EXPLORE

The Association of Exploration Geochemists Newsletter

NUMBER 65 APRIL 1989

PRESIDENT'S MESSAGE

Your Association, which was officially founded in 1970, is now beginning its 19th year. We have been, and continue to be, a growing organization with a positive outlook for the future of the minerals industries and allied fields and for the role of the geochemist in today's society.

Most of our members who were active during the early years of the Association in the Executive and Council, and on committees, have now passed their batons to younger members, many of whom are not as familiar with the early history, growing pains, and functioning of the Association. When we were smaller, our day-to-day operation was relatively simple, as compared to today, and could be handled by a relatively few people. As a result, most of the basic guidelines for each position in the Association have been passed on orally to the next office holder and have never been written down.

We are now in the process of compiling information for each office in the Association as well as historical information concerning all past office holders. This information will be put into an ***Operating Handbook*** *that will contain guidelines for present and future officers and committee members. The historical data concerning the Association will provide another way of recognizing past officers, who gave so freely of their time and talents to make the Association what it is today.*

By now, I hope that all of you have read the information that accompanied the 1989 dues notice concerning the delays in mailings of the Journal and the Newsletter. The delays resulted largely from an ongoing effort to increase the benefits of your membership. We are trying very hard to remedy the problem and hope to have the Journal and Newsletter mailings back on track during 1989. Your patience, especially that of new members in 1988, is appreciated by all concerned.

If you have not yet sent in your dues payment, please do so promptly. Follow-up reminders cost all of us time and money. I think your Association has a lot to offer you for your cost of membership. If, for any reason, you have decided not to renew your membership in 1989, I would appreciate your personally letting me know why. Clearly the Association cannot please everyone of you all of the time but we will try to do our best with the resources available. If there is a major problem out there, I want to know about it—and NOW! Thank you.

Maurice A. Chaffee
U.S. Geological Survey
Denver, Colorado

TECHNICAL NOTES

Overbank Sediment as a Sampling Medium in Geochemical Mapping

Editor's Note: *The following contribution from Norway presents some very interesting observations regarding the applicability of stream sediment geochemistry to routine exploration. It questions a basic premise, that active stream sediment is representative of the drainage basin geochemistry. An alternate sample medium is suggested for its superior ability to represent drainage basin geochemistry.*

Collection of active sediments from a streambed in contact with stream water is a widely used sampling medium in geochemical mapping. However, during normal discharge conditions of a river only one or at most a few sources of limited area may be exposed to erosion. The major parts of the stream will approach an equilibrium with its surroundings, which means that erosion and deposition of most places are at a minimum. Consequently clastic stream sediment may reflect only very limited parts of the drainage area.

It may even be that collection of active stream sediments at regular intervals along a drainage channel, a normal geochemical practice, actually provides no more than that which could be obtained from a few samples. Overbank deposits (flood plain sediment) are an alternative drainage sample type with a great potential in geochemical mapping.

Overbank sediments are products of major floods. Water discharge greatly exceeds the volume which flows within the ordinary river channel and material suspended in the water of a

continued on page 6

CONTENTS

Information for Contributors to EXPLORE

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

Format Manuscripts should be double-spaced and include illustrations where possible. Meeting reports may have photographs, for example. Text is preferred on paper *and* 5¼-inch IBM-compatible computer diskettes with ASCII (DOS) format, which can go directly to typesetting. Please include the metric system in technical material.

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

Quality Submittals are copy-edited as necessary without reexamination by authors who are asked to assure smooth writing style and accuracy of statement by thorough peer review. Contributions may be edited for clarity or space.

EXPLORE

Newsletter No. 65 APRIL 1989

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Full Page	U.S.$560
Half Page	U.S.$330
Quarter Page	U.S.$200

NOTES FROM THE EDITOR

Journal of Geochemical Exploration Volume 30, Number 3, and Volume 31, Number 1, have been issued since the last newsletter. The latter issue is the first one to be received by 1988 members. If you didn't get it, check that you paid your dues for calendar year 1988 and write Ines Filicetti at the Rexdale address given on the back cover of this issue.

Eion Cameron, Editor-in-Chief of the *Journal* has announced the following accelerated publications scedule:

31:2 (Regular papers) Feb. 8
31:3 (Regular papers) Mar. 20
32:1-3 (12th IGES) Apr. 12
32:1-2 (Chinese issue) May 12

In addition to the two special issues listed above, a large volume on *Epithermal Gold Mineralization of the Circum-Pacific* is due in 1989 (see EXPLORE 64, p.27).

Those who were not members in 1988 can still join and receive Volumes 31, 32, and 33 of the *Journal* by filling out the form on page 25 and indicating **$50.00 (US)** is being added for a 1988 membership.

Special thanks are due to **Keryl Fleming** of the Nevada Bureau of Mines and Geology for editing assistance with this issue. She has also accepted the demanding position of General Secretary for the 15th International Geochemical Exploration Symposium which will be held in Reno, April 28 through May 1, 1991.

The **Third Notice** of the 1989 dues may be found on page 25. Please check the mailing label on the back cover to see that you have "PAID 1989". Send dues and write about discrepancies to the Rexdale office.

For the same **$42.50** established early in the Association's history, members receive a substantial discount at AEG meetings, this publication, and the *Journal of Geochemical Exploration*. The *Journal* includes the proceedings of the AEG meetings and costs libraries $300 a year. Separately the proceedings volumes, like the three special issues mentioned above, generally cost between $100 and $200 US each.

You may have noticed the **artwork** on page 28 of the last issue. We anticipate a recurring need to fill spaces of varying sizes and invite contributions on mining, exploration, and analytical themes with or without explanations.

EXPLORE 64 was distributed to **4000** different professionals in the exploration industry. In addition to the regular membership mailing, it was disseminated by several council members from a number of booths and tables at the Northwest Mining Association annual meeting and the well attended soils course; by **Stan Hoffman** at the B.C.-Yukon Chamber of Mines meeting; by **Chet Nichols** at the McKelvey Forum in Reno; and by **Clark Smith** at the SME-SEG meeting in Las Vegas. **Marc Beaumier** of the Ministere de l'Energie et des Resources arranged for the issue to be dispersed to exploration geologists throughout Quebec where half of Canada's exploration budget is spent.

We still need **volunteers** to distribute issues at the many local and national meetings. If you plan to attend one in the next six months, please contact us at the Reno address given on the back cover.

Chet Nichols

A NOTE FROM THE SECRETARY

It has come to that time of the year again when the Association needs to nominate a slate of Councillors to stand for election, replacing our out-going Councillors who have served their two-year term. As you know, we have 12 Councillors, six of whom are elected or re-elected each year.

I know that all of you are up-to-date on the Constitution and By-laws concerning the nomination of Councillors but, just in case there are one or two out there who have forgotten, here's how it works. We get our nominations for Council from two sources: (1) by a resolution of the Council and (2) by having 6 voting members nominate a voting member for Council. Traditionally the past President, the President, and the Secretary generate a slate from qualified voting members and present it to Council for approval.

At least two more nominees are needed than the number of positions open. This means that we need 8 nominations about this time every year. In addition, Council members who have served a two-year term can, if they choose, run for a second two-year term. Thus someone can be a Councillor for the Association for 4 years if elected to a second term.

As one of those responsible for generating the slate of nominees, I would like to encourage voting members to consider running for Council.

Right now, our list of nominees comes from voting members who are friends, acquaintances, or otherwise known to the President, past President and Secretary. I would like to see some nominees from outside this rather narrow group and therefore strongly urge and request those of you who have an interest in the affairs of the Association to send in your NOMINATION FOR COUNCILLOR. We don't have all that much time left because we must send out the ballots at least two months before the next Annual General Meeting, which will be in Rio de Janeiro, Brazil, October 1989, so DO IT TODAY!!!

Sherman P. Marsh
U.S. Geological Survey MS973
Denver, Colorado 80225

LETTERS

Membership List and Directory of Geochemical Services

The 1988 Association of Exploration Geochemists Membership Listing and Directory of Geochemical Services was mailed in the fall to the entire membership. The volume has been well received and I was especially pleased to hear from one of the advertisers in Brazil who wrote 'Geosol is very satisfied with, and certainly will participate in the future issues of the Directory'.

Almost a dozen responses have been received from various sources about omissions from the premiere issue of the Directory of Geochemical Services. I would like to hear from anyone else with suggestions, comments, etc. in order to improve the next issue. The offer of Dr. Jose Luis Fernandez-Turiel who wrote 'I wish to become involved as local agent... to ensure that all laboratories, computer services companies, consultants, etc. in Spain, are listed' is exactly the type of offer I would appreciate having from more of the members outside North America. My aim is to produce a Directory with a much greater international representation.

Additional copies of the Directory are available to members for $10 US, or $20 US for non-members.

Yours truly,

Lynda Bloom
Analytical Solutions Ltd.
665 Roselawn Avenue
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Canada M5N 1L1
Tel. (416) 789-0148

Come to the Rio Meeting!

The organizing committee for the 13th International Geochemical Exploration Symposium (IGES) has been steadily planning for the next AEG meeting in Rio de Janeiro during October of this year. Developments for the meeting are moving along well, and on behalf of the organizing committee, we would like to bring AEG members and other recipients of the newsletter up to date.

The 13th IGES will be held as part of an overall event, including the Brazilian National Geochemical Congress, to extend over one week (Oct. 1 to 6). The registration and reception are set for Sunday, Oct. 1, with workshops on various geochemical themes to be held the Monday and Tuesday of the symposium week, coincident with the Brazilian National Geochemical Congress. Plans are firming up, and at present 8 workshops are scheduled. Themes for these are listed below:

1) Analytical Techniques for the Determination of Gold and PGE's; Selective Extraction Techniques Used in Exploration Geochemistry.
2) Geochemistry of Precious Metals in Laterite
3) Design and Interpretation of Geochemical Surveys / Microcomputer Applications in Geochemistry
4) Geochemical Exploration Techniques for Petroleum
5) Carbonatite Exploration
6) Ironstones and Gossans including Isotope Applications
7) Uranium Geochemistry and Exploration in Humid Tropical Terrains
8) Applied Rare Earth Element Geochemistry

The organizing committee is inviting coordinators for these workshops from 6 different countries and the input into these topics of new ideas from such diverse sources promises to be worthwhile.

The Brazilian Geochemical Congress, also taking place on the first two days of the symposium week, attracted over 400 participants from throughout Brazil and from a number of foreign countries when the first congress was held last year. With this demonstrated interest in geochemistry, the event represents an opportunity for all to learn about applications of our discipline in the exciting exploration terrains of Brazil.

During the final three days of the symposium week, the 13th IGES itself will be held. While there is a specific request for papers on the major themes described in the first circular, all quality papers will be considered for presentation and / or publication. We request prospective authors to review the geochemical exploration work they have been involved with and consider submitting a paper to make this symposium a quality event. The call for papers is already announced, and we would appreciate receiving manuscripts on 5.25-inch floppy diskettes as well as the typed versions.

Apart from the paper presentations and workshops, eight excursions to a number of ore bodies and mineral districts — and even to a petroleum production platform — are being arranged. In keeping with the wide range of interests of the delegates, a variety of deposit types has been selected, and excursions will be organized to diverse physiographic regions within Brazil. The destinations of these excursions are as follows:

1) Carajas Mineral Belt. This area in the Amazon Rain Forest represents one of the great mineral occurrences anywhere in the world. Iron ore reserves of over 18 billion tonnes (at over 60% Fe !) accompany deposits of manganese, bauxite, copper, and gold.

