

EXPLORE

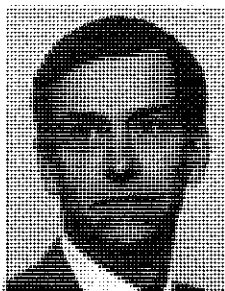
The Association of Exploration Geochemists Newsletter

NUMBER 64

NOVEMBER 1988

President's Message

The new Executive and Council of the Association were duly elected and installed at the Annual General Meeting held in May at the Goldschmidt Conference in Baltimore (see "A Note from the Secretary"). Special thanks are due to our outgoing President, **Stan Hoffman** (who remains as an ex-officio member of Council); to our outgoing Treasurer, **Lynda Bloom**; and to those members of Council who have completed their terms or who chose not to stand for re-election.



On behalf of the members of the Association, I welcome those members new to the Executive, the Council, and to our Committees. I would be remiss not to recognize the contributions of both continuing and retiring Regional Councillors, Committee Chairmen, Committee members, Editors, and the many other members who have contributed, or are continuing to contribute, their time and talents to the betterment of your Association. Most of these people are not formally identified in this issue but nevertheless perform important duties for your Association.

Although the work of the new Executive and Council has just begun, it is not too early for you to identify members interested in running for Council for the 1989-91 term. Ordinary Councillors are nominated by the current Executive and Council or are nominated by a petition from members at large. Any Voting Member in good standing is eligible for nomination to Council. The petition form is available from the Secretary in Denver and and may also be found on page 22 of EXPLORE 63. It must be completed and returned to the Secretary before December 31, 1988.

Two particularly notable events of interest to Association members took place at the Goldschmidt Conference. The first was our co-sponsorship of, and participation in, the highly successful and well-attended Platinum Symposium. It is encouraging to see that there may be life after gold.

The second event was the formal session and subsequent meetings, under the guidance of **Dr. Arthur Darnley** of the GSC, Ottawa, related to planning for a future geochemical map of the world. This idea is somewhat mind-boggling but one worthy of our support. The ancillary tasks to be performed in producing such a map will provide information that will be of interest to all geochemists.

A few of these tasks include establishing standard sample media and analytical methods for determining base-line chemical data for local, regional, and international levels of evaluation; determining the level of sample density that will provide meaningful data; determining whether data from different sample media and (or) analytical techniques can somehow be normalized and combined into one data set; determining how to take into account the gross differences between different regions of the world related to various geologic processes and to petrologic composition, both of which will be material

in interpreting the base-line chemical data; and selecting statistical techniques that can evaluate the chemical data as to precision, accuracy, and other parameters on a world scale. This is truly a major international effort that will require the assistance and cooperation of many people.

In closing, I emphasize that the AEG is your association. Please feel free to contact members of the Executive or Council with your comments or suggestions, whether positive or negative. A lack of response is interpreted to mean that you are happy with the status quo.

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

NEWS & COMMENT

Open House Forums In Canada

The ministries of the provinces and territories of Canada responsible for mineral exploration and development hold annual "open house" forums where technical presentations, reviews of activities, core displays, commercial exhibits, and poster displays are open to the public. These enable the explorationist to become acquainted with what is happening in government and industry.

The Cordilleran Roundup held in Vancouver February 2-5, 1988, with over 1,300 attendees was one such meeting. This type of forum, where government, industry, and academe combine to stimulate mineral exploration, is gaining popularity. The main drawing cards are geologic descriptions, rock specimens, drill core, map displays, and results of research for new discoveries. At the same time, individuals describe how a prospect was found and give particulars of the deposit geology and/or mining characteristics.

Continued on page 3.

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Notes from the Editor

Journal of Geochemical Exploration Volume 30, Number 2 has been issued since the last newsletter. As explained by the announcement on page 14, Volume 30 is received by 1987 members, and Volume 31 will be received by 1988 members.

Exploration Geochemistry Bibliography

November, 1984 to October, 1987 has been received by members as Special Volume Number 11, Supplement Number 2. It is an excellent and most useful compilation for those needing updated comprehensive indexing of geochemical subjects published in western languages including Russian papers available by translation and Chinese papers with English summaries. The volume is cross-indexed by area of location, metallic commodity, mineral name, subdiscipline,

and other key words.

We heartily thank **Herb Hawkes**, for this Herculean task well done and many years of bibliographic work for the Association. Henceforth, references should be sent to Dr. **L. Graham Closs**, Colorado School of Mines, Golden, CO 80401, U.S.A.

Another reference volume which has been received by current members without charge is the **1988 Membership Listing & Directory of Geochemical Services** which includes the Bylaws of the Association. The membership is listed alphabetically with address and telephone number and indexed by country. The directory portion covers analytical laboratories, consultants, data processing and plotting services, and much more.

Members joining now for

1988 may still receive the above-described Bibliography and Directory free along with the current issues of the *Journal of Geochemical Exploration*. This is also the time to use the same application (on page 25 to renew or initiate your 1989 membership.

Three special issues of JGE that will be received by members in the future are described in the section *Letters to the Editor*. They are the proceedings of the 12th International Geochemical Exploration Symposium, the proceedings of the AEG meeting in China, and a volume on epithermal gold mineralization around the Pacific. Something of the value of these works was indicated in this column last time: the proceedings of the 11th IGES held in Toronto (two-volume set) now costs \$268.25 from Elsevier.

EXPLORE #63 was distributed to **10,105 different professionals** in the exploration industry. More than

6,000 of these were mailed by the Northwest Mining Association to the combined memberships of NWMA and AEG and the attendance lists of several recent large meetings.

The remainder were distributed by individuals who passed them out with a little sales pitch to prospective members at professional meetings and during regular business contacts: **Stan Hoffman** in Canada, **Paul Taufen** in Brazil, **Graham Taylor** in Australia, **Alf Björklund** in Finland, **D.A.V. Stow** in the United Kingdom, and **Peter Rogers** in Nova Scotia.

As this is an effective way to promote membership in the Association, we encourage individuals to write to EXPLORE requesting bulk shipments. Please indicate the date, place, and name of the exploration meeting and the number of issues desired. Request should be made about 4 to 6 months before the meeting.

EXPLORE

Newsletter No. 64

NOVEMBER 1988

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Full Page	U.S.\$560
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Information for Contributors to EXPLORE

Scope This Newsletter endeavors to become a forum for late advances in exploration geochemistry and a key informational source. In addition to contributions on exploration geochemistry, we encourage material on multidisciplinary applications, environmental geochemistry and analytical technology. Of particular interest are extended abstracts on new concepts for guides to ore, model improvements, exploration tools, unconventional case histories, and descriptions of recently discovered 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 5/4-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.



