anyone wishing to contribute to the above questions or answers or to other subjects suitable to this forum, should address their correspondence to: Editor, **EXPLORE**, Questions and Answers, Denver Federal Center MS973, Denver, CO 80225, USA.

SPECIAL NOTES

Exploration Geochemistry and The Environment

The impact, cost, and time to meet current regulatory requirements for environmental purposes is being reduced by the application of tools we employ for exploration purposes. Furthermore, application of exploration geochemical sampling methods to document premining conditions both sharply reduces the potential for future environmental problems and can also be used to document premining conditions that probably existed at early mining sites now considered environmental problems and, therefore, now requiring remediation by regulatory agencies. The geochemistry of surface soils, stream sediments, and vegetation can now serve dual purposes; 1) identification of drill targets, and 2) background environmental documentation.

Two exploration geochemical tools are particularly appropriate and accepted by the environmental agencies; field portable x-ray fluoresence instruments (XRF) for the inorganic chemistry of solids and portable gas chromatographs for soil gases and volatile organics. The Environmental Protection Agency initiated an international symposium series on field screening methods to address new and emerging technologies to reduce costs, reduce turnaround time, and increase the scientific confidence in decisions based on chemical data collected at field sites. These goals are essentially the same as the goals for exploration geochemical sampling metholds. The next symposium will be held in March, 1991. A field conference demonstrating the use of three field portable XRF instruments was held December 4th through the 6th at one mining-related superfund site. Additional information about and from the conferences is available from Dick Glanzman (303) 771-0900, ext. 2309.

Richard K. Glanzman
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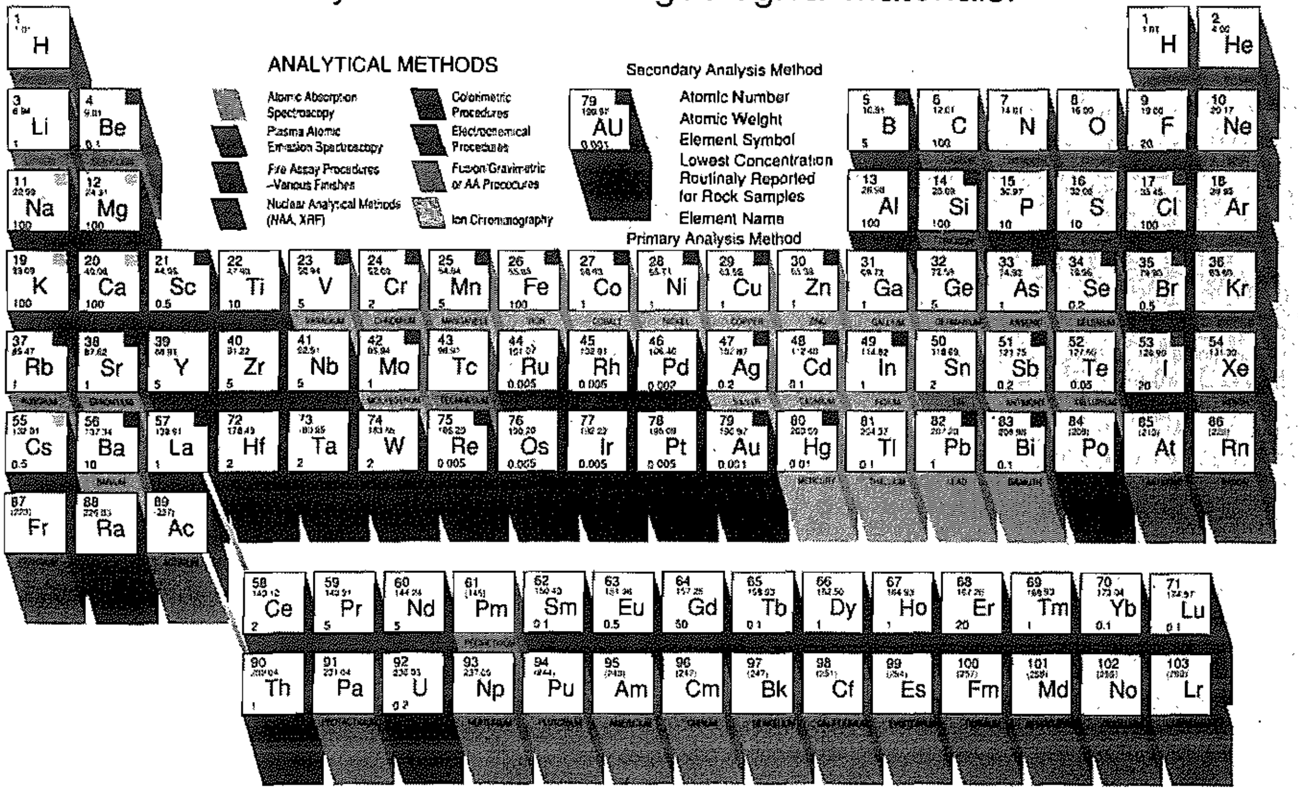
Denver, CO 80222
U.S.A.