2) Iron Quadrangle. In the state of Minas Gerais (General Mines), the iron quadrangle holds a number of Au deposits associated with iron formations including the Morro Valho deposit, which has produced Au for over 150 years. Wits-type Au in quartz pebble conglomerates and the iron formations themselves supply additional interest to this excursion in a very scenic part of Brazil.

3) Carbonatites of Araxa and Tapira. Mineral deposits of Nb, Ti, phosphate, and rare earths will be visited and the geology and geochemistry of the carbonatite deposits where these commodities occur will be reviewed.

4) Gold Mineralization in Bahia. The Fazenda Brasileiro deposit in the Weber greenstone belt and the Jacobina Wits-type gold deposit are included.

5) Proterozoic Copper, Chromium, and Emerald Deposits of Bahia. The Caraiba Copper deposit, the chromium at Campo Formoso, and the emerald deposit at Carnaiba will be visited.

6) Potassium and Magnesium Salt Deposits in Sergipe. Salt deposits of the Taquari-Vassouras evaporites in Sergipe on the eastern coast of Brazil will be visited in this excursion.

7) Campos Basin Petroleum Deposit. A visit to this petroleum basin near Rio de Janeiro will include a helicopter flight to a producing platform.

8) Gold and Emeralds of Goias. The large Crixas Gold deposit and the Santa Teresinha Emerald deposit will be visited on this excursion to central Brazil.

9) Gold, Lead, and Zinc deposits of Paracatu. The large Morro do Ouro gold deposit together with carbonate-hosted lead zinc ores of Morro Agudo are to be visited.

Further details regarding the excursions will be provided in the second circular. The next International Geochemical Exploration Symposium will be a quality event and we hope to see you there.

The Organizing Committee
13th IGES
Rio de Janeiro, Brazil

Journal News

An unusually large number of special issues are expected to be published in 1989, some delayed from 1988. The estimated page size and publication date are subject to large variance. All papers for the 12th IGES and Chinese special issues are edited and are in the hands of Elsevier.

JGE SPECIAL ISSUES

VOLUME	EDITORS	EST. PAGES	EST. PUB.
12th IGES	various	350	March, 1989
Chinese	Xie, Jenness	250	April, 1989
South Africa	Coetzee, Begley	150	June, 1989
Platinum	Dunn et al.	180	October, 1989
Gas Geochemistry	Kesler	120	October, 1989
Geochemical Mapping	Darnley, Garrett	150	November, 1989
Epithermal Gold	Hedenquist, White, Siddeley	450	December, 1989

Eion M. Cameron
Editor-in-Chief
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PERSONAL

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

Clifford R. Stanley receives a great deal of correspondence concerning Special Volume 14, and would like to advise that his new address is Department of Geology and Geophysics, University of Calgary, Calgary, Alberta T2N 1N4, Canada.

Stan Hoffman, past President of the AEG, wishes to advise members that, as of January 1, 1989, he will be offering his expertise as a consultant on behalf of **Prime Geochemical Methods Ltd.** See the advertisement on page 10 for address and telephone number.

TECHNICAL NOTES

continued from page 1

flooding river will be deposited on the river flood plain at an elevation higher than the normal stream channel. New overbank sediment will be deposited on top of older overbank sediment during later floods. Deposits of more or less horizontal strata, varying from a few millimeters to several decimeters, characterize the overbank deposits.

A vertical section through overbank sediment provides a sedimentation history. A composite sample of such a section will give an integrated picture of the chemical and mineralogical conditions in the whole drainage basin over a long time span, and by one sample it is possible to geochemically characterize the whole drainage basin.

Compare and contrast the representive nature of geochemical data obtained from active sediments versus overbank sediment. In Norway, experience in the use of overbank sampling has found that:

- Overbank sediment represents large drainage areas, and can, therefore, be collected at widely separated sample sites. They are more representative of drainage basin geochemistry than active stream sediment.
- Overbank sediments are transported physically in water suspension and little affected by chemical processes compared to stream sediment which occasionally has coatings of secondary oxides. The interpretation of the dispersion patterns of overbank sediments may, therefore, be relatively simple.
- Overbank sediments are less influenced by pollution than traditional stream sediments.
- Since younger overbank sediments are depositd on top of older overbank sediments, shallow sampling may provide evidence of the effects of pollution whereas by sampling at greater depths natural dispersion patterns existing before main epoches of pollution will be obtained.
- Sampling of overbank sediments can be performed at relatively low cost per unit area.
- Overbank sediments are well suited to be sample medium in a geochemical atlas of the world.

Rolf Tore Ottesen *and* **Tore Volden**
Geological Survey of Norway
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Gases as Geochemical Indicators of Concealed Mineral Deposits

Explorationists are coming to the realization that the days of easy prospecting are over. We find more and more that our search leads us to areas covered by barren, exotic overburden. If we are to find new mineral deposits, we have to develop new geochemical techniques to "see through" this overburden.

One such technique is to look for gaseous indicators that are exhaled from blind deposits. This idea is not new. In the classic volume on mining, ***De Re Metallica*** published in 1556, Georgius Agricolla noted ...*we search for the veins by observing the hoar frost, which whitens all herbage except that growing over the veins, because the veins emit a warm and dry exhalation which hinders the freezing of the moisture....* We can only speculate on the number of veins found by prospectors who heeded this ingenious observation, but modern investigators are indeed finding gas anomalies over buried deposits.

In this article I will discuss briefly the generation and migration of gases, how they are sampled and analyzed, factors affecting gas anomalies, present a case history of their use in glaciated terrain, and note some disadvantages.

Generation Earth outgassing continues today and a great variety of gases are expelled through volcanoes, spreading centers, and deep-seated faults. However, the gases that are most useful in geochemical exploration result from interaction of ore and gangue minerals with the hydrosphere, biosphere, and atmosphere. Sulfur gases, such as H_2S, CS_2, COS, and SO_2, are produced by reaction of ore and gangue minerals with groundwater. Sulfuric acid is a common product of sulfide oxidation, and, when these waters react

AEG ANNUAL GENERAL MEETING

14TH INTERNATIONAL GEOCHEMICAL EXPLORATION SYMPOSIUM

5TH SYMPOSIUM ON METHODS OF GEOCHEMICAL PROSPECTING

Prague, Czechoslovakia • August 29-31, 1990

Sponsors:
Association of Exploration Geochemists
International Association of Geochemistry and Cosmochemistry
Prague Geological Survey *and*
other geological organizations of Czechoslovakia

Symposium Themes:
1. Geochemistry related to human activity
2. Geochemical mapping: regional, ecological, and ore districts
3. Mathematical processing of geochemical information
4. Geochemistry of ore systems (U, Au, Pt, W, Sn, Cu, Pb, Zn and others): new approaches to solving prospecting and prediction problems

Pre-symposium Workshops August 28:
1. Panning in geochemical prospecting and its integration with other geochemical prospecting techniques
2. Biogeochemical research and prospecting
3. Geochemical modelling of ore districts
4. Teaching in geochemistry
5. Analytical techniques and reference samples
6. Geochemical data bases

Panel Discussions August 28-31:
Subjects to be announced.

Excursions:
★ August 25-27 Deposits of gold, scheelite, tin-tungsten, and polymetallic ores in southern and western Bohemia.
★ August 28 Geological and ore-deposit localities in the vicinity of Prague.
★ September 1-4 Polymetallic deposits in eastern Bohemia and Moravia and deposits of gold and polymetallic ores in the neovolcanites of Slovakia.

Exhibitions:
- Science publications and apparatus, computer technology and programmes.
- Films and videos on geochemical prospecting and geochemical solution of ecologic problems.

Official Language: English with a possibility of translating Russian contributions into English.

Abstract Deadline: June 30, 1989

All members of the AEG received the first circular directly from Czechoslovakia. For more details contact: ***Dr. Frantisek Mrna*** *General Chairman, Geological Survey of Prague, 118 21 Praha 1, Malostranske nam. 19, Czechoslovakia.*

with calcareous minerals, CO_2 is produced. Helium and radon produced by radioactive decay have been used in the search for deposits of uranium and thorium. Hydrocarbon gases (and helium) have been useful guides in exploration for oil and gas fields.

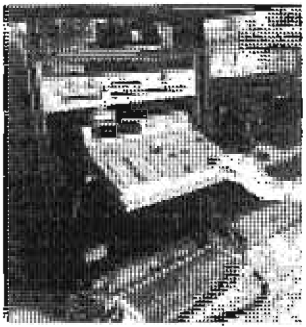

Figure 1. Truck-mounted gas analyzer (quadruple mass spectrometer) and programmable calculator.

Migration. Gases naturally migrate from regions of high pressure to regions of low pressure; i.e., from depth toward the surface. The two mechanisms of migration are (1) diffusion and (2) mass transport. Diffusion of gases, particularly through dense solids, is a very slow process (millimeters/year). Mass transport, on the other hand, can result in rapid movement of gases, because they are transported in a fluid (vapor or liquid) through interconnecting open spaces. Gas movement through faults and fractures has been documented, and indeed concealed faults have been mapped by measuring gases emanating from them. Similarly, gases readily move through soil or other unconsolidated overburden. Mass transport is probably the dominant mechanism that brings gases to the surface.

Affecting Parameters. Gas exhalatiions have been found to correlate with changes in barometric pressure. Field studies measuring radon and mercury vapor show that maximum outgassing coincides with maximum rate of fall of barometric pressure. Increased gas exhalation has also been found to correlate positively with earth tides and gases vent from faults during earthquakes as a result of increased permeability caused by tectonism.

Some gases are quite soluble in water, for example H_2S and SO_2, and may form solid or non-volatile compounds that preclude their escape to the surface. Groundwater has displaced helium anomalies up to 2 km from their source before venting. Rain can "seal-off" surface soil and inhibit or occlude the exhalation of gas.

Sampling. Gases are sampled by (1) extracting interstitial soil air from shallow depth, (2) placing collectors in the ground for extended periods of time, or (3) degassing soil or rock by heating. Soil gases are commonly sampled at a depth of 1/2 to 1 meter by drilling a hole with an auger or by driving a hollow probe into the ground. Either method must insure that atmospheric air is excluded.

Collectors composed of activated charcoal, zeolites, metal, or plastic are buried in the ground at shallow depth and left for 1 to 3 weeks. Gases are absorbed on these materials and later desorbed for analysis. Such collectors have the advantage of averaging short-term variations in gas exhalation.

Soils are good natural gas collectors because their organic and clay mineral constituents readily absorb gases. Rocks contain occluded or absorbed gases that are released by heating the pulverized rock for analysis. Some investigators measure gases in fluid inclusions; not only are these measurements applicable to geochemical exploration, but they can constrain or characterize ore-forming solutions.

Analysis. Early work on gases was hampered by inadequate and time-consuming analytical methods. Advances in analytical instrumentation, notably the gas chromatograph (GC) and the mass spectrometer (MS), now permit rapid and reliable analysis of gases.

Using a GC, several gases in a sample can be separated and analyzed. Good sensitivity is achieved by selecting different columns, detectors and operating conditions.

Mass spectrometers, especially the compact, quadruple types, are increasingly used for gas analysis. Many gases can be analyzed by rapidly scanning a broad range of masses (commonly from mass 2 to mass 300). The USGS uses the truck-mounted MS, shown in Figure 1, to perform gas analysis in the field. Small hand-held instruments analyse for single gases in the field, for example for O_2, CO_2, Rn, and helium. All instruments are calibrated with standard reference gases.

Mass units from AMU 2 to 100 are scanned in about 45 seconds and analytical data are recorded on magnetic tape.