Nancy L. Parduhn, Ph.D.
PRESIDENT, GEOCHEMIST

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News & Comment (Cont'd)

An example is the **Cordilleran Roundup**, an annual information event at Vancouver, which is sponsored by the British Columbia and Yukon Chamber of Mines in cooperation with the B.C. Ministry of Energy, Mines, and Petroleum Resources, the Geological Survey of Canada, the Department of Indian Affairs and Northern Development (Yukon), and the mineral exploration community. It is a four-day program, with the mornings given to oral and visual presentations and the afternoons to discussion and displays. The general format is as follows:

- DAY 1- A.M. Presentation by the Geological Survey of Canada and Department of Indian Affairs and Northern Development (Yukon).
P.M. Poster displays by above.
Core shack.
Prospector's tent.
Service and supply forum.
- DAY 2- A.M. Presentations by the British Columbia Ministry of Energy, Mines and Petroleum Resources.
P.M. Poster displays by above.
Core shack.
Prospector's tent.
Service and supply forum.
- DAY 3- A.M. Industry presentations — snapshot 89.
P.M. Prospector's tent.
Mineral Resource Forum.
- DAY 4- A.M. Industry/Government presentations.
P.M. Mineral Resource Forum.

The core shack and prospector's tent format is particularly useful in bringing mineral property owners and their holdings to the attention of the exploration industry. Industry presentations describe the most recent discoveries or update the development of active properties. In 1988 each deposit on the program was summarized as a "snapshot" in two pages: name of the project, description, location, land status, agreements, history, geology, current exploration, reserves, costs, and author. Deposits described included: **Lara, Windflower, Lawyers, Snip, Harrison Lake Au, Ketza River, Skukum Creek, Samatosum, Esperanza, Willa, Golden Bear, and Skyline.**

The popularity of this type of forum is documented by an ever increasing attendance and by the greater distance people are travelling to attend what normally would be considered a local event. The success of these forums suggests that this Canadian experiment might serve as a model to encourage exploration in other countries. Copies of a 24-page summary can be obtained from the Chamber at the address below for \$5 CDN.

The cost to attend the 1989 Cordilleran Roundup, including Chamber membership for the year, will be on the order of \$40.00 CDN. The next Cordilleran Roundup will be held in Vancouver from February 7th to 10th, 1989. For more information contact:

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All the open house forums are inexpensive to attend, being supported by industry and government to encourage exploration and mining activity. On occasion they focus on a geochemical theme, such as the 1985 Quebec "show and tell". A technical volume entitled *La Geochimie d'Exploration au Quebec — Seminaire d'information 1985* presents talks in English (3 papers) and French (14 papers). Document DV 85-11 (162 pages) is available at the following address for \$16.00 CDN including postage or on microfiche for \$6.00 CDN including postage:

Gouvernement du Quebec
Ministere de l'Energie et des Ressources
 1620 boulevard de l'Entente, Quebec City
 Quebec G1S 4N6 Canada

A Note from the Secretary


In this column I present highlights of the minutes of the Annual General Meeting held in Baltimore on May 12, 1988. This satisfies the requirements of the By-laws and provides those of you who could not be present with information on the proceedings and activities of your Association. If you have any comments or questions about the minutes, please contact me.

■ Attending Council members included: **C.E. Dunn, E.L. Hoffman, C.E. Nichols, and E.F. Weiland.** Members of the Executive included **S.J. Hoffman** (President), **M.A. Chaffee** (President-elect), and **S.P. Marsh** (Secretary). Nine members of the Association also attended the meeting.
 ■ The minutes of the 1987 Annual General Meeting were accepted.

Secretary's Report

■ The most notable change in the past year has been the publication of the outstanding new Newsletter, **EXPLORE**, which has been a real boost to the Association. The Association has received 164 new member applications in the last year bringing the membership for 1987 to a total of 865. To date, the membership for 1988 is 650. The membership is down only 12% (103) from 1987, an improvement from a decline of 22% from 1986-1987. With the publication of "Explore", the Association is looking forward to generating new members and having a good year in 1988.

■ The Distinguished Lecturer for 1987 was **Howard McCarthy** whose tour in the United States and Canada was enthusiastically received. Mr. McCarthy is very



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pleased with the results and enjoyed it very much.

■ The Student Paper Prize for 1987 was been awarded to **Don Saxby** for his paper entitled "Behavior of Scheelite in a Cordilleran Stream".

■ The Association is convening the next International Geochemical Symposium in Rio de Janeiro, Brazil in October, 1989. This meeting is one of several international symposia being sponsored by the Association over the next 4 years: Prague, Czechoslovakia in 1990, Reno, Nevada in 1991, and Beijing, China in 1992. The next Association meeting will be jointly sponsored with the Northwest Mining Association in Spokane, Washington on December 1-4, 1988.

■ No increase in annual dues is expected for the next year. In addition to EXPLORE, advantages to members in 1988 included: a new bibliography supplement, a directory listing laboratories throughout the world, which would also include a listing of current members and a reprint of the By-laws of the Association, a discount on books published by Elsevier and the Institute of Mining and Metallurgy, and a discount on *Practical Problems in Exploration Geochemistry* by A.A. Levinson.

■ The passing of **Dick Lewis**, the Regional Councillor for Brazil, was noted with regret. The Brazilian membership has recently elected **Paul Taufen** to fill the position. The Australian membership has elected **Graham Taylor** to be a Regional Councillor for eastern Australia.

Treasurer's Report

■ The Association ended 1987 with surplus of about

\$9000 (US). The use of VISA and Mastercard for payment of dues and publications was introduced during the last year and has been very well accepted. The total bank assets of the Association are \$128,000 (US) putting it in a healthy financial state. The budget for 1988 projects a deficit of about \$8000; it will be up to the Executive to cut costs and increase revenues. Audited statements for 1987 will be published in a future issue of "Explore".

The 1988-1989 Executive

President **M. A. Chaffee**
First V.P. **A. E. Soregaroli**
Second V.P. **D. D. Runnells**
Secretary **S. P. Marsh**
Treasurer **D. M. Jenkins**

The 1988-1990 Ordinary Councillors

The Association's Auditor recorded 203 unspoilt ballots. On the basis of the ballots counted the following Ordinary Councillors were elected from the ten candidates: **H. F. Bonham, C. E. Dunn, J. A. Jaacks, P. F. Matysek, F. R. Siegel, S. Clark Smith**

■ **Maurice A. Chaffee**, the Association's new President, stated that the Association was in the process of moving the position of Treasurer from Toronto to Vancouver, Canada and that the mandated appointment of auditors was being delayed until this move could be effected. An auditor from Vancouver would be appointed as soon as possible.

■ **C. Nichols**, EXPLORE's editor, encouraged the membership to submit items and articles of interest.