Continued on Page 14


ANALYTICAL METHODS
Atomic Absorption Spectroscopy
Plasma Atomic Emission Spectroscopy
Fire Assay Procedures -Various Finishes
Nuclear Analytical Methods (NAA, XRF)
Colorimetric Procedures
Electrochemical Procedures
Fusion/Gravimetric or AA Procedures
Ion Chromatography
Secondary Analysis Method
79 196.97 AU 0.001
Atomic Number
Atomic Weight
Element Symbol
Lowest Concentration Routinely Reported for Rock Samples
Element Name
Primary Analysis Method
H He
Li Be B C N O F Ne
Na Mg Al Si P S Cl Ar
K Ca Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga Ge As Se Br Kr
Rb Sr Y Zr Nb Mo Tc Ru Rh Pd Ag Cd In Sn Sb Te I Xe
Cs Ba La Hf Ta W Re Os Ir Pt Au Hg Tl Pb Bi Po At Rn
Fr Ra Ac
Ce Pr Nd Pm Sm Eu Gd Tb Dy Ho Er Tm Yb Lu
Th Pa U Np Pu Am Cm Bk Cf Es Fm Md No Lr

Special Notes

Continued from Page 12

Proposal for A Standard Laboratory Report Format

Electronic data transfer from analytical laboratories was embraced by the exploration community soon after the first laboratory offered an "electronic mailbox" service. Now, all major laboratories are offering similar services. Electronic data transfer offers many advantages, at virtually no additional cost. Substantially improved turnaround time is achieved by virtue of having all analytical data in a computer processable form as soon as the analyses are completed. Clients are also relieved of the data entry burden and the associated potential for additional errors.

Significant as these advantages are, we believe that the current methods of data transfer could be made much easier with the adoption of a standard laboratory format. Under the current system, each laboratory provides analytical data in their own format. In many cases, laboratories will provide data in a variety of formats, in response to client requests/demands. In addition, laboratories will occasionally change their reporting format, without notice to the clients. This results in each batch of data being a "special case" requiring editing and modifications on an "ad hoc" basis to convert the data from the distribution format to the format required by the application programs the client intends to use. Users of a large amount of analytical data often write computer programs to convert the data from the distributed format to the desired format; however, every time a geologist uses a new laboratory or a laboratory changes its distribution format, the program misbehaves or will not run. The time required to discover the problem and make the necessary program changes often exceeds the time that would have been required to simply enter the data manually.

In addition, laboratory report files often omit important or useful information such as: concentration units, detection limits, lab procedure codes etc. The absence of this important information has led some geologist (and rarely even a geochemist) to read gold values and wonder if they have great opt results or poor ppm results. After all, what does 0.025 gold mean?

The solution to this problem seems obvious. Some neutral organization, such as the AEG, should establish a standard laboratory report format. Laboratories that choose to, could offer data in the standard format, as well as any others they wished. Clients could have a single program or procedure for converting data into a form that they require for processing. Because the standard format would stay constant, minimal program modifications would be required as new laboratories were added. If such a standard was adopted, report reading programs would probably begin to appear in the public domain.

Adoption of the standard format would require additional programming on the part of each participating laboratory, but this would probably be a small requirement when compared to constantly modifying or adding multiple formats at the request of different clients. We believe that laboratories would be quick to adopt a standard as they are generally very responsive to client requests and preferences. Although we do not believe that a laboratory should be selected based on the details of data transfer, we have observed that geologists will refuse to use a particular laboratory because that laboratory's method of data transfer is more awkward than that of others.

We suggest that the AEG form a committee to establish a standard format for laboratory data files. As a starting point, we offer a suggested format as shown in Table 1 and described below.

1. Data files would be in ASCII characters
2. Each sample would be completely represented on one record (line). If numerous variables required that each line exceed 80, 132 or 255 characters per line, so be it.
3. The first 25 characters of a line would be reserved for the sample number.
   a. Sample numbers would be left justified.
   b. Sample numbers would appear exactly as shown on the sample submission form or, secondarily, on the sample bags. No hyphens, blank spaces or leading zeros would be added or omitted by the laboratory.
4. Analytical results would follow the sample number field in a series of 15 character data fields, one for each variable.
   a. The order of the variables would be specified in a file header line (see item 5, line 13 below).

b. The first character of a data field would contain a detection limit flag of < or > when the reported value was outside the analytical range.

c. The next 13 characters would contain the analytical value reported with the decimal place always included. In cases where the results are outside the detection limit, the detection limit would be reported in this field and appropriate detection limit flag would appear in column 1 of this data field, as described above.

d. The fifteenth column would contain various analytical qualifier codes, where applicable. Examples could be: non-standard sample weight used, insufficient sample, interference suspected, etc. Whenever non-standard analytical qualifier codes were used, they would be explained in the *free text* section following the data (item 7).

5. The data section of the file would be preceded by a 14 line header as follows:
    - line 1 laboratory job/batch/report number, laboratory name, laboratory location (city) of sample submission, laboratory location (city) of sample preparation, laboratory location (city) of analysis. When analyses were performed at more than one laboratory location, the predominant one would be reported.
    - line 2 name of individual submitting samples, client project name, client account code or PO number.
    - line 3 type of sample, date samples received, date of report, number of variables determined (number of data fields in data section).
    - line 4 sample preparation code (generic), right justified, in 15 column fields corresponding to the variable represented in the data field.
    - line 5 sample preparation code (laboratory), right justified, in 15 column fields corresponding to the variable represented in the data field.
    - line 6 analytical sample weight (grams), right justified, in 15 column fields corresponding to the variable represented in the data field.
    - line 7 laboratory analytical code, right justified, in 15 column fields corresponding to the variable represented in the data field.
    - line 8 sample digestion, right justified, in 15 column fields corresponding to the variable represented in the data field.
    - line 9 sample extraction or leach, right justified, in 15 column fields corresponding to the variable represented in the data field.
    - line 10 analytical method (equipment or procedure as opposed to sample digestion), right justified, in 15 column fields corresponding to the variable represented in the data field.
    - line 11 normal lower detection limit, right justified, in 15 column fields corresponding to the variable represented in the data field.
    - line 12 normal upper detection limit, right justified, in 15 column fields corresponding to the variable represented in the data field.
    - line 13 variable names, right justified, in 15 column fields corresponding to the variable represented in the data field.
    - line 14 report units, right justified, in 15 column fields corresponding to the variable represented in the data field.
6. The line immediately following the last sample in the report would contain the text:

   END—OF—DATA

   in columns 1-11.
7. Free text, containing whatever information the laboratory wished, could follow the END—OF—DATA line.