Case History. Soil gas anomalies for CO_2 and O_2 along a traverse over a massive sulfide deposit in Wisconsin are shown in Figure 2. Stratabound massive sulfide ore occurs in metasediments and metavolcanics that are covered by up to 65 m of glacial overburden. Acid ground waters, resulting from dissolution of sulfide minerals, react with calcite to produce the CO_2. Oxygen is consumed in this reaction and negative O_2 anomalies

coincide with the positive CO_2 anomalies. Geochemists in Great Britain and the USSR have found similar antithetical O_2 and CO_2 anomalies. Concentrations of metals in surface soil samples did not reflect the deposit.

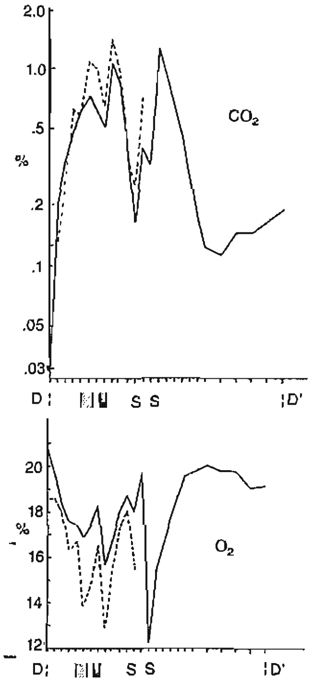

Figure 2. Plots of CO_2 and O_2 in soil gas along a traverse over the Crandon massive sulfide deposit, Wisconsin, USA. Tick marks on horizontal axis are sample sites; sampling interval is 15 m except at the right where it is 30 m. Total traverse length is about 450 m. Hachured block = stringer ore, dotted block = massive ore, s = isolated lenses of sulfides. Solid and dashed lines represent sampling and analysis on two different days.

Other Applications. At one time oil and gas deposits were discovered by finding hydrocarbon megaseeps on the surface. Oil and gas exploration today uses the detection of microseeps of hydrocarbon gases. These seeps may have no obvious surface expression but they can be direct indicators of oil or gas fields at depth. Gas caps in some fields contain several percent He, and soil gas He anomalies have delineated petroleum deposits. Hydrocarbon gases have also been found over base and precious metal deposits.

Disadvantages. Gases are more difficult to sample and analyze than soil or rock. Many natural phenomena such as barometric pressure and rainfall affect gas exhalations. Gas anomalies can be displaced by groundwater, or along faults. Knowledge of the geology, mineralogy, and hydrology in the exploration area helps to interpret gas anomalies.

Gas measurements do offer hope for prospecting in areas covered by exotic overburden (alluvium filled valleys, gravel covered pediments, glacial till, or barren rock) where conventional surface sampling may fail. They are at least one more tool in the prospector's "bag of tricks."

The work of many people is included in this note without giving credit. I would be happy to send a list of references to anyone interested.

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A Test in Pattern Recognition:

Defining Anomalous Patterns in Surficial Samples which Exhibit Severe Nugget Effects - II

In the technical note of the same title in EXPLORE (No. 63, July 1988, pp. 12-14), the groundtruth of a computer-simulated Au geochemical anomaly (Figure 2a), and two realizations of that groundtruth were presented.

These two realizations were collected with sample sizes such that an an average of 0.25 and 1 grain per sample (Figures 2b and 2c, respectively) were collected over the anomaly.

A third realization of an unknown groundtruth (with sample sizes corresponding to 0.25 grains per sample) was presented in Figure 2d.

As promised in the first technical note, the groundtruth for the realization of Figure 2d is presented in Figure 3a and a similar realization from this groundtruth using a sample size corresponding to, on average, 1 grain per sample is presented in Figure 3b.

For both of the example groundtruths and their realizations presented in these two articles, it appears possible to correctly define the location of the anomaly with samples containing, on average, 1 grain per sample (Figures 2c and 3b), but virtually impossible to correctly define the location of the anomaly when sample sizes producing, on average, 0.25 grains per sample are used (Figures 2b and 2d).

Clearly, larger sample sizes have improved our ability to recognize the anomaly because they have decreased the variance produced by the nugget effect and created a more stable geochemical response.

Sampling theory (Gy, 1982), grain size studies (Clifton et al. 1969) and Poisson statistics (Ingamells 1981; Figure 1) have demonstrated that extremely large sample sizes are generally required to obtain Au analyses with precisions of 50% or less.

Unfortunately, the precision associated with the realizations using sample sizes corresponding to, on average, 1 grain per sample is 200%, calculated using the following formula:

$$p = \frac{200}{\sqrt{g}}$$

where p is the precision expressed in % (equal to twice the coefficient of variation - standard deviation divided by the mean) and g is the average number of grains in the sample.

This is much higher than the 50% precision level, which based on theoretical considerations, has been recommended by several authors (e.g. Clifton et al. 1969); yet in the example shown, the precision is low enough to allow us to define the correct location of the simulated anomaly.

This apparent discrepancy is not a result of these specific randomly sampled realizations of the groundtruths, but rather can be shown to be caused by several other important factors.

First, the objective of the geochemical survey must be considered.

One may wish only to locate an anomaly, or may wish to go further by locating the anomaly and defining the sample site containing its highest relative concentration.

Obviously, in the second case, a lower level of analytical precision (high level of sample reproducibility), and thus a larger sample size, is required.

The second factor which must be considered is the number of samples which were collected from anomalous sites.

Clearly, if the sample density of the survey is so low that only one sample will likely be collected from anomalous material, a very high level of sample reproducibility (low level of precision) is required to ensure that the sample records an anomalous concentration.

The chance of detecting the anomaly (c) will be equal to the chance of detecting a gold grain in the anomalous sample (d), and thus is only a function of sample size (at least for this case).

However, if several samples will likely be collected from anomalous material, either because of a larger sample density or a larger anomaly, the chance of detecting the anomaly in one of these samples can be calculated by the following formula:

$$c = 1 - (1 - d)^n$$

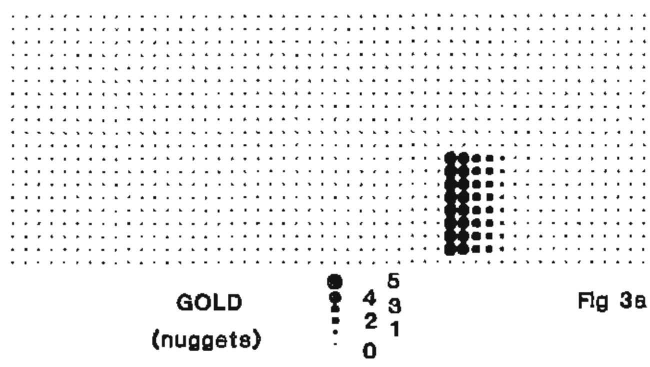

Fig 3a

Groundtruth for Au-bearing quartz vein with eastward dispersion (size of dots represent relative concentrations). Groundtruth for figure 2d.

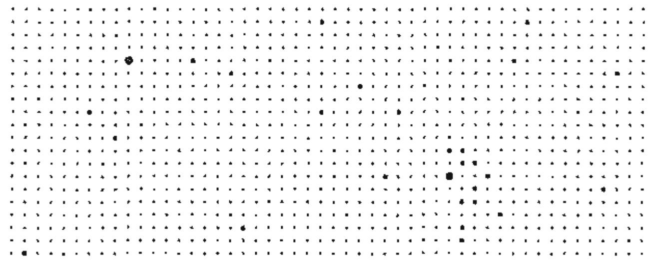

Fig 3b

New Horizon Software.

Sample realization of groundtruth (3a) using (given a specific anomalous concentration) an average of 1.00 nugget per sample at the anomalous sites.

where n is the number of samples collected from anomalous material.

The chance of anomaly detection is no longer solely a function of d, the chance of detecting at least one gold grain in an anomalous sample; it is a function of both d and n.

Thus, if 5 samples were collected from anomalous material and each of these samples had a 20% chance of containing a gold grain (corresponding to an average of approximately 0.25 grains per sample), the chance of one of these 5 samples being anomalous is 67%.

With 10 samples collected from anomalous material, the probability of obtaining one anomalous sample becomes 89%.

Clearly there is safety in numbers.

The last factor considered here involves the criteria by which we define a set of anomalous concentrations as an anomaly.

These will vary depending on the circumstance of the survey, but for a single element which is subject to a nugget effect, these criteria will largely be a function of the number and spatial distribution of the anomalous samples (i.e. - the pattern the anomalous samples make on the map).

The absolute magnitudes of the sample concentrations will generally be less important due to the large variance imposed by the nugget effect.

Thus, we may require that several nearly adjacent samples record anomalous concentrations before we confidently consider the region they define to be an 'anomaly'.

The chance of obtaining anomalous concentrations in m of the n samples collected from anomalous sites can be calculated by the following formula:

$$c = 1 - (1 - d^m)^h$$

where:

$$h = \binom{n}{m}$$

Thus, if we require that 2 of 5 samples collected from anomalous material record anomalous concentrations before we have enough confidence to say we have correctly located the anomaly, the chance of anomaly detection becomes 34%. If 3 of the 5 anomalous sites must record anomalous concentrations, the probability of detection drops to 8%. Raising the requirements for anomaly detection reduces the probability of detection.

Therefore, the probability of anomaly detection is dependent on a variety of factors.

Those factors considered here include the size of the sample, and thus the chance of collecting a gold grain from an anomalous site, the number of anomalous sites, and the number of samples which must be anomalous before the 'anomaly' can be located with confidence.

It is important for geochemists to consider all of these factors in light of their survey objectives in order to define the sample size required to produce a survey which has only a small chance of not detecting an anomaly when it is present.

In this way, exploration expenses can be directly related to the probability of anomaly detection, and geochemical surveys can be designed and implemented in the most cost efficient manner.

This brief example forms part of a larger project investigating the relationships between sampling theory, sample size, sample density, pattern recognition, cost effectiveness and practicality (logistical feasibility) in geochemical exploration surveys.

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Terrain Analysis in Exploration Geochemistry

An examination of the characteristics of the surficial geologic landscape is an essential step in any land-use planning process. Terrain geologists commonly assess properties of the landscape which may have an environmental or engineering effect on a resource use or development (i.e. aggregate and mineral extraction, forestry operations, pipeline and hydroelectric development, settlement location facilities, etc.). Mapping of terrain and soil landscapes also has great potential for use in geochemical exploration programs, such as to determine depth of overburden, direction of glacial transport, and deglaciation patterns.

Most of the Canadian Cordillera has been subjected to multiple glaciations in the Pleistocene, and glacial deposits have been subsequently reworked in the Holocene. Terrain analysis (surficial geological mapping) provides information about the physical characteristics of the surficial geologic landscape. Among important parameters affecting lateral and vertical geochemical dispersion which can be evaluated are:

- genesis and composition of surficial deposits
- direction of glacial transport and source of transported debris
- glacial stratigraphy, thickness of surficial deposits, and depth to bedrock
- landform-geologic boundary relationships
- slope gradient, aspect, and position
- soil type, texture, and composition
- site drainage, seepage, and groundwater flow patterns

Exploration decisions based on results of incorrectly designed or interpreted soil surveys can prove costly. Highly variable sample composition, genesis, depth of deposit, landscape position and drainage regime can introduce *excessive noise* into a data set. Discussion of many of the effects various site and physical properties have on geochemical dispersion patterns is presented in an SEG-AEG publication by **Fletcher et al. (1986),** *Exploration Geochemistry: Design and Interpretation of Soil Surveys.* Important soil descriptive parameters are: site topography, site drainage, groundwater movement, overburden transport and origin, sample texture, soil type and soil horizon, and depth to bedrock.