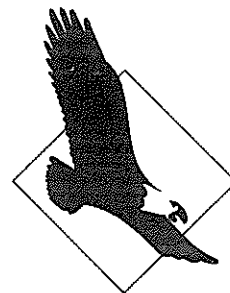
Sherman P. Marsh
*U.S. Geological Survey MS973
Denver, Colorado 80225*

health and economic well-being that too frequently are overlooked or ignored. Actions taken without appropriate understanding of the environment at and near the land surface can result in satisfaction of one need at the expense of another. For example, natural selenium is concentrated to toxic levels by irrigation waters in the San Joaquin Valley of California, where a significant percentage of the nation's food is grown. This same situation occurs at numerous other locations in the United States where the natural hazard is further amplified by activities such as waste disposal and mining — as well as irrigation. Such inadvertent problems have recently raised both local and national alarm and have generated intense conflicts between various special-interest groups. Until we have a better understanding of the environment at the surface of the Earth, new hazards and conflicts will continue to appear in unexpected places, resulting in untold financial, health, and social costs to government and individuals.

The proposed Environmental Geochemistry Program will address naturally occurring toxic elements such as selenium, boron, and cadmium, to name only a few. The Program will provide not only needed geochemical information, but of equal importance, an integrated multidisciplinary framework within which broad-scale environmental and resource-management issues can be addressed. A key aspect of the Program will be coordination with other USGS programs and with other international, federal, and state agencies, academia, industry, and environmental organizations. This coordination will constitute the nation's first fully integrated, inter-organizational geoscience assessment of the land surface. Priorities for topic and study-area selection will be based on present knowledge of potential natural contamination or degradation hazards, on the perceived need for a rapid response,

and the interest and cooperation of other agencies.

The Environmental Geochemistry Program will produce scientific surveys, reports, and assessment maps of naturally occurring toxic elements. It will also bring together (a) a national database of geochemistry and surficial-Earth parameters useful to many diverse groups, including other federal and state agencies, land-use planners, environmental organizations, and exploration companies, and (b) a more quantitative understanding of natural processes that affect the makeup and stability of our environment. Environmental-assessment strategies will be developed that will allow evaluation and prediction of areas with environmental contamination or degradation hazards due to natural processes or human intervention. The results of research from the Environmental Geochemistry Program will help define the best approaches to effectively solve present environmental problems, to know when



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NEWS & COMMENT

Environmental Geochemistry Program —A Proposed New USGS Initiative—

The environment at the surface of the Earth pervasively impacts our quality of life both positively and negatively. Our simultaneous needs for food, shelter, ener-

gy, minerals, and clean water all require us to interact intimately with this environment. However, there are also naturally hostile aspects of our environment that affect our

cleanup is infeasible given the natural constraints, and to formulate optimum land-use strategies that will minimize potential future

environmental problems.

Lorraine H. Filipek
USGS, Box 25046, MS 973
Federal Center
Denver, Colorado 80225

TECHNICAL NOTES

The Five-Element Suite: An Indication of Non-Magmatic Ore Types Related to Rifting and Basin Development

The five-element suite is classically developed in hydrothermal veins containing minerals with the characteristic transition metals nickel and cobalt, the semi-metals arsenic and bismuth, silver, and a variable presence of uranium. Five-element veins occur on a scattered basis throughout the world in such famous districts as Cobalt-Gowganda, Great Bear Lake and the Erzgebirge, as well as many others.

The mineral assemblage in five-element veins contains ordinary base-metal sulfides, but consists mostly of arsenides and sulfarsenides. Also striking is the low iron content of the assemblage; even pyrite and arsenopyrite are absent. A touch of mercury is present, although paragenetically separated from the other minerals, and its presence is sporadic. Most five-element districts contain significant amounts of uranium as uraninite, although uranium is conspicuously missing in the Thunder Bay,

Cobalt-Gowganda, and Kongsberg-Modum districts.

The five-element assemblage, or the portions of it that carry nickel-cobalt mineralization, is rare in hydrothermal deposits. In fact, only five types of deposits carry this type of mineralization, as shown in Table 1, which lists them in order of abundance of the five-element type assemblages. Note that all of these with the exception of sandstone-type uranium deposits are the foci of controversies regarding their genesis. This observation is perhaps not surprising, as the five-element assemblage may be an indication of unusual and specific geochemical parameters for formation of the deposits.

Shale-hosted stratiform copper deposits are good representatives of the five-element assemblage, except for silver. Arsenic is low, and most minerals are sulfides rather than arsenides. Also present here, but very poorly represented in the five-element suite, is an elemental association characterized by molybdenum, tellurium, selenium and cadmium. This association is recurrent in two other deposit types to be discussed.

Unconformity-type uranium veins have variable amounts of nickel-cobalt-arsenic mineralization, as well as sometimes abundant base metal sulfides and even gold. The molybdenum-selenium-tellurium-cadmium association is also characteristically present. A conspicuous point is the absence of both arsenopyrite and barite.

Mississippi Valley-type lead-zinc deposits have an accessory mineral suite that

Table 1. Five-element Associations 1. Five element (Ni-As-Ag-Co-Bi) veins.e.g. Cobalt-Gowganda district, Ontario; Thunder Bay district, Ontario.

2. Shale-hosted stratiform copper deposits (in part).e.g. Manfeld rucken, Germany; Shaba veins, Zaire.

3. Unconformity-type uranium veins.e.g. Athabasca Basin, Saskatchewan.

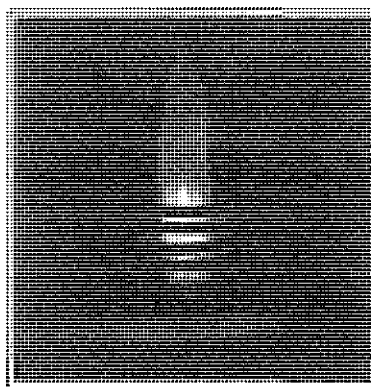
4. Mississippi Valley-type lead-zinc deposits (in part).e.g. Viburnum trend and Fredericktown district, Missouri.

5. Sandstone-type uranium deposits.e.g. Colorado Plateau,U.S.A.

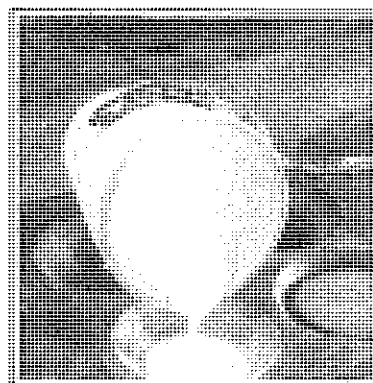
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is exceptionally well developed in the Viburnum Trend and Fredericktown districts of southeast Missouri, but occurs in a number of other districts as well. Notably, the molybdenum-selenium-tellurium-cadmium association is absent, and the silver content of the mineralization is low.