Lines 5 and 7 in the header would contain whatever codes the laboratories chose to use and the meaning of these codes should be described in the section after "END—OF—DATA."

Lines 4, 8, 9, and 10 would contain generic codes which would be defined as part of the standard format protocol.

The proposed format obviously contains redundancies and perhaps more detail than many people would require; however clients would be free to skip over any information that they are not concerned with. Laboratories may choose to omit some information and suffer whatever consequences arise if their clients would like to see that information.

Others viewing this format will probably want other information transferred, or perhaps the general format modified. These comments are welcome. If a standard report format is to be adopted, it must be useable by as large a user group as possible.

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Table 1. Example of a standard format for electronic data transfer from analytical laboratories.

```
 1   X12230-981                   Best Assay Labs      Podunk, Nevada  Bullethole, Nevada        Reno, Nevada
 2   Fred Smith              Gold            Hill                    901123-001
 3   soil                    90/11/22                                 90/12/01              4
 4                                    SIEVE < 80#         SIEVE < 80#         SIEVE < 80#         SIEVE < 80#
 5                                             S1                  S1                  S1                  S1
 6                                             30                0.25                0.25                0.25
 7                                           FA30                 G22                 X13                 A32
 8                                LITHARGE FUSION                HN03                HN03                HN03
 9                                                                                   MIBK
10                                 FIRE ASSAY AAS        HYDG GEN AAS                 AAS       COLD VAPOR AA
11                                             10                 0.5                 0.5                 200
12                                         100000              100000              100000             1000000
13                                             AU                  AS                  SB                  HG
14                                            PPB                 PPM                 PPM                 PPM
15   XG-0100-W               <             10.000               6.000<              1.000               0.030
16   XG-0200-W                             21.000               7.000<              1.000               0.050
17   XG-0300-W               >         100000.000               7.000               1.000               0.030
18   XG-0400-W                             19.000               7.000               2.000               0.050
19   XG-0500-W               <             10.000               7.000<              1.000<              0.020
20   XG-0600-W               <             20.000w                   i                   i                   i
21   XG-0700-W                             56.000               6.000               2.000<              0.020
22   XG-0800-W               <             10.000               7.000<              1.000<              0.020
23   END—OF—DATA
24
25   w indicates low sample weight used
26   i indicates insufficient sample available

     column no. →            25                 40                  55                  70                  85
```

Special Notes,

Continued from Page 15

KLIP Geochemical Data Release

Data are now available on floppy diskette from the Kirkland Lake Initiatives Program (KLIP) of the Ontario Geological Survey, a four year, reconnaissance-scale reverse-circulation drilling project in the Kirkland Lake area of northeastern Ontario. The KLIP data complement the currently available database from the overburden sampling program in the Black River-Matheson (BRIM) area, which lies immediately north of the KLIP area. The data should be of great interest to exploration companies.

Data for overburden and bedrock samples collected in the KLIP area from the 1979, 1980, 1981 and 1982 reverse circulation drilling programs have been published as Ontario Geological Survey Open File Reports 5335, 5355, 5356, 5394, 5395, 5456, and 5737. These data have recently been made available as a series of either dBaseIV or ACSII text files on 5.25 inch or 3.5 inch PC-DOS/MS-DOS compatible floppy diskettes. Sample locations, material types, and results of geochemical and mineralogical analyses are provided. Requests for data must be accompanied by the required diskettes: 1) one double sided, high density 5.25 inch disk or 2) one double sided, double density or high density 3.5 inch disk. There is no charge to copy the data onto diskettes.

For more information contact:

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Toronto, ON M7A 1W4
Canada
TEL: (416) 965-1183

Mining, Minerals, and Me

The Mineral Information Institute, a not-for-profit organization, is sponsoring an educational package titled Mining, Minerals, and Me. The package consists of ten activity centered modules designed for use in elementary school classrooms. Each module contains an assortment of rocks, minerals, posters, puppets, handbooks and a teacher's guide which have been designed to help students recognize the significance of our mineral resources and their proper development. Each of the ten modules is oriented towards a specific grade level range from K through 6 and can be purchased separately.

Additional information can be obtained from:

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Deputy Director
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TEL: (303) 297-3226.

Rio '89 Special JGE Volume

All manuscripts have been received, edited, and submitted for publication for the special issue of the Journal of Geochemical Exploration containing papers from the 13th International Geochemical Exploration Symposium held in Rio de Janeiro, Brazil in October, 1989. This JGE special issue will fill all of Volume 40.

Thanks go out to all of the contributers and editors involved in this special volume effort.

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Environmental Monitor

This first *Environmental Monitor* brief is brought to you from an exploration geochemist (an explorationist), who ventured into the arena of environmental scientists (environmentalists). The following chart serves to grossly compare the two fields:

	Explorationist	Environmentalist
subject of investigation	lithosphere, hydrosphere, biosphere, atmosphere	lithosphere, hydrosphere, biosphere, atmosphere
media	soil, water, vapor, plants, microbes, rocks	soil, water, vapor, plants, microbes, rocks (aquifers)
major analytical tools	atomic absorption, ICP, portable GC/MS, portable gas sniffers, pH meter, Eh meter, conductivity meter	atomic absorption, ICP, portable GC/MS, portable gas sniffers, mass spectrometer, pH meter, Eh meter, conductivity meter
data analyses tools/aids	statistical software, kriging, contouring software, databases	statistical software, kriging, contouring software, databases
employers	mining companies, government	government, consulting firms
history	started in 1930's; boomed with the advent of AA and ICP, in the 1960's & 1970's.	started in the 1960's; boomed with increased environmental awareness plus environmental laws in 1970's.