The Terrain Classification System (Ryder and Howes, 1984), provides a standardized system for classifying surficial geologic materials and their dominant physical characteristics. Aerial

Figure 1.

photographs are used to map the distribution of different terrain types of large, often inaccessible areas in a cost-effective manner. By combining stereoscopic analysis of aerial photos with ground truth followup, a terrain scientist is able to reliably map and describe the distribution of discrete terrain units using genesis, texture, drainage, landform expression, slope and geomorphic process (e.g., mass wasting). Terrain maps are commonly displayed on a photo mosaic (Figure 1), topographic (Figure 2), or orthophoto base. The landscape represented within the dashed square of Figure 2 is displayed by the 3-dimensional sketch of Figure 3.

Unfortunately, terrain maps are rarely prepared prior to designing and/or interpreting soil surveys. Why unfortunately? A preliminary photo interpretation of the surficial geology could significantly enhance the effectiveness of a sampling program, thereby reducing costs. For example, appreciating the direction of ice movement, location of deep overburden, genesis of soil parent material, location of wetlands, and recognition of areas of thin overburden cover can fundamentally affect where a survey is conducted, what sample density is selected, and how the data are interpreted. The subsequent geochemical interpretation might benefit from orientation and/or followup of the surficial landscape by field terrain mapping to augment or refine the photo interpretation.

As an example, consider the broad, northern valley of Figure 1 underlain by sedimentary rocks. Tributary valley glaciers coalesced in the main valley and then flowed in a northwesterly direction. Rock outcrops, shallow colluvium (talus), and thin glacial till occur on the steeper, mid to upper slopes (Rs/Cv, Rhs/Mbv/Cbv, Ca, Rs/Cbv). Geochemical anomalies in these areas would be generated by active downslope mechanical and hydromorphic dispersion and would normally lie close to their source (25-300 m). Anomalies in shallow-till on some midslope areas (Mbv/Rh/Ov) reflect a close-to-bedrock source although mechanical transport is mainly subparallel to the valley ice movement. Hydromorphic anomalies could be located by sampling seepage zones, streams, or shallow organics (Ov).

The lower slopes are mantled by thicker till (probably 1 to 3m average depth) with scattered organic deposits occupying wet depressions (Mbh/Obv). Geochemical anomalies in well-drained tills display a theoretical characteristic shape comprising a sharp up-ice cut off with concentrations declining and the anomaly broadening in a down-ice direction. Secondary hydromorphic anomalies are likely to form in the organic wetlands.

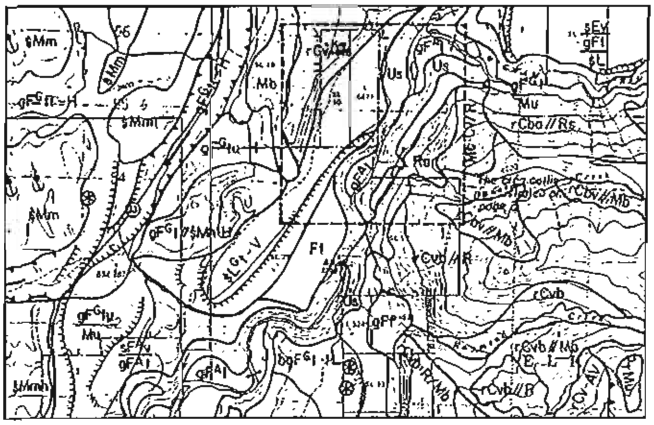

Figure 2.

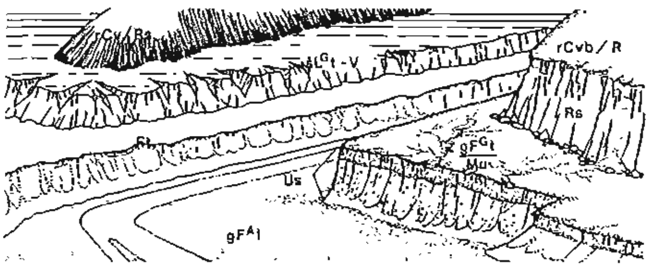

Figure 3.

In the valley bottom secondary dispersion is important and sampling bogs (Ob, Obv) and stream sediments (FAL) is likely to locate hydromorphic anomalies. Thick till and hummocks and ridges of stratified drift (Mb/FGr, FGrt/obv, FGr/Mb) probably prevent the easy recognition of the bedrock sources of mechanically derived anomalies without trenching or deep overburden sampling.

Mineral exploration in glaciated areas is often made difficult by the presence of overburden. However, a terrain scientist working with a geochemist should, in most cases, be able to determine how the glacial sediments can be used to indicate rather than obscure bedrock sources of mineralization. A correctly designed and interpreted geochemical survey, incorporating fundamental terrain analysis, can result in significant time and cost savings to an exploration program. In fact, the cost involved in carrying out terrain mapping is very small in comparison to the money which can be wasted on poorly designed programs and incorrectly interpreted results.

The **Pearl Harbor File** has been discussing the interpretation of soil survey data from a VMS property in Newfoundland. In this issue the column illustrates how geochemical interpretation can benefit from a terrain analysis.

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Ryder, J.M. and D.E. Howes, 1984 *Terrain Information - A User's Guide to Terrain Maps in British Columbia.* Surveys and Resources Mapping Branch, Ministry of Environment, Victoria, B.C. 16p.

PEARL HARBOR FILE

Volcanic Massive Sulphide in Newfoundland — Conclusion

Part 1 and Part 2 of the VMS case history reported in Issues 62 and 63 indicated that strikingly different soil survey results could describe the same area, a factor attributed to sampling. The second set of data is probably more reliable, a judgement based on a more homogeneous data set and less erratics in the distribution of elements such as Fe and Mn. We found that it was a mistake to believe the first set of data without confirming the occurrence of anomalous conditions. Money would have been wasted, probably nothing of importance discovered, and control of the land relinquished. Is this an odd example, or could it be the norm? How many readers of this column have tested the quality of their data before proceeding to the next stage of exploration? I would appreciate hearing your experience on this matter.

This property continues to be under active exploration and a VMS prospect has yet to be discovered. In order to provide some suggestions on what should be done next, I asked Mr. Denny Maynard, a terrain geologist who has written a separate column in this issue, to examine the surficial deposits of the property through an air photo interpretation. This exploration procedure sees only rare application, but in view of its low cost and excellent potential to *save* needless expenditures through a focussing of effort, it would be my recommended followup aproach.

The interpretation provided by Maynard is summarized on Figure 6 and has been augmented by discussions with the author and reference to published regional Quaternary reports and maps. We should always be careful of the tendancy of specialists to interpret property data independently of each other, without reference to other workers on the same ground, to the detriment of their own recommendations.

The sampled landscape is rather featureless, covered by glacial till of variable thickness. Bedrock-controlled ridges, mantled by thin till (probably ranging from 0.5 - 3 m depths) occur in the west of Figure 6. Erosional slopes and incised stream channels in the northeast also have bedrock close to surface. Subdued gentle slopes underlain by till up to 15 metres thick drain to the north and east. Wetlands, occupied by thin organic deposits, occur in linear depressions within the ridged terrain and in larger depressions on the subdued ground.

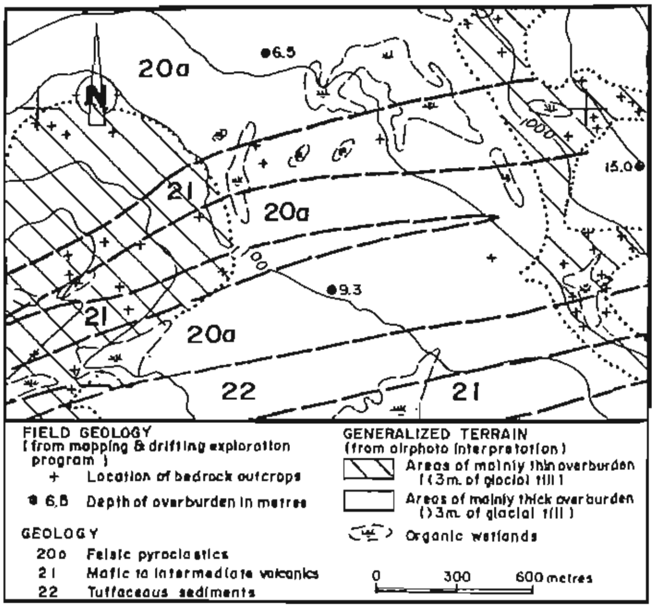

Figure 6.

Very few archive soil anomalies of any element are associated with the *shallow to-bedrock* ridged terrain (other than in seepage depressions) in the west. This implies a bedrock source of significant concentrations of base metals is unlikely in this area. By contrast, multielement soil anomalies in the east coincide with areas having less than 3 m of drift. Areas of thicker till are not associated with many anomalous signals. Clearly, data from the latter areas should be considered separately from data from the thin drift environments.

Quaternary maps and the local terrain suggest the last ice-flow direction was southwesterly. Earlier glaciations probably followed a more extensive southward flow. Bedrock sources are thus predicted to lie to the north and/or northeast. Tills representing both flow directions occur in the area of thicker overburden. Geochemical signatures from bedrock immediately underlying anomalous soil sites are unlikely to be translated to the surface soil through 8 to 10 metres of low permeability till without lateral displacement. Possible presence of an early till deposited by southward flowing ice would complicate interpretation by providing a second source in addition to a source northeast of an anomalous area where the bedrock is near the surface.

A program of trenching, pitting or deep overburden sampling would determine the three dimensional characteristics of surface soil anomalies and check for chemical and physical differences in underlying till. Till fabric studies reconstructing vertical variation in ice directions would assist in predicting probable location of bedrock sources of metal responsible for the surface soil anomalies. Predicted source area locations could then be compared to positions of known conductors to establish drill targets.

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ANALYSTS' COUCH

Bias in Analyses for Gold

A significant trend in the values obtained for Au in rocks by various methods has been reported previously (Hall and Bonham-Carter, 1988). It was found that the mean value by direct neutron activation analysis (INAA) was greater than the mean by fire assay-based methods (FA) which, in turn, was greater than the mean value by methods incorporating wet chemical digestion (e.g., aqua regia, AR). This pattern was also evident in a round-robin analysis carried out to characterize three soil reference samples for Au in which 15 commercial laboratories and the GSC participated. The results for these and two porphyry copper drill-core samples are illustrated in Fig. 1.

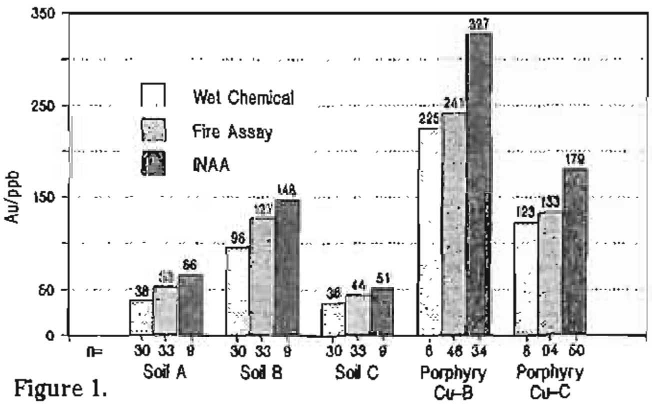

Figure 1.