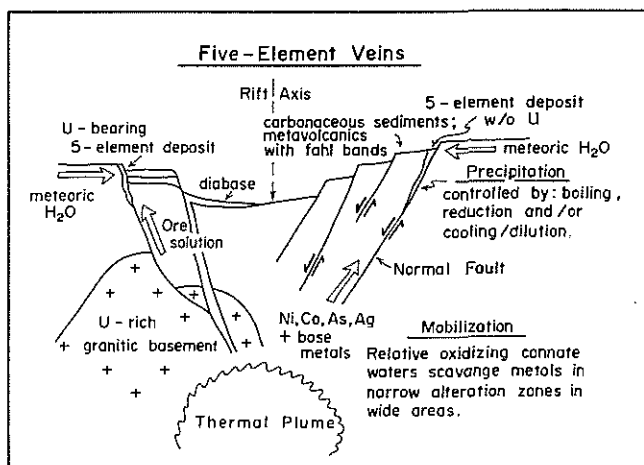
The sandstone-type uranium assemblage has a well-developed molybdenum-selenium-tellurium-cadmium association with only minor five-element type mineralization. Barite and arsenopyrite are both absent, but silver may be more significant.

All of the foregoing is suggestive of a pattern which is underlain by a more fundamental process. Transport of nickel and cobalt is the main problem, and occurrence of these metals in hydrothermal

mobilization and deposition of a five-element ore solution. Mobilization is governed by high temperatures, probably in the neighborhood of 400°C, high salinity and relatively oxidizing conditions, probably controlled by the magnetite-hematite buffer. Deposition is governed by reduction, dilution, and cooling; boiling appears to play a role as well.

The five-element veins are thus of non-magmatic origin, as are the other four deposit types previously discussed. If this assertion is accepted, how then did the five-element veins originate and what is their relationship to the four other non-magmatic ore types?

Kissin (1988) has shown that there is a strong association between most five-element ore districts and rift



deposits is limited to the five cases just discussed.

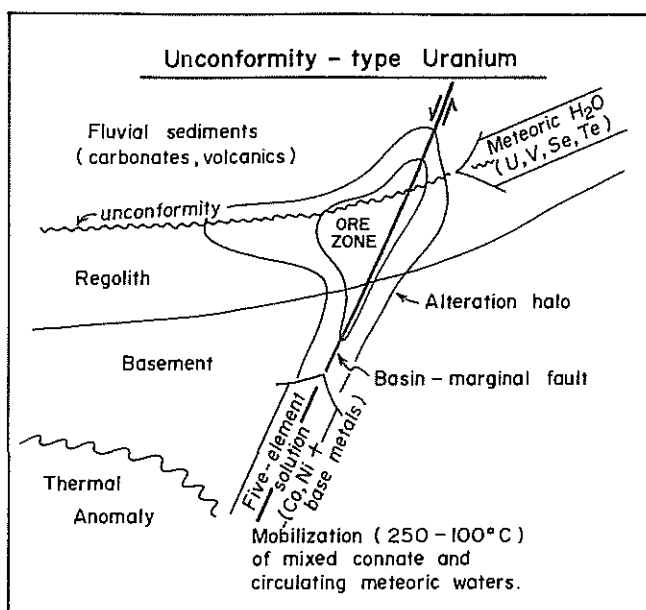
Crerar *et al.* (1985) have shown that temperature and salinity play an important role in determining the relative stabilities of tetrahedral vs. octahedral complexes. High temperature and salinity favor the stability of tetrahedral complexes of nickel and cobalt, which are also the forms in which solubility is enhanced. Cobalt and nickel in igneous rocks are normally strongly partitioned into magmatic phases and do not enter magmatic-hydrothermal solutions. Oxidizing conditions in neutral to slightly alkaline solutions also will augment transport of arsenic and suppress transport of iron.

The foregoing outlines some of the parameters for

Figure 1. Hypothetical genetic mechanism for five-element veins. The system is centered on an active continental rift overlying a thermal plume.

structures in the continental crust (Figure 1). The thermal anomaly associated with rifting can produce temperatures up to 400°C at relatively shallow depths. Connate waters mobilized in this environment scavenge metals from narrow alteration zones, but over large areas. A spectrum of rock types serves to supply the metals to the solution. Granites, black shales, and sulfide-rich metavolcanics are all suitable, but granites appear to be required if uranium occurs.

These solutions are highly saline and relatively oxidiz-



ing at the hematite-magnetite buffer. They travel to near the surface via the open structures associated with rifting where they deposit their ores due to cooling and dilution by meteoric water and are reduced by such local factors as carbonaceous sediments or the sulfides in fahlbands. Diabasic hypabyssal intrusions associated with rifting may act as throttles localizing boiling beneath them.

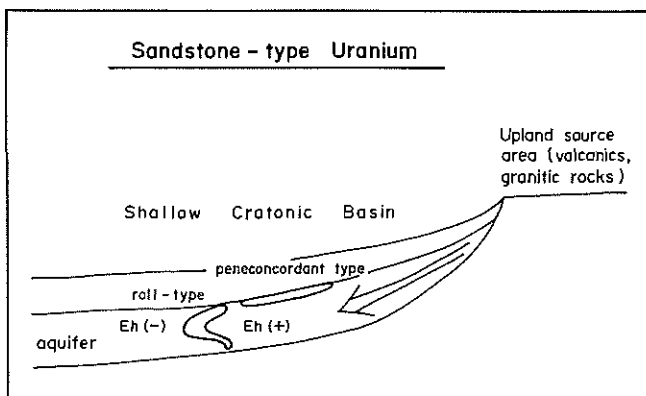
The unconformity-type uranium deposit has factors in common with five-element veins (Figure 2). The scenario shown here is modified after the model of Wallis *et al.* (1985) for the McLean deposit of the Athabasca Basin of Saskatchewan. The basin is centered on a thermal anomaly producing temperatures in the range 100 to 250°C. A solution resembling a five-element ore solution is generated within the basin and rises to the vicinity of an unconformity usually with fluvial sediments. Here, reduction occurs largely

Figure 2. Generation of an unconformity-type uranium deposit at the margin of a thermally anomalous cratonic basin (modified after Wallis *et al.*, 1985).

controlled by accumulations of carbon. Meteoric water, apparently carrying uranium as well as such elements as selenium, tellurium, and vanadium, seems to interact with the five-element solution, forming the deposit.

Sandstone-type uranium deposits (Figure 3) represent one end of a spectrum which passes through the unconformity deposits to five-element veins at the other end. The ore-depositing solution de-

Figure 3. Generation of sandstone-type uranium deposits of roll-type, with indigenous reductant, or penconcordant type, with introduced reductant. Uranium may be derived from pyroclastics in basinal fill, as well as from upland areas.