Obviously the environmentalists and the explorationists have a lot in common, and crossovers (in terms of scientific papers and personnel) are very common. If the two groups can compare notes more frequently, they very likely can avoid the "reinvention of the wheel" many times over.

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Environmental Services Group
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Denver-Based Geochemical Exploration Discussion Group

Following a successful trial series of three talks in February-April, 1990, a Denver-based *Geochemical Exploration Discussion Group* has organized a complete program of presentations for the 1990-1991 season.

The meetings are held on the third Tuesday of each month at 4:30 p.m. in Room 201 of Berthoud Hall on the Colorado School of Mines campus. Speakers are asked to prepare presentations lasting approximately 45 minutes and this is followed by 30 minutes of informal discussion. Attendances range from the low 20's to the high 30's and all those interested are welcome to attend.

In late 1990, the Discussion Group heard presentations by Alan Coope and Owen Lavin (Newmont) on the use of standard reference samples, by John Watterson (USGS) on microbiological prospecting and by Richard Horsnail (Amax) on the interpretation of panned concentrate gold anomalies in Eastern Belgium. The ongoing program for 1991 is as follows:

January 22, 1991
MALCOLM MASON, American Copper and Nickel Co.
Bulk Sampling Program and Quality Control of Assay Data, Mineral Hill, Montana

February 19, 1991
RICHARD NIELSEN, Geocon, Inc.
Trace Element Characteristics of Nevada Ores and Metallogenic Models

March 19, 1991
STEVE CONE, Cone Geochemical Inc.
Flow Injection Analysis and Its Application in Exploration Geochemistry

April 16, 1991
AL HOFSTRA, U.S.G.S.
Genetic Models for Jerritt Canyon District

The Discussion Group is continually updating its mailing list and all who would like to receive the monthly mailings should send their name and address to J. Alan Coope, Newmont Exploration Limited, 1700 Lincoln Street, Denver, CO 80126, U.S.A.

Profesional Registration of Geoscientists — British Columbia Notice

The Association of Professional Engineers and Geoscientists of British Columbia is responsible for professional registration of geoscientists by virtue of the Engineers and Geoscientists Act of the Province, proclaimed 2nd August 1990. This is a result of an initiative undertaken by the Association at the urging of many members of the geoscience community.

Prohibition on the practice of geoscience by non-members, as defined by the terms of the Act, is expected about 1st July 1992. This allows sufficient time for individuals engaged in the practice of geoscience to apply for registration. Applications will be accepted beginning 1st January 1991. Information and registration forms may be requested from the Association of Professional Engineers and Geoscientists of British Columbia by mail, telephone, or FAX.

A two year "grandfathering" period will allow present practitioners to apply. This will end 31st December 1992.

The Association of Professional Engineers and Geoscientists of British Columbia
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Vancouver, BC V6K 2N6
Canada
TEL: (604) 736-9808
FAX: (604) 736-2984

ANALYST'S COUCH

Field analysis using an anodic stripping voltammeter

Studies are underway at the Geological Survey of Canada (GSC) into applications of a field portable instrument, the PDV 2000 made by Chemtronics of Australia, based upon anodic stripping voltammetry (ASV). The unit weighs 12 kg, can be battery operated and can fit under an aircraft seat; a complete description is given in Lintern *et al.* (1988). Briefly, the electrochemical cell comprises a glassy carbon working electrode whose surface can be coated with mercury, a Ag/AgCl reference electrode and a Pt counter electrode. Sample and electrolyte solutions are introduced via an entry port in the acrylic cell and are removed following analysis by activating a drain button; a maximum volume of 10 ml is accommodated. Programs are entered using a built-in keyboard and results are displayed, in units of concentration or current generated, on a digital readout or on paper tape. An RS 232C port allows attachment of a microcomputer for data viewing, manipulation and storage. ASV consists basically of two processes: the first step is the deposition whereby metal ions are reduced at the working cathode and are preconcentrated from solution; and secondly, a positive potential scan is applied, stripping the metals back into solution at their respective oxidation potentials, the currents so generated being proportional to their concentrations. The resultant voltammogram provides the analytical data and peak height or area can be measured. The sensitivity achieved is dependent upon the plating time employed (the longer the negative potential is applied, the more metal is deposited) and the sweep or scanning rate chosen. A supporting electrolyte is required to ensure a conductive medium and to minimise migration of ions due to the electrical field; this preference or indeed demand for high salt matrices makes ASV unique compared to atomic absorption spectrometry (AAS) for example where such samples pose analytical challenges. Electrolytes can be judiciously chosen to separate element peaks which would otherwise overlap at a common potential and negate measurement.

The project described in summary form here is the application of the PDV 2000 to the determination of Zn, Cd, Pb and Cu in sulphide-selective leaches and waters. A mercury film is plated initially onto the carbon electrode thus forming a substrate of large surface to volume ratio and providing a high amalgam concentration during analyte deposition. Cadmium, Pb and Cu can be determined simultaneously using a plating potential of -900 mV; Zn is not reduced at this potential and requires a more negative value of about -1200 mV. However, a Cu-Zn intermetallic compound, Cu-Zn_n (n=1,2,3), is formed in the mercury film which is stripped off near the oxidation potential of Cu(-190 mV). This results in a decrease of the Zn peak (-1010 mV) with a corresponding increase in the Cu peak. Gallium is added to preferentially bind with the Cu, thus leaving Zn free to be oxidised. Nickel interferes in a similar manner to Cu on Zn, though to a lesser extent. Figures 1 and 2 demonstrate the tolerance of a 10 $\mu g\ l^{-1}$ (ppb) Zn solution to the addition of Cu and Ni, respectively, in the presence of 500 $\mu g\ l^{-1}$ Ga. In geoanalysis, excesses of Cu and Ni over Zn of 30- and 40-fold are rare; calibration by the method of standard additions (i.e. adding known spikes) was found to be valid when the Zn peak was reduced to 50% but not beyond. A chloro-acetate buffer was used in this work; a sodium chloride-ascorbic acid electrolyte showed a more limited range of tolerance to Cu in analysis for Zn but a wider range (by approximately a factor of two) to Ni.