Mean Au values for replicate analyses of five reference samples by three distinct methods

The data fall clearly into three groups of analytical methods classified according to sample decomposition procedure, regardless of the final measurement technique employed (Table 1). For the three soils, the average value for Au obtained by wet chemical methods is 58-70% of that by direct INAA, while the corresponding figure for the two drill-cores is 69%. Methods based upon fire assay (e.g., FA/AAS, FA/ICP-ES) yield, on average, 81-86% of the mean value obtained by INAA for the soils; the corresponding figure for the drill-cores is somewhat lower, at 74%.

These differences are significant as the precision associated with each mean is good. For example, analysis of soil A in triplicate by three INAA laboratories yielded a relative standard deviation of 10%. The low results for these and 31 rock samples by AR/GFAAS were investigated further at the GSC. Recoveries of Au spikes added to the sample during digestion confirmed that there was no evidence for loss of Au by adsorption of the undissolved sample, reduction to metallic Au or vaporization.

The residues remaining after aqua regia digestion were filtered off and analyzed by INAA. Significant amounts of Au were found in the residues, sometimes even exceeding the amount

TABLE 1. Classification of methods

	WET CHEMICAL	FIRE ASSAY	NEUTRON ACTIVATION
Decomposition	Aqua regia or $HBr - Br_2$ Separation by extraction into MIBK	Pb fire assay Separation via cupellation into Ag bead	None
Analysis	Flame AAS GFAAS ICP – ES	Flame AAS GFAAS DCP – ES INAA (Ag bead) ICP – MS	INAA directly

AAS Atomic absorption spectrometry
GF Graphite furnace
ICP Inductively coupled plasma
DCP Direct current plasma
ES Emission spectrometry
MS Mass spectrometry

leached. This is illustrated graphically in Fig. 2. The best-fit line obtained by plotting Au by AR/GFAAS vs Au by INAA has a slope of only 0.55. However, when the Au remaining in the residue is added to that leached by aqua regia and this value is then plotted against Au by INAA, a slope of 0.95 is obtained which is not significantly different from 1.00. Hence, indications are that the INAA value is accurate and that aqua regia is ineffective in solubilizing all the Au.

Modifications to the aqua regia procedure, such as prior evaporation with HF or HCl, did not improve results. Typically, the weight of the residue remaining after HF-aqua regia decomposition on a 10-g sample would be about 8 g (i.e., it is not a "total" attack). The distribution of Au in these soil samples was particularly homogeneous. A decrease in the sample weight from 10 g to 1 g while maintaining the volume of aqua regia at 25-30 ml did increase the extraction efficiency dramatically (Table 2). Addition of HF further improved extraction to the point that results are virtually identical to those by INAA. Reduction of

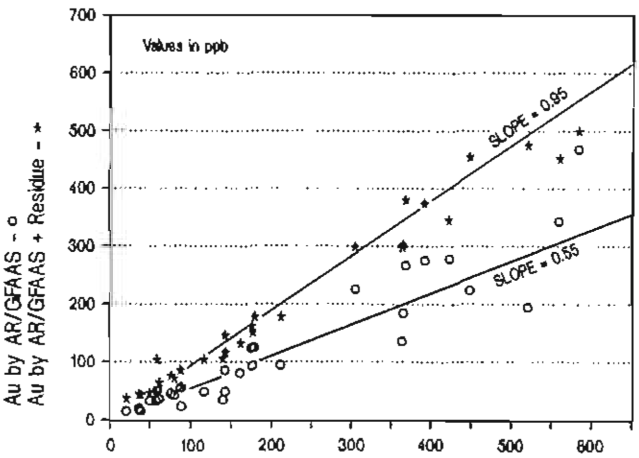

Figure 2

Gold by aqua regia/AAS (± Au in residue) versus gold by INAA sample size from 10 g to 1 g to ensure complete recovery of Au is NOT being advocated in view of the well-known nugget effect!

It is thought that the low extraction efficiency by aqua regia (also shown by HBr-Br_2) is due to a lack of intimate, prolonged contact between the 10-g sample and the acid mixture. Occasional manual stirring is carried out during the evaporation with aqua regia but constant agitation is more desirable. Magnetic stirring is not easily adapted to large-scale production and tends to promote only localized mixing. Hot-plates equipped with shaking tables are no longer manufactured for safety reasons. Heating by microwave irradiation, with its different mechanism of energy transfer, may solve this problem and is now under investigation at the GSC.

The slightly low results for the soils by fire assay-based methods compared to INAA were within the limits set by the associated standard deviations. This is not the case for the porphyry copper drill-cores (low by 26%). However, the presence of high concentrations of Cu is known to be detrimental in obtaining a clean separation of Au (and PGEs) into the Pb button in Pb fire assay. Modification to the procedure (e.g., leaching with HCl) may not have been adequate in removing Cu prior to fusion. Some loss of Au to the slag and during cupellation, depending upon sample matrix, is not unexpected (Diamantatos, 1984, 1987).

It is extremely difficult to assess the accuracy of any analytical method for Au in the absence of certified standard reference materials (SRMs) at these lower levels (10-300 ppb).
A joint program between the GSC and CANMET is now at the stage of preparing six rock samples for certification in Au and the PGEs. Initial distribution for the purpose of certification will take place in 1989. In the meantime, it would be informative if the INAA laboratories would provide us with replicate data on the SRMs routinely analyzed and used in their calibration procedures. While the literature provides us with studies on Au in geological materials using wet chemical and fire assay methods, there is an obvious absence of practical papers on Au by INAA, except for those employing radiochemical separations.

The significance of the bias described here is (a) that results for Au by wet chemical methods may be lower than INAA by as much as 50% in some cases and (b) that caution should be used in interpreting data obtained by more than one method. This low bias for Au by wet chemical methods is variable and dependent upon the sample matrix. For example, it has been found to be almost insignificant (10%) in some ore-grade materials. Although good precision is vital in analysis for gold, it is most important to the exploration industry that this problem of accuracy be resolved.

TABLE 2. Effects of modifications to the aqua regia (AR) leach

Values in ppb, brackets indicate number of analyses

SAMPLE	ANALYSIS BY GFAAS					INAA
	10-g sample			1-g sample		No Decomposition
	AR	HCl + AR	HF + AR	AR	HF + AR	
Soil A	37 ± 1 (1)	36 ± 2 (2)	37 ± 2 (2)	51 ± 2 (3)	67 ± 2 (3)	66 ± 7 (9)
Soil B	88 ± 15 (3)	72 ± 1 (2)	81 ± 6 (2)	104 ± 3 (3)	126 ± 16 (3)	148 ± 16 (9)
Soil C	32 ± 4 (3)	30 ± 5 (2)	34 ± 4 (2)	55 ± 4 (3)	52 ± 7 (3)	51 ± 10 (9)

GFAAS: Graphite furnace atomic absorption spectrometry
INAA: Instrumental neutron activation analysis

NB: *This study is described in more detail in a paper to be submitted to the Journal of Geochemical Exploration.*

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MEETING REPORTS

Prospecting in Arid Terrain

The Second International Conference on Prospecting in Arid Terrain, jointly sponsored by the Australian Institute on Mining and Metallurgy, the Institution of Mining and Metallurgy, London, and the Association of Exploration Geochemists, was held at the University of Western Australia on 26-30 April, 1988. There were 255 registrants including 30 from overseas representing 16 countries.

After opening speeches, **Jim Ross** (Western Australia) presented the keynote address *Prospecting in arid terrains - geological problems and opportunities*, which focused on the deeply weathered lateritized environments typical of the Yilgarn Block of Western Australia. Many of the papers which followed, including several on West Africa, addressed the nature of lateritic terrains in now-arid environments, and exploration for gold. There is no doubt that such terrains are the source of much low cost gold in Australia and other countries. However the number of operating mines casts doubt on problems associated with finding them.

It was not until the last day that the emphasis shifted to prospecting in the many other arid environments, with **Paul Theobald** (USA) giving examples of exploration techniques in loess environments of Saudi Arabia, Mexico, and Alaska. The use of calcrete (**Willem Van Der Westhuizen**, South Africa) and resistant minerals (**D. Kuster**, Germany) in various parts of Africa, although hardly novel techniques, added some variety.

There was a great emphasis on geochemical prospecting techniques, with the discovery of many new deposits in Australia being attributable to geochemistry (albeit Au anomalies in RAB and/or RC drilling). Whereas during the "nickel boom" of the early 1970's laterite was considered to be a hindrance to exploration, today due to considerable research (e.g. in CSIRO) and sophisticated analytical and data handling techniques, laterite is a widely utilized sampling medium. The discovery of the Johnston Range gold deposits by multi-element laterite geochemistry (**Ray Smith**, Western Australia) bears witness to this.

Other topics addressed were groundwater resources for mining ventures (6 papers), remote sensing techniques (6), geophysics (2), geology (3) and the environment (1). One successful application of remote sensing was the use of an airborne Thematic Mapper Simulator to distinguish mafic from ultramafic rocks in the PGE-mineralized Munni Munni Complex of WA (**Colin Simpson**, Canberra). Participants were also privileged to hear the first public discussion of exploration leading to the discovery of the huge Kingtyre uranium deposit in the Great Sandy Desert (**D.G. Jackson**, Western Australia).

Copies of the Abstract Volume may be purchased from the Australian Institute of Mining and Metallurgy, Clunies Ross House, 191 Royal Parade, Parkville, Victoria, Australia 3052 for $A45 plus postage. It is the intention of the Organizing Committee to publish the full texts of papers in a special Aust. I.M.M. volume.

After many months of below average rainfall, Perth was an apt venue for an arid terrains conference. However, despite the obvious detailed planning by **Bryan Smith** and the staff of Worsley Alumina, the heavens opened on the day of the field excursion to Boddington-Worsley south of Perth. Bauxite has been mined in these environmentally sensitive jarrah forests since 1966.

Following analysis of some lateritic pisolites, a major gold deposit 4 km long containing 45 Mt at 1.8 g/t in laterite overlying a previously unrecognized greenstone was discovered in the early 1980's. The mine, which poured its first gold at the beginning of August 1987, is set to increase gold output to more than 250,000 oz p.a. following the completion of a major expansion. Despite the ever-present red mud, the 80 participants were given detailed explanation of the local geology, lateritic profiles, bauxite and gold distribution, and environmental factors.

Approximately 60 registrants visited various gold deposits in the Eastern Goldfields on pre- and post-conference field trips, and a further 8 participants visited the Pilbara region. An excursion guidebook for Boddington and Eastern Goldfields can be obtained from University Extension, University of Western Australia, Nedlands, Western Australia, 6009 for $A20.

At the completion of the Conference, a Workshop on the very topical theme Exploration in Lateritic Environments was attended by 60 participants. Topics discussed were climatic effects on lateritic weathering, regolith terrain mapping, geochemical exploration and geophysical exploration . This concluded a most successful week and plans are now being drawn up to hold the third conference possibly somewhere in North America in 1991.

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First International Gold Conference

The First International Gold Conference was held October 20- 22, 1987, in San Jose, Costa Rica, sponsored by the Ministry of Natural Resources, Energy, and Mines of Costa Rica, Minera Nacional S. A. [MINASA] (a Costa Rican government mining company), Los Alamos National Laboratory, and the United States Geological Survey. The Regional Office for Central America Programs (ROCAP), United States Agency for International Development provided funds for the conference. Over 250 participants from 15 countries were in attendance.