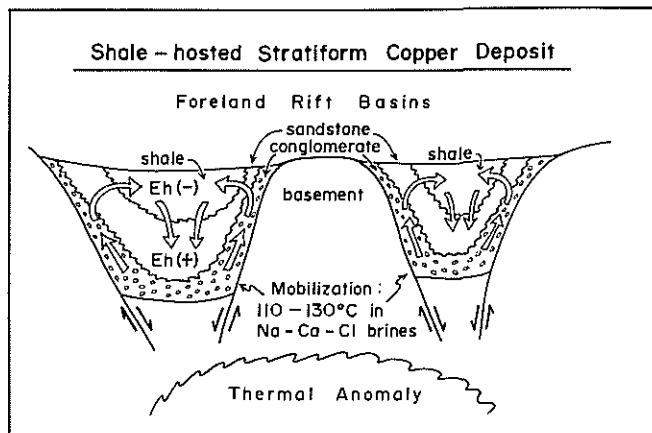
rives its metals from the weathering of pyroclastic volcanics and/or uranium-rich granites. The oxidized solution in a shallow continental basin travels toward the center of the basin where either an introduced or an indigenous reductant precipitates a roll or a peneconcordant deposit. The five-element type mineralization associated with this sort of deposit is merely a trace, reflecting its derivation from a generalized source under oxidizing conditions and precipitation by strong reduction.

The genesis of stratiform, shale-hosted copper deposits is still a highly controversial topic, and the mechanism presented in Figure 4 is one proposed recently by Jowett *et al.* (1987) based on the Polish Kupferschiefer. Foreland rift basins are subject to anomalously high heat flow, which mobilizes oxidized connate brines. The solutions pass upward along the

and pass to the margin where deposition occurs. The basin may require some anomalous heat flow, however, to attain the temperatures proposed. In contrast to the cases discussed previously, the solution is reduced and carries lead and zinc in much greater abundance than copper.

There is a long-standing controversy on the nature of the ore-carrying solution, which I do not propose to resolve here. However, whether chloride complexing or bisulfide complexing is the mechanism, nickel-cobalt sulfides are the least soluble components and will precipitate first in the paragenetic sequence. The reducing character of the ore solution will prevent transport of arsenic, although it is unclear why the silver content is low in these deposits.

Figure 6 is intended to summarize the relationship



sides of the basin, the dips of which are much exaggerated here, and into a zone of reduction in the shale. The process is envisaged as occurring during diagenesis of the sediments, while permeabilities are quite high. Although the temperatures are fairly low, the salinities are high, resulting in reasonably effective transport of cobalt and nickel.

Finally, Figure 5 illustrates the Mississippi Valley-type lead zinc deposit. The generalities of this diagram are not particularly controversial, and the situation shown is approximately that in south-east Missouri. Connate brines are mobilized in source beds usually believed to be shaley

Figure 4. Generation of shale-hosted stratiform copper deposits by circulation of connate brines in diagenetic stage sediments filling foreland rift basins. Deposition occurs by reduction in shales (areas of Eh(-); after Jowett *et al.*, 1987).

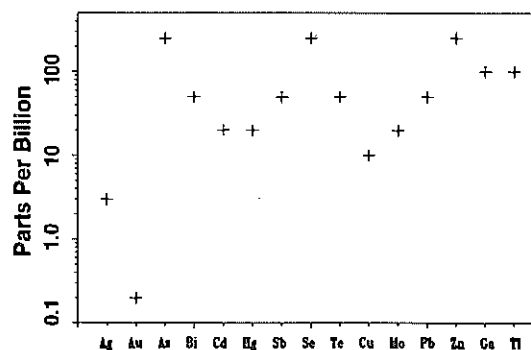
between the five types of ore deposits just discussed. The vertical axis represents temperature, and the horizontal axis represents the approximate degree of involvement of the ore solution with basement. Looking then at the uranium-bearing deposits, the highest temperatures are associated with the five-element veins, which are essentially entirely derived by

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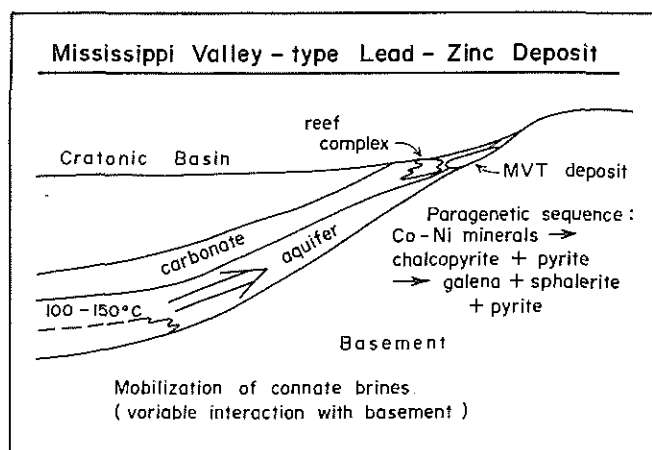


Figure 5. Generation of a Mississippi Valley-type deposit by migration of connate brines to a pinch-out and/or facies change.

interaction with basinal fluids. Thus, some deposits which have traditionally been difficult to classify, e.g. Pribram and the Beaverlodge district of Saskatchewan, may be intermediates. According to this idea, as well, sandstone-type deposits may lie at the opposite end of the spectrum, formed at low temperatures and derived entirely from basinal fill.

The stratiform copper and Mississippi Valley-type deposits overlap, and they may be in a sense closely related. It has been shown, for example, that oxidation of a Mississippi Valley ore solution can yield a stratiform copper ore solution.

In conclusion, then, the five-element association in ores appears to characterize

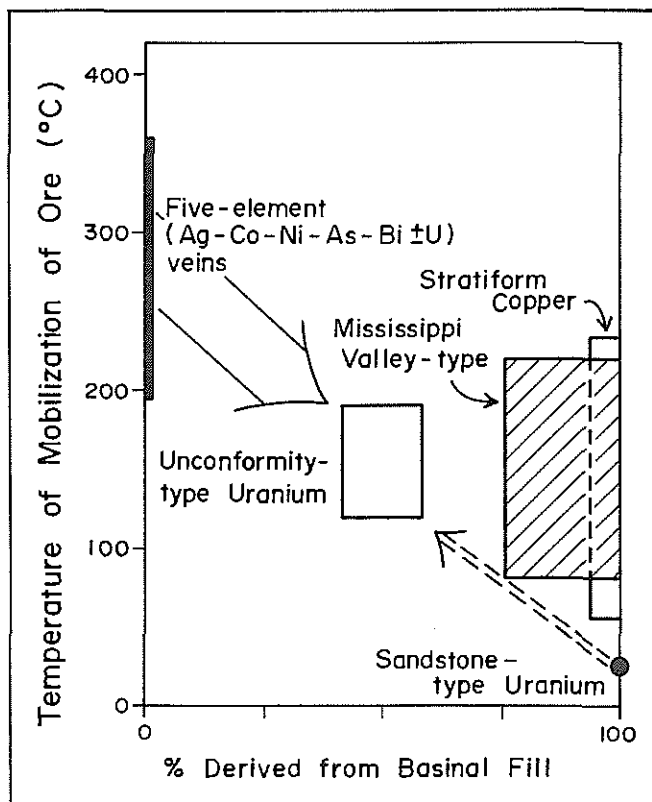


Figure 6. Proposed relationship between temperature of mobilization of ore (after Crerar *et al.*, 1985) vs. percentage derivation of ore components from basinal fill. Arrows indicate transitional relationship between five-element veins and unconformity-type uranium deposits and possible relationships between sandstone-type and unconformity-type uranium deposits.

nonmagmatic genesis of a spectrum of ore deposit types related to differing phases of development of sedimentary basins.