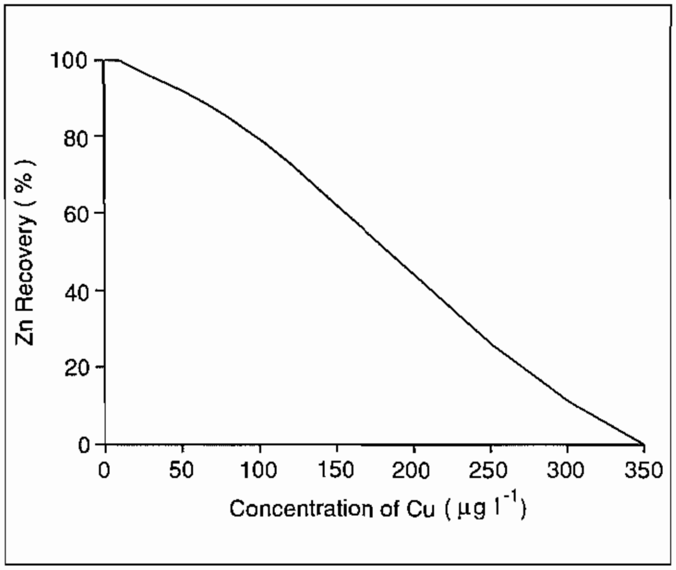

Figure 1. Effect of Cu on a 10 $\mu g\ l^{-1}$ Zn solution in the presence of 500 $\mu g\ l^{-1}$ of Ga.

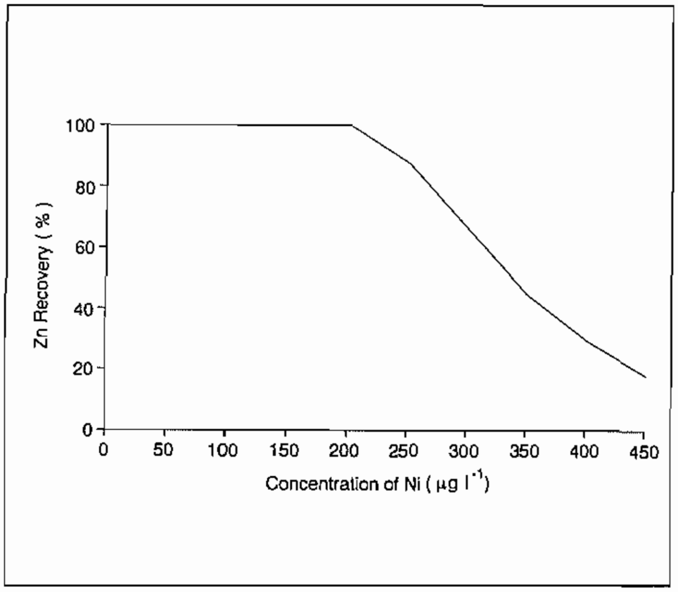

Figure 2. Effect of Ni on a 10 $\mu g\ l^{-1}$ Zn solution in the presence of 500 $\mu g\ l^{-1}$ of Ga.

Table 1 indicates the detection limits obtained for these elements in a 10-ml sample solution at plating periods of 60 and 300 seconds (s) and scan rates of 375 and 900 mV s^{-1}. As the plating time is the dominant factor in the analytical efficiency and a linear improvement in detection power with deposition was not seen, all subsequent work was carried out at a 60-s plate and a 900 mV s^{-1} scan rate. Cadmium was most sensitive to deterioration of the Hg film, manifesting itself in a lack of precision. Plating of the Hg was performed twice daily (5 min. task). Waters were analysed by adding a 5-ml sample aliquot to the cell followed by 5 ml of buffer (+ 500 $\mu g\ l^{-1}$ Ga when determining Zn) and applying one of the two voltage programs. Results are given in Table 2. The method of standard additions was preferred to direct calibration to eliminate any matrix effects and calibration drift; thus analytical time totalled approximately 4 min. per sample for the determination of the Cd, Pb and Cu "package" and 4 min. for Zn. The cell was rinsed with deionised water between samples. Agreement with certified values is excellent for the two reference standards, SLRS-1 and NBS 1643a. Three replicate analyses of 1643a gave the following precisions, expressed as relative standard deviation: 5.5% for Zn, 3.7% for Cd, 1.7% for Pb and 3.8% for Cu. The hydrothermal vent waters were spiked at 10 $\mu g\ l^{-1}$ of Cd and Cu and 12 $\mu g\ l^{-1}$ of Pb; values obtained by ASV and flame AAS following preconcentration with APDC and MIBK extraction agreed well. The Salton Sea brines demonstrate the capabilities of the technique in analysing high salt matrices contain-

TABLE 1. Detection limits for Zn, Cd, Pb and Cu by ASV at 60-s and 300-s plating periods and stripping rates of 375 mV s^{-1} and 900 mV s^{-1}

	Detection limit ($\mu g\ l^{-1}$)*		
Element	375 mV s^{-1} 60-s	900 mV s^{-1} 60-s	900 mV s^{-1} 300-s
Program 1:			
Zn	1.2	0.7	0.6
Cd	0.4	0.3	0.2
Pb	0.4	0.3	0.1
Program 2:			
Cd	0.6	0.5	0.3
Pb	0.6	0.4	0.2
Cu	1.5	1.3	0.8

*The values are given as concentration in a 10-ml solution in the electrochemical cell.