In 1986, regional geologic and geochemical studies were begun by the United States Geological Survey and Los Alamos National Laboratory, in cooperation with the Costa Rican Ministry of Natural Resources, Energy, and Mines, and the University of Costa Rica. Because the data identified areas with potential for undiscovered gold deposits, the government of Costa Rica requested that the results be disseminated at an international gold conference.

The conference was opened by Jose M. Blanco, General Manager of MINASA, Jorge Rodriquez, President of MINASA, and Alvaro Umana, Minister of Natural Resources, Energy, and Mines. The government's support for the mining sector was clearly stated. A modern mining law is now before the Costa Rican legislature. The morning sessions concluded with presentations by Carl Duisberg (ROCAP) and Joe Frank (Los

Alamos) and program overviews by Norman Page (U. S. Geological Survey), Stephen Bolivar (Los Alamos), Nester Chamorro (MINASA), and a discussion of the regional geology of Central America by Dr. Gregorio Escalante, a consultant in San Jose.

The afternoon presentations highlighted the U.S. Geological Survey's regional geologic studies. Steve Ludington described the geologic history and stratigraphy of Costa Rica and the volcanologic framework for the epithermal gold deposits. Dave Ponce presented regional gravity and aeromagnetic maps of Costa Rica.

Bill Bagby provided a stimulating discussion on the Tilaran-Montes del Aguacate gold district. Three models for gold deposits were presented: a) Sado-type epithermal vein deposits suchas those in the Sacrafamilia District, b) hot-spring Au-Ag deposits like the one at Canamazo, and c) stockwork quartz veins that occur along the margins of silicic intrusions. Bagby and Ludington both noted the spatial association between gold mineralization and rhyolitic intrusions.

Norman Page, speaking for Don Singer, presented the methodology and results of a country-wide mineral resource assessment of Costa Rica, including estimates for numbers of undiscovered deposits for several deposit types. The results of the U.S. Geological Survey studies are available in a geologic folio (U.S. Geological Survey, Miscellaneous Investigations Map I - 1965).

Alejandro Arauz began the next session with a discussion of the orientation survey, on which the regional geochemical survey was based. Greg Cole described the data processing methods used in the study, as well as new techniques to be used in the future. The geochemical studies resulted in a series of geochemical maps that revealed spatial patterns that Larry Maassen was able to correlate with major geologic units, areas of known mineralization, and urban contamination.

Stephen Bolivar showed how regional geochemistry could be used to identify not only the gold district, but individual subdistricts within the gold belt that contain elemental signatures suggestive of possible hot- spring Au-Ag deposits. The morning sessions concluded with a presentation by Allen Clark (East-West Center), who attempted to quantify the value of the Los Alamos and U.S. Geological Survey regional program. He was able to show net benefit/cost ratios from 17:1 to 33:1, depending on discounting procedures.

The results of the Los Alamos geochemical work are presented in a geochemical atlas, available through MINASA, which contains several geochemical maps at a scale of 1:200,000, and a description of sampling and data-processing methodology (Los Alamos Informal Report LA-10969-MS). All raw data are included on microfiche.

The afternoon session began with Ray Krauss (Homestake Mining Co.), who showed that environmental protection can be complementary to mining, using McLaughlin, California as an example. The remaining afternoon sessions were by Costa Rican officials who described legal aspects of the current mining law, including import restrictions, tax laws, import duties, and lending policies.

The third day was devoted to a field trip to the Bellevista- Montezuma gold prospect, which is being developed by Rayrock Yellowknife Resources. Miguel Alan, site geologist, provided an overview of the project. About 80 field trip participants, mostly foreign visitors, examined the geology exposed by development and the progress of a 10,000 m rotary drilling program. This deposit is an excellent representative of the type of bulk-tonnage epithermal gold deposits found in Costa Rica.

The most exciting results of the conference were the compilation and dissemination of an extensive database on viable precious-metal deposits being developed in Costa Rica, and that the potential exists, discovered through an interagency, interdisciplinary program, for the discovery of large hot-spring Au-Ag deposits as well as possible extensions of the known gold belt.

Stephen L. Bolivar &
Steve Ludington
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SPECIAL NOTES

Associated Societies

The Canadian Quaternary Association

The Canadian Quaternary Association (Association canadienne pour l'etude du Quaternaire) was founded in 1979 to bring together researchers and practitioners with an interest in the Quaternary Period in Canada. The Association (also known by the acronym **CANQUA**) was incorporated in March 1988. Its objectives are the advancement and dissemination of knowledge about the Quaternary Period, by means of public meetings and exhibits, through the publication of newsletters, position papers, and papers from meetings, and through lecture series and field conferences. The Association also has a mandate to co-operate with other Quaternary Associations both inside and outside Canada.

Membership in CANQUA stands at close to 300, and interests of the members represent all areas of research involved with the Quaternary. CANQUA is a member of the Canadian Geoscience Council, and it is also an affiliated Society with the Geological Association of Canada. The membership is represented by a Council of twelve members; two from the Pacific region, two from the plains and Arctic, three from the Central region (Ontario), three from the Eastern region (Quebec), and two from the Atlantic.

CANQUA, together with its sister association in Quebec, **AQQUA,** and National Research Council, was responsible for an invitation to, and the subsequent hosting of, the *XIIth Congress of the International Quaternary Association* in Ottawa in late July and early August, 1989. The theme of the meeting will be ***Late Glacial and Post-Glacial Processes and Environments in Montane and Adjacent Areas.*** In 1990 CANQUA has invited AMQUA (The American Quaternary Association) to a joint meeting at the University of Waterloo. The topic will be ***Rapid Change in the Quaternary Record***

The Association is now involved in the Proxy Data Resource Group in the Royal Society of Canada's development of the Canadian input to Global Change. This will be the major thrust of international scientific bodies through the course of the next one or two decades. Reports on the activities of the Association appear in the CANQUA Newsletter/Bulletin which is issued twice a year. Scientific publications for CANQUA are released through *Geographie physique et Quaternaire.* For further information on CANQUA please contact:

Alan V. Morgan
President, CANQUA
Quaternary Sciences Institute
University of Waterloo
Waterloo, Ontario N2L 3G1

International Geochemical Mapping

The February 1988 issue of *EXPLORE* contained a two column statement outlining the objective, plans, and future arrangements for this new project. It was an abbreviated version of documentation previously submitted to the IUGS/IGCP Selection Committee in Paris. The project was formally accepted by this Committee in February. This was an important event, which will encourage government earth science organizations to give official support and allow their scientists to participate. Without this type of organizational backing the project cannot move ahead in any significant way.

The project was launched in May as planned, on the opening morning of the VM Goldschmidt Conference in Baltimore at a session entitled International Geochemical Mapping. Eight papers on various aspects of the subject were presented by speakers from Canada (**Darnley, Garrett**), China (**Xie Xuejing**), Norway (**Bolviken**), UK (**Plant**), and USA (**Duval, McNeal**). Arrangements are being made to have several of these papers published in a special issue of the Journal of Geochemical Exploration during 1989.

The inaugural business meeting for the project took place later during the same conference. The business meeting was opened by **Dr. Maurice Chaffee** (USA), President of the Association of Exploration Geochemists. IUGS rules governing the extablishment of IGCP Projects required that the Project Leader be formally elected. Dr. Chaffee proposed Dr. A.G. Darnley (Canada); this was seconded by Dr. B. Bolviken (Norway) and Prof. Xie Xuejing (P.R.C) and the motion was carried unanimously.

Organization

The principal item of business was the organizational structure for the project. The aim is to encourage broad geographic participation in parallel with the establishment of specialized working groups. The latter will have to deal with technical problems on an international basis. It was agreed that under the guidance of a Steering Committee, there will be four Technical Committees plus a number of geographically distributed Regional Committees. The Steering Committee, under the chairmanship of the IGCP Project Leader, will be composed of the leaders of the Regional and Technical Committees.

The Technical Committees will each have a minimum of 5 members. Responsibilities will be divided as follows:

Field Methods Committee: to include all matters concerning selection of sample media; methods of sample collection; sample spacing, including utlra-wide spacing; sample mass; particle size(s) for analysis; collection of replicate samples; use of composite samples; selection and collection of material for reference standards; in-field sample processing, etc.

Analytical Methods Committee: to include all matters concerning sample preparation and digestion; selection of analytical techniques; use and adoption of reference materials; provision of international inter-laboratory reference materials; expansion of analytical suites, etc.

Data Processing and Management Committee: to include recommendations on the organization and contents of a world index of geochemical surveys; methodology for levelling/normalizing diverse data sets; development of standard formats for trans-border data-sets and map publication; evaluation of data interpretation methods for the principal user-groups, etc.

Radiometric Methods Committee: to include all aspects of the collection, standardization, compilation and interpretation of geochemical data obtained by airborne gamma-ray spectrometry. A working group has already commenced work on methods for combining existing airborne radiometric data under the auspices of the International Atomic Energy Agency, Vienna. The Convenor is **Mr. A. Y. Smith** of the IAEA. Note that the Radiometric Methods Committee has comprehensive responsibility for this particular technique.

The function of each of these committees is to produce technical reports, summarising recommended methods and procedures, based on a review of international information and experience.

Nominations for membership of the Technical Committees were solicited. Some have already been recieved. It is requested that additional names should be sent to the Project Leader as soon as possible.

Regional Committees: the following geographoic regions were identified as having institutional arragnements which would facilitate an early commencement of work; leaders names are given where known:

J. McNeal(USA) .... North America (incl. Greenland)
Xie Xuejing .... China
F. Mrna (CSSR) .... Eastern Europe
B. Bolviken (Norway) .... Western Europe
P. V. Koval .... USSR

It is believed that there are good prospects in the near future for establishing Regional Committees to represent Latin America, India and Australasia.

In addition, steps will be taken to encourage the formation of Committees representing Africa, SE Asia, Japan, and the Middle East. The UN and related International Aid Agencies are being informed and their assistance requested to spread information about the relevance of the project to agriculture and health as well as to resource development.

National Committees: it is expected that some countries which intend to take an active part in the International Geochemical Mapping Project, and which have geochemical data to contribute, or geochemical programs to arrange, will wish to extablish a national committee for geochemical mapping. This is particularly important where countries are large and several agencies are involved. Thus, steps have already taken place in Canada to establish such a body. **Dr. P.H. Davenport** of the Newfoundland Department of Mines is Chairman. Detailed arrangements will obviously vary. It is important that each participating country should have a national representative who can participate in meetings of the relevant Regional Committee.

Future Meetings

Paper and/or Poster Sessions on International Geochemical Mapping are being planned for the following international conferences which have been identified as suitable occasions for 1) organization of paper and/or poster sessions on the theme of Regional Geochemical Mapping to stress methodology, products, and applications, 2) Technical Committee workshops to review specific problems:

1989 July, International Geological Congress, Wash., D.C.
1989 October, IGES, Rio de Janeiro
1990 August, IAGC, Prague
1991 (various options, suggestions invited)
1992 IGC, Japan

It is expected that, in addion to the major international meetings, Regional Committees will identify other suitable events, conferences etc., within their own geographic regions where periodic IGM Regional Meetings can be held to plan and coordinate regional activities.

Questions to be Resolved

Following the decisions on the organizational aspects of the project, a number of scientific matters were raised. Some are mentioned below. It is anticipated that, as the project progresses, many of them will be the subject of workshops prior to the formulation of recommendations. Decisions will have to be taken. During the formative stages of the project, comments on these and other issues would be welcomed.