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The Use of Metal Ratios in Platinum-group Element Prospecting

Introduction

At present there are few useful indicators in exploration for platinum-group element (PGE) deposits. The general opinion is that large, layered intrusions formed from high-MgO magmas are a good target using the models based on the PGE deposits of the Bushveld, Great Dyke, Penikat and Stillwater intrusions.

Many intrusions may be broadly divided into a lower ultramafic zone, a middle mafic zone and an upper intermediate zone. Coarse-grained pyroxenites or gabbros occurring close to the transition from the ultramafic to mafic zone, and which contain chromite or sulphides, may be enriched in PGE. However, many intrusions are neither exposed well enough nor mapped well enough to use this model.

Most current exploration programmes for PGE consist of sampling of mafic and ultramafic rocks and determining Rh, Pt, Pd and Au. Frequently a few samples will have Pt and Pd contents of about 100 ppb. While contents of 100 ppb Pt and Pd are anomalous in mafic and ultramafic rocks they could simply represent the presence of sulphides and not necessarily indicate a favourable environment for a PGE deposit. The topic of this paper is how to use the ratios of Ni and Cu to the PGE to decide the significance of such low geochemical values.

Factors Effecting the Distribution of Ni Cu and PGE in Mafic and Ultramafic Rocks

The distribution of the PGE, Ni, and Cu in mafic and ultramafic rocks is thought to be controlled by sulphides, chromite, olivine and platinum-group minerals (the reasons for this is discussed in more detail in Barnes *et al.* 1988). The distribution of major rock types and the effects of olivine and chromite crystallization are illustrated in Fig. 1a. Because all known PGE-deposits are in layered intrusions that formed from high-MgO basaltic magma, the chilled rocks of an intrusion with potential for a PGE-deposit should lie in the high-MgO basalt field. However, in a normal exploration programme only cumulate rocks may be available to sample. If these rocks contain cumulus olivine or chromite they will be displaced from the original liquid composition along the olivine or chromite vectors (Fig. 1a), i.e. towards the right-hand corner of the diagram. The liquid from which the olivine and chromite has been removed, and cumulate rocks that subsequently form from the depleted liquid, will be displaced in the opposite direction. Cumulate rocks from an intrusion with PGE potential should lie along the olivine or chromite vector and pass through the high-MgO basalt field.

The Pd/Ir ratio changes

rapidly during olivine and chromite crystallization and hence is a good discriminator of the degree of evolution of the magma and its potential to produce a PGE deposit. Unfortunately Ir analysis is expensive and thus the Pd/Ir ratios are not always available. Figs. 1b and 1c show the distribution of the major mafic and ultramafic rocks for Pd/Rh and Pd/Pt versus Ni/Cu. However, these diagrams are not as effective at discriminating an intrusion with PGE potential because the ratios of Pd/Rh and Pd/Pt are affected less by olivine and chromite crystallization.

Sulphide segregation also has an important influence on the formation of PGE-deposits. The effects of sulphide segregation cannot be seen on Figs. 1a,b and c, because Ni and Cu both have similar partition coefficients into sulphide liquid.

Partition coefficients for Pd

and Ir into a sulphide liquid are not known exactly (they are in the range 1000 - 100,000) but they are usually assumed to be similar. Therefore, as in the case of the Ni/Cu ratio, the Pd/Ir ratio of the magma or cumulate is not changed by the segregation of a sulphide liquid. In order to study the effect of sulphide saturation the Ni and Cu to PGE ratios must be considered. Fig. 2a shows the fields for mafic and ultramafic rocks on a plot of Ni/Pd versus Cu/Ir.

If sulphides have not been removed from the magma then the Ni/Pd and Cu/Ir ratios will be similar to that of extrusive rocks (komatiites, high-MgO basalts, and flood basalts) and the intrusion had potential to form a PGE-deposit. However, to generate a PGE-deposit some sulphide segregation is necessary. Because the partition coefficients for Cu and Ni into sulphides are much less

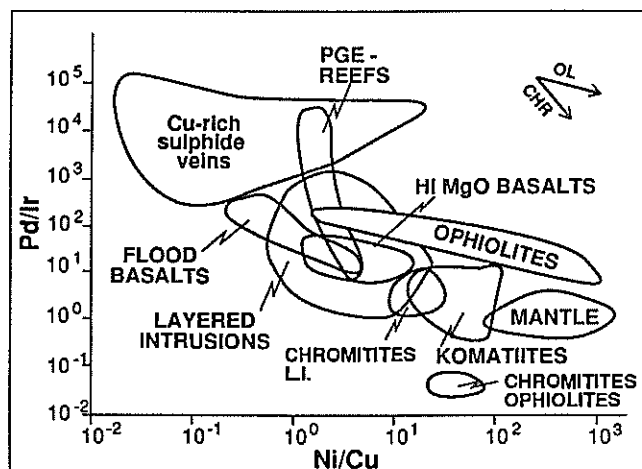


Figure 1a.

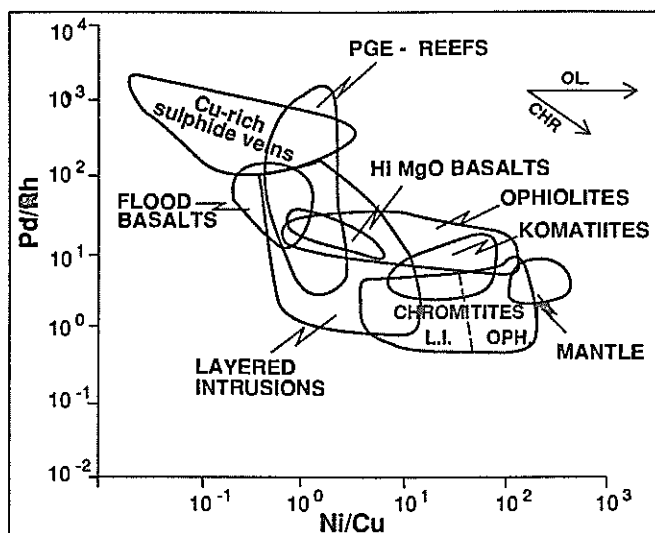
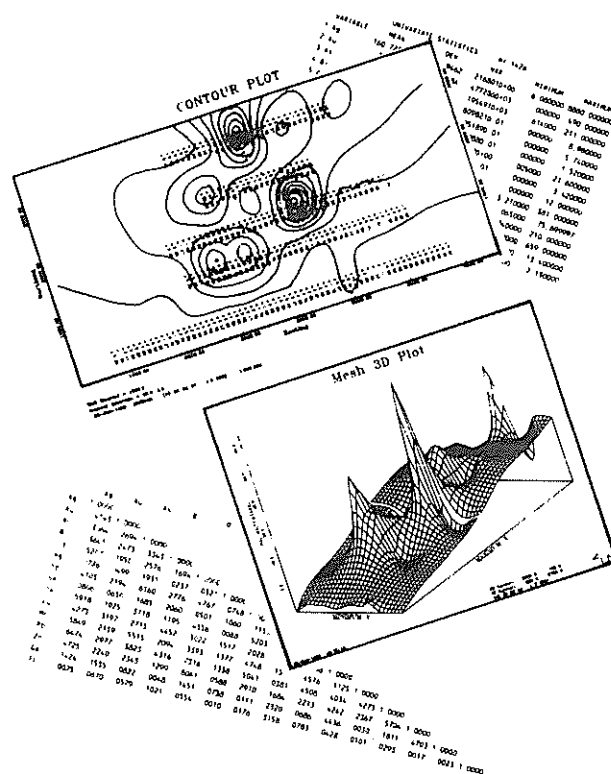