TABLE 2. Results of analyses of water samples for Zn, Cd, Pb and Cu by ASV after a 60-s plating period, with a 900 mV s^{-1} stripping rate

	Concentration ($\mu g\ l^{-1}$)							
	Zn		Cd		Pb		Cu	
Water Sample	ASV	Other[a]	ASV	Other[a]	ASV	Other[a]	ASV	Other[a]
SLRS-1 (river reference)	<2	1.34[b]	<0.6	0.015[b]	<0.6	0.106[b]	3.7	3.58[b]
NBS 1643a (reference)	68	72[c]	8.1	10[c]	29	27[c]	21	18[c]
P1492 (hydrothermal vent)	12	11	9.8	10	12.5	13	9.9	10
P1495 (hydrothermal vent)	37	38	9.4	10	13.5	13	10.0	10
P1494 (hydrothermal vent)	36	34	10.5	10	11.9	12	11.0	10
F25 (groundwater)	378	392	10	11	<0.6	<1	31	29
F72 (groundwater)	426	410	22	21	3.2	4	44	40
S-04 (seep)	26	24	<0.6	<1	<0.6	<1	35	36
Gold creek (seep)	332	344	2.4	3	<0.6	<1	3350	3400
Brine-10 (Salton Sea)	10000	11000	3800	4000	1700	1700	5100	4900
Brine-15 (Salton Sea)	14000	13000	3900	4000	1800	1700	7200	7000

[a] Analysis by flame or graphite furnace atomic absorption spectrometry, unless otherwise specified.
[b] National Research Council of Canada certificate of analysis (1987).
[c] Gladney et al. (1987).

ing up to 5% Na and 15% Cl. The high concentrations of the analytes necessitated 50 μl rather than 5 ml sample aliquots.

The sulphide-selective leach, earlier evaluated by Olade and Fletcher (1974), was employed in this work as it is so readily adaptable to a field laboratory (hot plates etc. are not required). Reference materials (AEG-GXR series and standards prepared under the Canadian Certified Reference Materials Project) were selected to test the ASV technique. To each sample of 500 mg, an equal weight of $KClO_3$ was added, followed by 5 ml of 12M HCl. The test-tube was capped and agitated for 30 min., diluted to 40 ml with water and the residues separated off by centrifugation (settling by gravity in the field). The oxidising nature of the solution precluded taking an aliquot larger than 50 μl for analysis by ASV. Results for Zn and Pb by one program, and for Pb and Cu by the other, are shown in Tables 3 and 4, respectively. The same leaches were analysed by flame AAS for validation and results agree well with the exceptions of Zn in GXR-4 and the UM ultramafic series where the ratios of Cu:Zn are extremely high; well beyond 20:1. The other partial leach data, shown for comparison in Tables 3-4, are those reported by: Olade and Fletcher (1974) using this attack (UMs); Viets *et al.* (1984) using HCl, KI and ascorbic acid (GXRs); and Lynch (1990) using aqua regia. All results for Cd by ASV were below the detection limit of 8 $\mu g\ g^{-1}$, the highest value found by AAS being that of 4.1 $\mu g\ g^{-1}$ in GXR-2.

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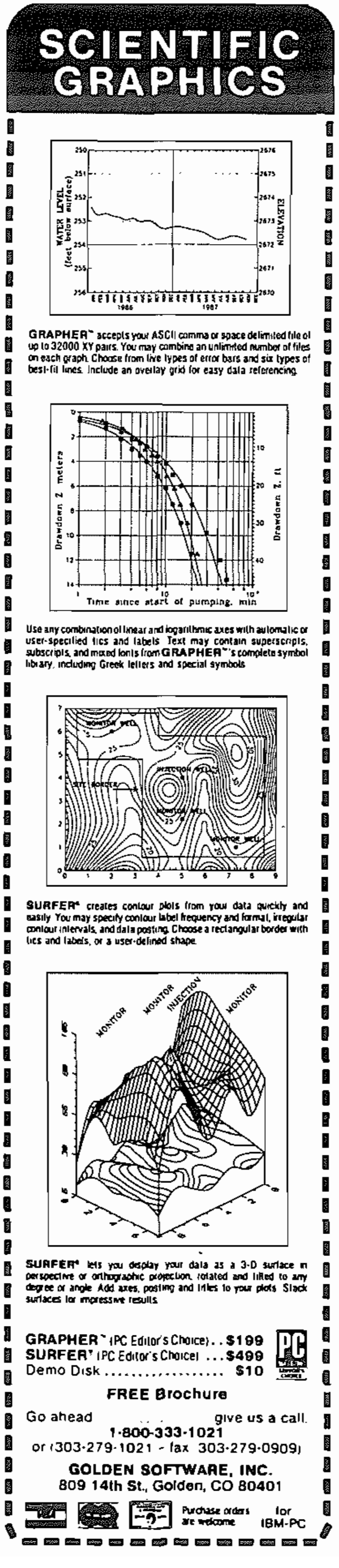

Analyst's Couch *Continued from Page 19*

TABLE 3. Results of analyses of standard reference materials for Zn and Pb by ASV after a 60-s plating period, with a 900 mV s^{-1} stripping rate.