1) In many countries there are increasing signs of awareness amongst scientific policy makers that geochemical surveys can have environmental significance. Scientific concern about the rate of "global change" is beginning to attract media attention and creating some popular pressure for government action, which in turn creates a need for factual information. Recognising that most existing geochemical surveys were conducted for mineral exploration purposes, what additional steps could be taken in order to maximise the environmental usefulness of existing or new data? For example, could additional analyses of retained sample material be undertaken; how might the design of future surveys and analytical procedures be modified?

2) Given the desirability of obtaining a global geochemical overview as rapidly as possible, there is an urgent need to establish the most satisfactory method(s) for wide-spaced sampling. In this context, the question of single or composite samples is important. Stream (or river) sediments are generally considered to be the most universally available sampling media. On the basis of Norwegian experience, a strong case has been made for "overbank" sampling, but questions have been

raised as to whether the technique is of widespread applicability (?).

3) Could the major river systems of the world be sampled by means of a few thousand samples in order to acheive worldwide coverage quickly? What would be the analytical requirements in order to detect significant regional differences? Could the material collected serve for control reference purposes?

4) There is a need to subdivide the world into physiographic-climatic zones, within each of which, geochemical methods can be optimised. It will be necessary to have overlap between the zones so that data can be normalised. Where are the most suitable areas for these overlap studies? Who will perform them?

5) Should samples be totally or partially digested? For geological purposes the former is preferable; for mineral exploration applications some partial extractions are advantageous and this is especially true for environmental interpretation. Conversely, it is easier to obtain standardized data where total extractions are used.

6) A number of countries involved in providing technical assistance hold large amounts of geochemical data pertaining to developing countries. These data are potentially suitable for incorporation in world maps and it is highly desirable that they should be used, otherwise there will be no information about some areas of the world. It will be necessary to obtain formal permission from the countries concerned before these data can be used for this purpose. Who should take this initiative?

All geochemists are asked to inform their colleagues about this project especially any contacts they have in developing countries in order to encourage the widest possible support and involvement. It is expected that there will be a small fund available to assist a few participants from developing countries to attend project meetings. More information can be provided by the Project Leader:

Dr. A. G. Darnley
IGCP International Geochemical Mapping Project
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario
Canada K1A 0E8
Tel. (613) 995-4909
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Telex 053-3117 EMAR OTT

AEG COUNCIL MINUTES

Actions of September 8, 1988

1. The Treasurer reported that there would be a shortfall of about $20,000 in 1988. This is due to numerous reasons, including funding symposia, printing the Directory and Bibliography, publishing the new format of this newsletter, publishing special volumes, and some rather complicated financial arrangements with Elsevier.
2. It was recommended that the Executive study the possibilities of a dues increase for 1989, not to exceed $10 for all classes of membership and not to exceed a total of $50.
3. Neneth and Thody of Vancouver, B.C., Canada were appointed auditors for the Association.
4. Council approved a copyright search to see if the name EXPLORE had been copyrighted.
5. Council approved 49 affiliate members and 1 student member.

Actions of October 6, 1988

1. After careful study, Council recommended that the dues for 1989 remain at the present rates of $42.50 for Members and Associate Members, $20.00 for Students, and $100.00 for Corporate members.
2. The possibility of a trade mark for EXPLORE was researched and found to be feasible. Appropriate papers were being processed.
3. A "flyer" containing the 1989 dues notice and explanatory information about the Association and about the publication of the Journal for distribution to all members, was approved by Council.
4. A publicity "flyer" for distribution at the Northwest Mining Association Meeting, was approved by Council.
5. A new Student Prize Committee was formed under the Chairmanship of R. Klusman and is actively soliciting papers.
6. Further progress was reported on obtaining subscriptions to our Journal for libraries in developing countries.
7. The duties and terms of office for Regional Councillors were defined and approved by Council.
8. Council approved an expenditure of funds for producing a T-shirt with the Explore logo on the back and the Association logo on the front. These are to be sold at meetings and through the mail as a fund raiser for the Association.

Sherman P. Marsh
U.S. Geological Survey MS 973
Denver, Colorado 80225

INFORMATION REQUESTED

Lost Members

We do not have the correct address for the following members whose mail has been returned as undeliverable. If you know how to contact any of these people please notify the Association secretary or Erick Weiland, Terra Technology, 5531 East Kelso St., Tucson, AZ 85712. Thank you for your help.

Atkinson, Ross David
Sparks, Nevada

Beswick, Anthony E.
Naughton, Ontario Canada

Birk, Dieter
Sydney, Nova Scotia Canada

Brake, Sandra S.
Golden, Colorado

Brozowski, Robert A.
Marquette, Michigan

Campbell, Terry L.
Oklahoma City, Oklahoma

Carpenter, Donald J.
Hye Mt, New Mexico

Chater, Geoffrey
Fort Worth, Texas

Chisholm, J.M.
Kensington, N.S.W. Australia

Dousset, Pierre-Edouard
Caen, France

Duchscherer, W.
Golden, Colorado

Evans, Geoffrey M.
San Jose, Costa Rica

Felder, F.
Don Mills, Ontario Canada

Garnett, David L.
Menai, N.S.W. Australia

Gerdenich, Michael J.
Ann Arbor, Michigan

Giles, David L.
Lakewood, Colorado

Gintautas, Peter A.
Denver, Colorado

Herron, Calvin R.
Bishop, California

Hill, Walter E.
Winnemucca, Nevada

Hill, John, G.
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Trost, Paul B.
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Van Ingen, Robert
Toronto, Ontario Canada

Veek, Bruce M.
Reno, Nevada

York, Terrel M.
Lakewood, Colorado

NEW MEMBERS

To All Voting Members:

Pursuant to Article Two of the Association's By-Law No.1, names of the following candidates, who have been recommended for membership by the Admissions Committee, are submitted for your consideration. If you have any comments, favorable or unfavorable, on any candidate, you should send them in writing to the Secretary within 60 days of this notice. If no objections are received by that date, these candidates will be declared elected to membership. Please address comments to Sherman P. Marsh, Secretary AEG, U.S. Geological Survey, Mail Stop 973, Box 25046, Federal Center, Denver, Colorado 80225, U.S.A.

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

[illegible]ING MEMBERS

[illegible]z, Alejandro J.
[illegible]gist
[illegible]m Coates & Assoc.
San Jose, Costa Rica

Leigh A. Readdy
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Weber-Dieffenbach, Klaus
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Wright, James, H.
Willeton, W.A., Australia

STUDENT MEMBERS

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Virginia, U.S.A.

Johnson, Robert L.
Idaho, U.S.A.

Oliver, Tom
Arizona, U.S.A.

Pujolriu, Lluisa
Barcelona, Spain

RECENT PAPERS

Recent Papers on Analytical Geochemistry

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

Pertinent papers from Geostandards Newsletter, published in April and October yearly, are too numerous to cite. This journal is a "must" for the geochemist. Where the number of authors on one paper is greater than four, "et al." is used. This list covers those issues received by the author since those listed in EXPLORE 64.

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

Aualiitia, T.U. and Pickering, W.F. 1988. *Sediment analysis-lability of selectively extracted fractions.* Talanta, 35: 559-566.

Dan, D. and Dong, Y. 1988. *A PVC-coated carbon rod ion-selective electrode for thallium and its application to the analysis of rocks and minerals.* Talanta, 35: 589-590.

de Benzo, Z.A., Fernandez, M.R., Carrion, N., and Eljuri, E. 1988. *Determination of Cu, Zn, Fe, and Mn in slurries of ashed plant tissue by atomic absorption spectrometry.* At. Spectrosc., 9: 87-92.

Franklin, T.C. and Adeniyi, W.K. 1988. *Cationic surfactants in electrochemical determination of sulfide minerals.* Anal. Chim. Acta, 207: 311-317.

Gilbert, M.J.M., Powell, H.K.J., and Fardy, J.J. 1988. *Determination of cobalt in plant digests by adsorption stripping voltammetry.* Anal. Chim. Acta, 207: 103-109.

Harada, A., Tarutani, T., and Yoshimura, K. 1988. *Spectrophotometric determination of germanium in rocks after selective adsorption on Sephadex gel.* Anal. Chim. Acta, 209: 333-338.

Haswell, S.J., Mendham, J., Butler, M.J. and Smith, D.C. 1988. *Determination of arsenic in solid samples by cold acid solubilisation hydride generation atomic absorption spectrometry.* J. Anal. At. Spectrom., 3: 731-734.

Iwasaki, K. and Haraguchi, H. 1988. *Determination of rare earth elements in geological samples by inductively-coupled plasma atomic emission spectrometry after oxalate coprecipitation and cation-exchange column separation.* Anal. Chim. Acta, 208: 163-172.

Kanda, Y. and Taira, M. 1988. *Sequential multi-element analysis of sediments and soils by inductively-coupled plasmal atomic emission spectrometry with a computer-controlled rapid-scanning echelle monochromator.* Anal. Chim. Acta, 207: 269-281.

Kiss, E. 1988. *Ion-exchange separation and spectrophotometric determination of boron in geological materials.* Anal. Chim. Acta, 211: 243-256.

McLaren, J.W., Beauchemin, D., and Berman, S.S. 1988. *Analysis of the marine sediment reference material PACS-1 by inductively coupled plasma mass spectrometry.* Spectrochim. Acta, Part B, 43B: 413-420.

Nakamura, T., Okubo, K., and Sato, J. 1988. *Atomic absorption spectrometric determination of copper in calcium carbonate scale and carbonate rocks by direct atomization of solid samples.* Anal Chim. Acta, 209: 287-292.

Roelandts, I. 1988. *Application of inductively coupled plasma spectrometry to the determination of nine rare earth elements in nine new United States Geological Survey reference samples.* At. Spectrosc., 9: 49-54.

Tessier, A. and Campbell, P.G.C., 1988. *Comments on the testing of the accuracy of an extraction procedure for determining the partitioning of trace metals in sediments.* Anal. Chem., 60: 1475-1476.

Tielrooy, J.A., Vleeschhouwer, P.H.M., Kraak, J.C. and Maessen, F.J.M.J. 1988. *Determination of rare-earth elements by high-performance liquid chromatography/inductively-coupled plasmalatomic emission spectrometry.* Anal. Chim. Acta, 207: 149-159.

van Delft, W. and Vos, G. 1988. *Comparison of digestion procedures for the determination of mercury in soils by cold-vapour atomic absorption spectrometry.* Anal. Chim. Acta, 209: 147-156.

Vanhoe, H., Vandecasteele, C. Desmet, B., and Dams, R. 1988. *Determination of beryllium in environmental samples by electrothermal atomic absorption spectrometry.* J. Anal. At. Spectrom., 3: 703-707.

Exploration Geochemistry

This list comprises titles that have appeared in major publications since the compilation in EXPLORE 64. Journals routinely covered and abbreviations used are as follows: Economic Geology (EG); Geochimica et Cosmochimica Acta (GCA); The USGS Journal of Research (USGS JR), Circular (USGS CIR); and Open File Report (USGS OFR); Geological Survey of Canada Papers (GCS Paper) and Open File Report (GCS OFR); Bulletin of the Canadian Institute of Mining and Metallurgy (CIM Bull); Transactions of Institute of Mining and Metallurgy, Section B: Applied Earth Sciences (Trans IMM). Publications less frequently cited are identified in full.

Compiled by **L. Graham Closs**, Department of Geology and Geological Engineering, Colorado School of Mines, Golden, Colorado 80401, Chairman AEG Bibliography Committee. Please send new references to Dr. Closs, *not* to EXPLORE.

Barrett, T.J. and Jambor, J.L. (Eds.) 1988. *Seafloor Hydrothermal Alteration.* Can. Min. 26(3): 429-888.