Figure 1b.

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- Basic statistics and correlation matrices
- Contour plotting
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- Scatter diagrams
- Histograms
- R-mode factor analysis
- Q-mode factor analysis



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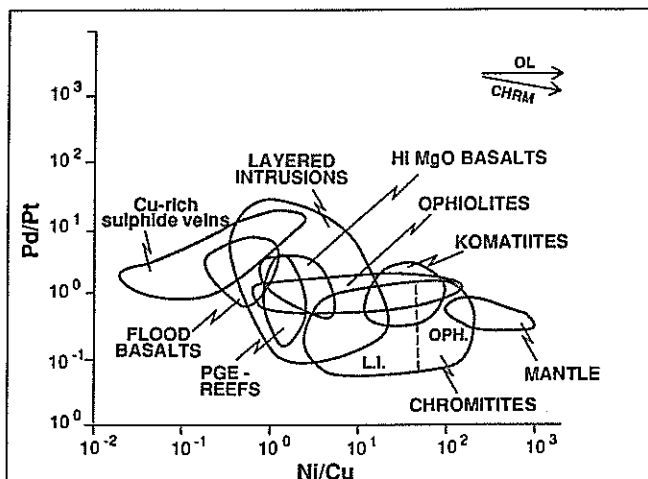


Figure 1c.

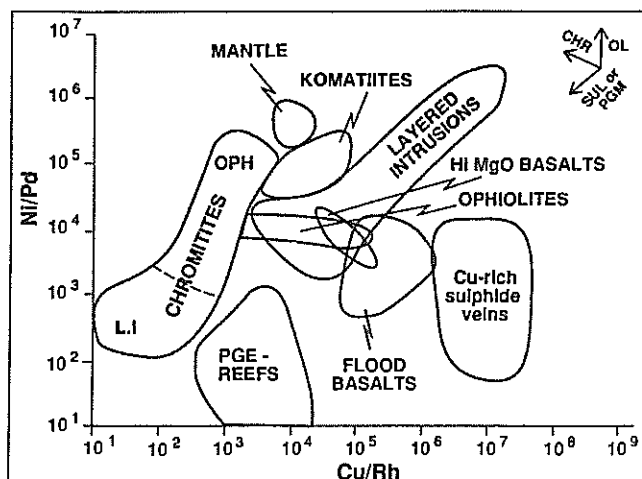


Figure 2b.

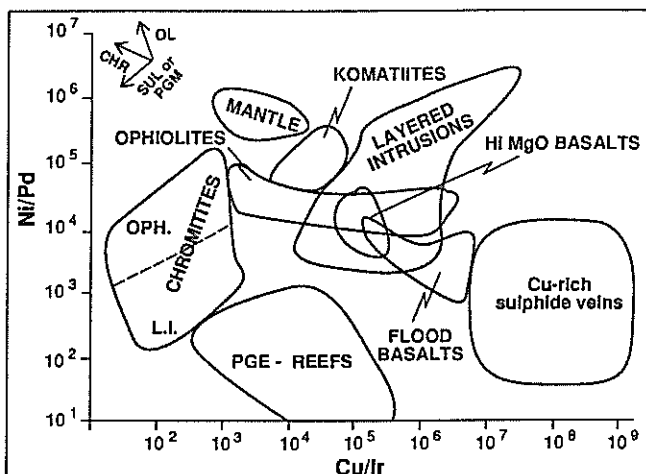


Figure 2a.

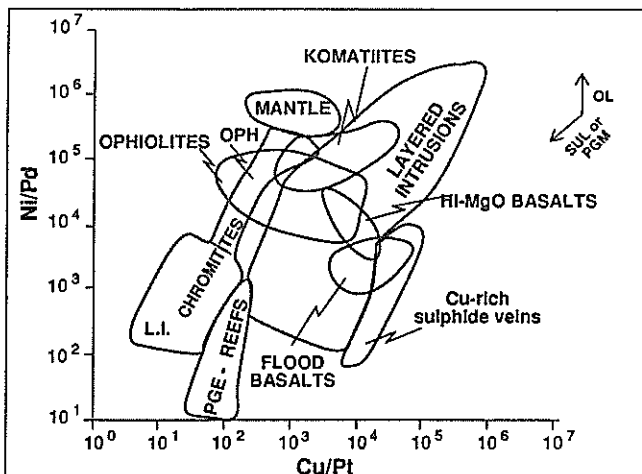


Figure 2c.

than for PGE, the segregation of sulphides from a magma causes the Ni/Pd and Cu/Ir ratios to increase in the cumulate and decrease in the fractionated magma, relative to the initial magma. Any cumulate containing the first formed sulphides should be enriched in PGE relative to Ni and Cu and will tend to plot below the field defined by extrusive rocks. If rocks plot in this area it suggests that processes favouring the formation of a PGE-deposit operated. The fractionated magma may subsequently form a cumulate containing later sulphides, but this rock will be depleted in PGE because of the earlier sulphides will have stripped the magma of PGE. Rocks formed from magma depleted in PGE by an earlier sulphide segregation will plot above the field of extrusive rocks defined by komatiites, high-MgO basalts and flood basalts. Such rocks do not make good exploration targets, they do however

suggest that PGE-enriched rocks might lie stratigraphically below them. It should also be remembered that if each cyclic unit in an intrusion represents a new influx of magma the process may be repeated several times.

The same approach has also been applied to the Cu/Rh and Cu/Pt ratios (Figs. 2b and c). These diagrams are not as discriminating as the Cu/Ir diagram because the effect of olivine addition and sulphide removal is similar for Figs. 2b and c, i.e. it raises the Ni/Pd ratio and does not change the Cu/Rh or Cu/Pt ratio. Thus an olivine cumulate may falsely appear to be depleted in PGE and rocks formed from magmas which have separated olivine will appear enriched in PGE.