Sample	Concentration ($\mu g\ g^{-1}$)							
	Zn				Pb			
	$KClO_3$-HCl		Other partial leach[b]	Total[a]	$KClO_3$-HCl		Other partial leach[b]	Total[a]
	ASV	AAS			ASV	AAS		
GXR-1	478	490	625	760	558	520	675	730
(jasperoid)	488	500			550	530		
GXR-2	432	450	410	530	665	680	620	690
(soil)	456	470			660	670		
GXR-3 (hot	144	136	170	207	16	14	12	15
spring deposit)	140	139			12	10		
GXR-4	<16	64	59	73	36	38	42	52
(copper millhead)	<16	63			38	39		
GXR-5	30	35	48	49	12	11	13	21
(soil)	34	37			12	13		
GXR-6	58	64	82	118	68	67	73	101
(soil)	60	66			72	65		
UM-1	<16	27	35	97	<8	7		
(ultramafic)	<16	25			<8	6		
UM-2	<16	30	14	32	37	42		
(ultramafic)	<16	15			39	43		
UM-4	<16	11	18	63	15	15		
(ultramafic)	<16	13			15	16		
TILL-4	<16	20		66	28	27		50
(till)	22	20			25	26		
LKSD-4	148	153	189	194	76	87	93	91
(lake sediment)	152	153			76	87		
STSD-4	46	46	82	107	14	11	13	16
(stream sediment)	42	43			15	11		

[a] Values for the GXR-series are taken from Govindaraju (1989); the UM-series from Cameron (1972); and the remaining from Lynch (1990).

[b] Values for the GXR-series are taken from Viets et al. (1984); the UM-series from Olade and Fletcher (1974); and the remaining from Lynch (1990).

TABLE 4. Results of analyses of standard reference materials for Pb and Cu by ASV after a 60-s plating period, with a 900 mV s^{-1} stripping rate.

Sample	Concentration ($\mu g\ g^{-1}$)							
	Pb				Cu			
	$KClO_3$-HCl		Other partial leach[b]	Total[a]	$KClO_3$-HCl		Other partial leach[b]	Total[a]
	ASV	AAS			ASV	AAS		
GXR-1	552	520	675	730	1020	980	940	1110
(jasperoid)	546	530			1035	990		
GXR-2	630	680	620	690	64	68	66	76
(soil)	640	670			68	70		
GXR-3 (hot	15	14	12	15	<21	10	10	15
spring deposit)	13	10			<21	8		
GXR-4	36	38	42	52	5965	6050	2300	6520
(copper millhead)	36	39			5956	6090		
GXR-5	12	11	13	21	310	347	340	354
(soil)	11	13			333	350		
GXR-6	65	67	73	101	28	34	55	66
(soil)	66	65			36	34		
UM-1	<8	7			3684	3660	3896	4100
(ultramafic)	<8	6			3730	3890		
UM-2	35	42			768	830	951	950
(ultramafic)	38	43			800	840		
UM-4	15	15			576	560	594	580
(ultramafic)	13	16			601	570		
TILL-4	25	27		50	128	154		223
(till)	23	26			139	156		
LKSD-4	77	81	93	91	24	28	30	31
(lake sediment)	77	81			28	28		
STSD-4	13	11	13	16	46	52	66	65
(stream sediment)	14	11			52	51		

[a] Values for the GXR-series are taken from Govindaraju (1989); the UM-series from Cameron (1972); and the remaining from Lynch (1990).

[b] Values for the GXR-series are taken from Viets et al. (1984); the UM-series from Olade and Fletcher (1974); and the remaining from Lynch (1990).

The PDV 2000 was tested under field laboratory conditions in the Snow and Ruttan Lake regions of northern Manitoba this summer and found to be very robust. The effectiveness of oil to precipitate Zn, Cu, Cd and Pb from mine processing waste was evaluated together with the potential of using surface waters in geochemical exploration. The use of a microcomputer was mandatory at low levels of these metals to allow the analyst to examine the voltammograms and alter the default mode of peak computation where appropriate. Further application studies are in progress, notably that involving the determination of Au which is supported by 6 mining companies. This technique finds widespread use in environmental analysis where it enjoys the advantage of specifically measuring the "labile" element, i.e. the free hydrated ion and those complexes easily dissociated under experimental conditions. This instrument is also being evaluated for analysis required on-site in electrogeochemical exploration methods ("CHIM" solutions).

N.B. Details of this work are given in a manuscript submitted to *Chemical Geology*.

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Analytical Geochemistry

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

Pertinent papers from Geostandards Newsletter, published in April and October yearly, are too numerous to cite. This newsletter is a "must" for the geochemist. Where the number of authors on one paper is greater than four, "et al." is used. This list covers those issues received by the author since those listed in **EXPLORE** Number 68.

Compiled by **Gwendy E.M. Hall**, Head of Analytical Methods Development, Geological Survey of Canada, 601 Booth Street, Ottawa, K1A 0E8, Canada. Please send new references to G.E.M. Hall, *not* to **EXPLORE.**

A useful issue entitled "Fundamental Reviews", Anal. Chem., *62*, 1990 has been published. Particularly pertinent reviews in this issue include recent advances in ICP-AES, ICP-MS, AAS and electrochemical techniques. An updated "bible" on standard reference materials, their descriptions and elemental concentrations, has been published by Geostand. Newsl. (July, 1989, Spec. Iss.) - this is a NECESSITY for every geochemist concerned with quality control/quality assurance. Requests for this issue can be made through G.E.M. Hall: (FAX (613) 996-9990).

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CALENDAR OF EVENTS

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

■Jan 7-11, '91 Short course entitled "Hydrothermal Alteration: Its Relationship to Mineralization," University of Nevada, Reno, Nevada (Mining, Division of Continuing Education, University of Nevada, Reno; Reno, Nevada 89557. TEL: (303) 784-4046).

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Calendar of Events

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■Feb. 17-21, '91. Exploration in a changing environment, mtg., Sydney, Australia, by Australian Society of Exploration Geophysicists, and Geological Society of Australia (ASEG/GSA, Box 925, Crows Nest, N.S.W., 2065, Australia).