Granath, G.1988. *Pattern recognition in geochemical hydrocarbon exploration: A fuzzy approach.* Math. Geol. 20(6): 673-691.

Grunsky, E.G. and Agterberg, F.P. 1988. *Spatial and multivariate analysis of geochemical data from metavolcanic rocks in the Ben Nevis area, Ontario.* Math. Geol. 20(7): 825-861.

Gubac, J.1986. *On the character of distribution of chemical elements in Nature.* Math Geol. 18: 429-432.

Guha, J. et al. 1988. *Gold mineralization patterns in relation to the lithologic and tectonic evolution of the Chibougamau min-*

THE ASSOCIATION OF EXPLORATION GEOCHEMISTS

P.O. Box 523, Rexdale, Ontario, M9W 5L4 Canada

APPLICATION FOR AFFILIATE MEMBERSHIP & THIRD NOTICE OF 1989 DUES

The Association of Exploration Geochemists (AEG) is a professional nonprofit organization promoting interest in the application of geochemistry to the mineral industry and related fields. The AEG encourages membership from individuals or organizations working with geochemical data for a variety of uses including mineral exploration, analytical technology, computer processing, environmental geochemistry, geobotany, biogeochemistry, and other applications.

Membership in the AEG offers many benefits. Advances in geochemical technology are presented regularly in symposia, short courses, distinguished lecturers' workshops, field trips, the *Journal of Geochemical Exploration* (1200 pages annually), this newsletter, and Special Volumes published or cosponsored by the AEG. Annual membership dues of $42.50 U.S. include the *Journal of Geochemical Exploration*, EXPLORE, bibliography updates, discounts on most Special Volumes, and discounts on registration fees for symposia or short courses.

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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

■Apr. 19-21, '89 **Conference Juneau & Trade Show.** Alaska Miners Association, on the metallogeny and mineral development of Southeast Alaska, the Yukon and British Columbia (Albert H. Clough, Conference Chairman, C/O U.S. Bureau of Mines, P.O. Box 020550, Juneau, AK 99802-0550 Tel. 907-364-2111)

■Apr. 24-26, '89 Workshop on **engineering and environmental applications of geophysics**, Seattle WA (May 19-21, Atlanta, GA)(Chuck Bierley, 133 S. Van Gordon #200, Lakewood, CO 80228. Tel. (303) 988-1648)

■Apr. 23-26, '89 Amer. Assoc. **Petroleum** Geologists, ann. mtg., San Antonio, TX (AAPG, Box 979, 1444 S. Boulder, Tulsa, OK, 74101. Tel: 918-584-2555)

■May 1-5, '89 Geology of **industrial minerals** of the Pacific Northwest, Portland, OR (Ron Geitgey, Oregon Dept. of Geology & Mineral Industries, 910 State Office Bldg., Portland, OR 92701. Tel: 503-229-5580)

■May 14-17, '89 **GAC/MAC** Geol. Assoc. Canada/Mineralogical Assoc. of Canada, ann. mtg., Montreal (Colin Stearn, Rm. 238, 3450 University St., Montreal, H3A 2A7. Tel: 514-398-4082)

■May 23-25, '89 **Gold 89 in Europe**, Int'l Symposium on gold metallogeny, exploration and beneficiation, (F. Tollon, Laboratoire de Mineralogie, Universite Paul Sabatier, 39 Allees Jules Guesda 31400 Toulouse, France. Tel: 61.53.02.35)

■June 26-30, '89 **Gold geology & exploration,** intl. mtg., Shenyang, China (Zhu Fengsan, Chinese Soc. of Metals, 46 Dongsixi Dajie, Beijing, People's Republic of China. Tel: Beijing 553768)

■July 9-19, '89 **28th Intl. Geological Congress**, Washington, D.C. (Bruce B. Hanshaw, Box 1001, Herndon, VA 22070-1001. Tel: 703-648-6053)

■Aug. 7-11, '89 **Caribbean Geological Conference**, Christiansted, St. Croix, U.S. Virgin Islands (Fred Nagle, Dept. of Geological Sciences, Box 249176, Univ. of Miami, Coral Gables, FL, 33124. Tel: 305-284-4253

■Aug. 14-19, '89 Symposium: **Precambrian Granitoids** (petrogenesis, geochemistry, and metallogeny)(Organizing Committee, Dept. of Geology, Univ. of Helsinki, P.O. Box 115, SF-00171 Helsinki, Finland)

■Sept. 7-9, '89 International **Gold Expo**, Reno, Nevada (Engineering & Mining Journal, Industrial Presentations Inc.,12371 East Cornell Avenue, Aurora, CO 80014, Tel. (303) 696-6100)

■Oct. 1-6, '89 **13th International Geochemical Exploration**, Symposium (Dorival C. Bruni, Sociedade Brasiliero da Geoquimica, P.O. Box 2432CEP 20010, Rio de Janiero, BR RJ)(see No.64, p.27)

■Oct. 2-6, '89 **Remote sensing** for exploration geology, mtg., Calgary, Alberta (Robert H. Rogers, Box 8618, Ann Arbor, MI, 48107-8618. Tel: 313-994-1200

■Oct. 16-20, '89 **Mathematical methods in geology**, intl. mtg., Pribram, Czechoslovakia (Vaclay Nemec, GEOINDUSTRIA, Geologicka 2, 152 00, Praha 5 Barrandov, Czechoslovakia)

■Oct. 22-25, '89 **Gold 89** mtg., Reno, NV, Soc. of Mining Engineers and Australasian Inst. of Min. and Metall. (Meetings Dept., SME, Box 625002, Littleton, CO, 80162. Tel: 303-973-9550)

■Nov. 6-9, '89 **Geological Society of America** ann. mtg., St. Louis, with associated societies (Vanessa George, GSA, Box 9140, Boulder, CO, 80301. Tel: 303-447-2020)

■Apr. 1-5, '90 **Geology and ore deposits** of the Great Basin, Reno, NV (Geol. Soc. Nevada, Box 12021, Reno, NV 89510)

■May 6-12, '90 **Pacific Rim 90** congress, on the geology, structure, mineralisation, economics and feasibility of mining and development in the Pacific Rim, Gold Coast, Queensland, Australia (The AusIMM Pacrim 90, P.O. Box 731, Toowong Qld 4066, Australia, Tel. 07-371-7900 (¢617-371-7900 (international)

■June 28-July 3, '90 **IMA 1990** 15th Gen. Meeting of the International Mineralogical Association, Beijing, China (Dr. Wang Zejiu, Chinese Academy of Geological Sciences, Baiwanzhuang Road 26, Fu Wai, Beijing 100037, China)

■July 2-6, '90 **Minerals, materials & industry**, Edinburgh, Scotland. 14th Congress of the Council of Mining and Metallurgical Institutions (The Secretary, IMM, 44 Portland Place, London W1N 4BR, England

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

■Aug. 25-31, '90 **14th International Geochemical Exploration** Symposium, Praha, Czechoslovakia (Geological Survey /UUG/, Symposium on geochemical prospecting, Malostranske nam. 19, 118 21 Praha 1, Czechoslovakia)

■Apr. 28-May 1, '91 **15th International Geochemical Exploration** Symposium, Reno, NV (Richard B. Jones, Nevada Bureau of Mines & Geology, Univ. of Nevada, Reno, NV 89557-0088. Tel: 702-784-6691)

*Note to AEG Colleagues: There will be 1500 spaces available for low-cost housing for the **28th International Geological Con-***

gress in Washington, D.C., July, 1989, at University dormitories at The George Washington University, Georgetown University, and American University. Read the second circular for the Congress carefully when you receive it and make your reservations for the low-cost housing as soon as you can because these spaces will undoubtedly be "exploration targets" for our association as well as other professional groups and colleagues.

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, D.C. 20052

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Index to Issue Numbers 61-64

BIBLIOGRAPHY

1. **Asmusson, Dennis G.** *Mineral Development Opportunities in Minnesota.* no. 63, p. 9, July, 1988
2. **Barnes, Sarah-Jane.** *The Use of Metal Ratios in Platinum-group Element Prospecting.* no. 64, p. 8, November, 1988
3. **Bloom, Lynda B.** *Analytical Imprecision and Data Interpretation.* no. 61, p. 8, October, 1987
4. **Bloom, Lynda B. and Steel, Ken.** *Black River - Matheson (BRIM) Data on Floppy Diskettes.* no. 61, p.6, October, 1987
5. **Callahan, John E.** *A Safe Heavy Liquid.* no. 64, p. 14, November, 1988
6. **Chaffee, M.A. and Plant, J.A.** *Workshop on Anomaly Selection Criteria: Summary Report.* no. 61, p. 12, October, 1987
7. **Darnley, A.G.** *International Geochemical Mapping.* no. 62, p. 14, February, 1988
8. **Davenport, Peter, H.** *Newfoundland Profile.* no. 63, p. 7, July, 1988
9. **Feldman, Sandra C.** *Mapping Hydrothermal Alteration with High-Resolution Remote Sensing Imagery.* no. 63, p. 14, July, 1988
10. **Filipek, Lorraine H.** *Environmental Geochemistry Program - a Proposed New USGS Initiative.* no. 64, p. 4, November, 1988
11. **Hall, Gwendy E.M.** *The Determination of Pt and Pd in Waters.* no. 64, p. 12, November, 1988
12. **Hoffman, Stan J.** *Pearl Harbor File.* no. 62, p. 8, February, 1988
13. **Hoffman, Stan J.** *Volcanogenic Massive Sulfides in Newfoundland - Pearl Harbor File.* no. 63, p. 16, July, 1988
14. **Hoffman, Stan J.** *Volcanogenic Massive Sulfides in Newfoundland - Pearl Harbor File.* no. 64, p. 12, November, 1988
15. **Keith, Stanley B.** *Magma Series: Chemistry and Mineral Deposits.* no. 61, p. 5, October, 1987
16. **Kissin, Stephen A.** *The Five-Element Suite: An Indication of Non-Magmatic Ore Types Related to Rifting and Basin Development.* no. 64, p. 5, November, 1988
17. **Lechler, Paul J.** *Platinum-Group Element Exploration in Nevada.* no. 63, p. 10, July, 1988
18. **Maciolek, J.B. and Jones, V.T.** *Mobile Mercury Application in the Search for Gold.* no. 61, p. 6, October, 1987
19. **Matysek, Paul** *British Columbia Profile.* no. 61, p. 1, October, 1987
20. **Matysek, P.F., Day, S.J. and Gravel, J.L.** *Gold in Moss-Mat Sediments and Stream Sediments.* no. 62, p. 1, February, 1988
21. **Pardubn, Nancy L.** *Microbial Methods of Mineral Exploration.* no. 62, p. 5, February, 1988
22. **Schwarz, Frederick P.** *Geochemical Signature of the El Realito Gold Prospect, Sonora, Mexico.* no. 62, p. 6, February, 1988
23. **Smith, A.Y.** *International Geochemical Mapping.* no. 61, p. 8, October, 1987
24. **Stanley, Clifford R.** *PROBPLOT, An Interactive Computer Program to Fit Mixtures of Normal (or Log-Normal) Distributions with Maximum Likelihood Optimization Procedures (AEG Special Volume #4).* no. 63, p. 16, July, 1988
25. **Stanley, Clifford R. and Smee, Barry W.** *A Test in Pattern Recognition: Defining Anomalous Patterns in Surficial Samples which Exhibit Severe Nugget Effects.* no. 63, p. 12, July, 1988

INDEX

Index to Issue Numbers 61-64 *(Cont'd.)*

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