■Feb. 25-28, '91. SME of AIME ann. mtg., Denver, Colorado (Geochemistry: Robert R. Craig, Newmont Exploration, P.O. Box 669, Carlin, NV 89822.

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

■Mar. 11-14, '91. Society of Engineering and Mineral Exploration Geophysicists 4th Annual Symposium on the Application of Geophysics to Engineering and Environmental Problems, University of Tennesse Conference Center, University of Tennesse, Knoxville, Tennesse (Richard A. Hopkins, Chairman, Marrich Inc., 6000 Kaywood Road, Knoxville, Tennesse 37920. TEL: (615) 573-4188).

■Apr. 15-19, '91. Environmental polution mtg., Lisbon, by European Centre for Pollution Research and others (Int'l Conference on Environmental Pollution, 11-12 Pall Mall, London SW1Y 5LU, England. TEL: 01-930-6825; FAX: 01-976-1587)

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

■Apr. 26-May 1, '91. 15th International Geochemical Exploration Symposium, Reno, NV. (Keryl Fleming and Mario Desilets, Nevada Bureau of Mines & Geology, Univ. of Nevada, Reno, NV 89557-0088. TEL: (702) 784-6691, FAX (702) 784-6691.

■Apr. 29-May 2, '91. Remote sensing and exploration geology, mtg., Denver, Colorado (Nancy Wallman, Environmental Research Institute of Michigan, Box 8618, Ann Arbor, MI. 48107-8618, TEL: (313) 994-1200, x3234, FAX: (313) 994-1575)

■May 5-10, '91. Geology of industrial minerals mtg., Banff, Alberta (Wylie Hamilton, Alberta Research Council, Alberta Geological Survey Department, Box 8330, Station F, Edmonton, Alberta, T6H 5X2, Canada. TEL: (403) 438-7676)

■May 13-17, '91. Brazil Gold '91 (USA-Charles Thorman, USGS (Denver), FAX: (303) 236-5448; Canada-C.Jay Hodgson, Queens U., FAX: (613) 545-6592; UK-Robert Foster, U. Southampton, FAX: 59-3052; Australia-David Groves, U. Western Australia, FAX: 9-386-6577)

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

■Aug. 30 - Sept. 3, '91. Source, transport and deposition of metals mtg., Nancy, France (25 Years SGA Meeting, CREGU BP 23, 54501 Vandoeuvre-les-Nancy Cedex, France, FAX: 33-83-44-00-29)

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

■Sept. 16-19, '91. Second International Symposium on Environmental Geochemistry, Uppsala, Sweden (Prof. Dr. Mats Olsson, Department of Forest Soils, Swedish University of Agricultural Sciences, Box 7001, S-750 07 Uppsala, Sweden, TEL: 46 18 672212, FAX: 46 18 300831)

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

■Aug. 24-Sept. 3, '92. 29th International Geological Congress, Kyoto, Japan (Secretary General, IGC-92 Office, P.O. Box 65, Tsukuba, Ibaraki 305, Japan, TEL: 81-298-54-3627; FAX: 81-298-54-3629)

Please check this calendar before scheduling a meeting to avoid overlap problems. Let this column know of your events. Please include telephone number, and telefax number if available.

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FORTHCOMING JGE ARTICLES

Following is the list of titles contained in the next issue of the Journal of Geochemical Exploration to be published.

VOLUME 39, NOS. 1-2 SPECIAL ISSUE

INTERNATIONAL GEOCHEMICAL MAPPING

International Geological Correlation Program Project 259

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edited by ARTHUR G. DARNLEY and ROBERT G. GARRETT
Geological Survey of Canada, Ottawa, Ont. K1A 0E8, Canada

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Preface
International geochemical mapping *A.G. Darnley (Ottawa, Ont., Canada)*
Some problems, strategical and tactical, in international geochemical mapping
Xie Xuejing (Hebei, P.R. China)
Geochemical patterns related to major tectono-stratigraphic units in the Precambrian of northern Scandinavia and Greenland
A. Steenfelt (Copenhagen, Denmark)
Geochemical metallogenic provinces: a discussion initiated by results from geochemical mapping across northern Fennscandia
B. Bolviken (Trondheim, Norway), G. Kullerud and R.R. Loucks (West Lafayette, Ind., U.S.A.)
Regional geochemical data compilation and map preparation, Labrador, Canada
R.G. Garrett, R.M.P. Banville and S.W. Adcock (Ottawa, Ont., Canada)
A comparison of regional geochemical data from lakes and streams in northern Labrador: implications for mixed media geochemical mapping
P.H. Davenport (St. Johns, Nfld., Canada)
Metallogenic domains and their reflection in regional lake sediment surveys from the Meguma Zone, southern Nova Scotia, Canada
P.J. Rogers and A.K. Chatterjee (Halifax, Nova Scotia, Canada), and J.W. Aucott (London, U.K.)
Tectonic terranes, metallogeny, and regional geochemical surveys: an example from northern British Columbia
W.J. McMillan, S. Day, and P.F. Matysek (Victoria, B.C., Canada)
Regional geochemistry and the identification of metallogenic provinces: examples from lead-zinc-barium, tin-uranium, and gold deposits
J.A. Plant, N. Breward, P.R. Simpson, and D. Slater (Nottingham, U.K.)
Application of geochemical mapping techniques to a complex Precambrian shield area in Labrador, Canada
A. Kerr and P.H. Davenport (St. John's, Nfld., Canada)
Modern aerial gamma-ray spectrometry and regional potassium map of the conterminous United States
J.S. Duval (Reston, Va., U.S.A.)

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

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