Conclusions

The use of Ni and Cu to PGE ratios could be an interesting exploration tool for PGE deposits. Plots of Pd/Ir versus

Ni/Cu and Ni/Pd versus Cu/Ir can be used to distinguish the effects of olivine and chromite fractionation and sulphide segregation and thus help to define intrusions with potential for a PGE-deposit. Because Ir analyses are expensive, Rh and Pt may be used instead of Ir, but these elements may present ambiguous results.

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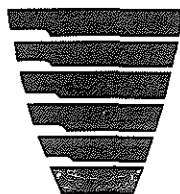
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Volcanogenic Massive Sulfides in Newfoundland

As time has been short between the writing of this column and publication of Issue 63, I will leave *conclusion* of the VMS case history for Issue 65.

In Issue 63, Figure 3 displayed the Cr data for a soil survey looking for Au and asked the question "do you see anything peculiar in the data display?" Before answering this question one might ask "why look at aqua regia leachable Cr data searching for Au?" Is one looking for the Cr-bearing mica, fuchsite, which is sometimes prevelant around Au deposits? I would not suggest that was an objective here. Perhaps one is looking for major geochemical patterns which would help unravel the nature of the underlying geology or the composition of the overburden. That is a valid application.

Geochemical data show an unusual pattern of lines alternating between high (170 to >250 ppm) and low (<11 to 55 ppm) values, particularly in the east. This unusual distribution would immediately suggest chrome contamination introduced from pulverizer plates, if the samples were rock chips, but such a source for Cr is unlikely using nylon mesh sieves to separate the minus 80-mesh fraction used for soil samples. If the distribution is not contamination-related, could it be an analytical error? Again, would you be particularly worried about obtaining the valid aqua regia leachable Cr results?

The inductively coupled plasma (ICP) used to determine Cr (as well as 29 other elements simultaneously) normally proves reliable Cr results, the amount of Cr depending on the sample and the strength of the extraction. However, the ICP requires a sophisticated computer program and numerous corrections to ensure reliable chemical determinations for all elements. Although Cr is probably not of direct exploration interest, it could indicate erroneous computer-calculated correction factors which could affect determinations of elements you might be interested in (i.e., base metals, As, Sb). The lab was asked to investigate.

Their examination revealed many very small soil samples were submitted for analysis. Analysis was not possible on the available minus 80-mesh fraction and so to provide a set of results, the lab elected to pulverize those very small samples in their entirety (i.e., pebbles as well as fines) prior to the analysis (introducing Cr from the pulverizer plates) and added an appropriate \$2.00 surcharge for the procedure. Under pressures of the field season the additional charge was not appreciated until after the geochemical interpretation.

The field individual responsible for the small samples was working under contract. As large soil samples weigh more than small soil samples and carrying them any distance can reduce sampling rates significantly, small samples were taken. The ap-

parent analytical error was actually a sampling error, which once recognized, was rectified in future surveys.

Editors reminder: Readers of this column are encouraged to send in their case histories for future publication. I will be revolving between sampling, analysis, and interpretational examples. Please assist me with writeups from your files.

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Analysts Couch

The Determination of Pt and Pd in Waters

Our knowledge of the migration of Pt and Pd in surface and ground waters in extremely limited, largely owing to the lack of practical and sensitive methods by which to analyze for these elements in this medium. Pogrebnyak *et al.* (1984) have studied streams draining a Pt-Pd occurrence in Transbaikalia, associated with CuS mineralization, and found Pt to range from <5 ppt (ng/liter) to 40 ppt and Pd to range from <1 ppt to 10 ppt. However, all detectable Pt was present in suspended form (0.3 μ m), whereas the majority of Pd was present as a true solute.

An elegant but time-consuming method requiring yield determinations has been employed by Hodge *et al.* (1986) at the Scripps Institution of Oceanography to study Pt in the marine environment. Using 2 liter samples, they found Pt to range from 0.10 to 0.25 ppt in a depth profile of the Pacific Ocean off the California coast.

At the Geological Survey of Canada (GSC) there has been much effort in the past several years devoted to establishing analytical methods to determine Pt and Pd in vegetation, as well as improving detection limits and accuracy for these elements in rocks and sediments. Thus, we decided to investigate procedures for the determination of these elements in waters, not only to explore their migration in the vicinity of an ore deposit but also to obtain

more information on their geochemical cycles (uptake in vegetation, controls on solubility, etc).

The method now established is an extension of that employed for Au in waters (Hall *et al.*, 1986). Briefly, Pt and Pd are absorbed onto 300 mg of activated charcoal from a filtered (0.45 μ m) 1 liter water sample which has been acidified with 10 ml of concentrated HCl (0.1M). The charcoal is filtered off, ashed at 650°C and the analytes solubilized in 1.5 ml of aqua regia.

Following evaporation and cooling, the volume is made up to 5 ml, thus effecting a concentration factor of 200. Analysis is carried out by ICP-mass spectrometry (ICP-MS) or graphite furnace atomic absorption spectrometry (GFAAS). These techniques are of comparable sensitivity but the former is essentially simultaneous owing to its rapid scanning facility. Detection limits are in the order of 0.5 to 1.5 ppt, based upon 3 x the standard deviation of blanks taken through the procedure; recoveries are greater than 95% for both elements.

Five tap water samples, spiked at 25 ppt, produced results of 24.6 ± 1.4 ppt for Pt and 24.9 ± 0.4 ppt for Pd. The feature of calibration by isotope dilution in ICP-MS is particularly attractive since addition of the isotope prior to concentration would eliminate any variability in recovery values.

Furthermore, sample intro-

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duction by electrothermal vaporization (ETV) in ICP-MS, rather than by nebulization, requires only μl volume so that the concentration procedure can be designed to result, for example, in only 1 to 2 ml (Park and Hall, 1986). Hence, analysis by isotope dilution ETV-ICP-MS provides even lower limits of detection for Pt and Pd, in the range 0.1 - 0.5 ppt. Gold is also fully recovered by this procedure and can be determined by either analytical technique.

It was found that the minimum quantity of concentrated HCl required to maintain 50 ppt Pt and Pd in solution for at least two months was 10 ml/liter (0.1M). An acidity of 0.05 M retained Pt in solution for 20 days but Pd dropped by 40% over this period. If transportation of acid in the field is difficult, it is the practice at the GSC for analyzing Au in waters, simply to filter in the field and to leach Au adsorbed onto the walls of the container later in the laboratory, using Br_2HCl . This procedure was tested for Pt and Pd, after allowing standard solutions to sit for several weeks. Partial recovery was obtained for adsorbed Pd, while lost Pt was not recovered at all. However, if 20 ml of Br_2HCl were used undiluted as leachate in the bottles, then 90% of the adsorbed Pd was recovered; again, this procedure was completely ineffective for Pt. Thus, until further leaching experiments are complete, we advise acidifying the filtered water sample within 24 hours of collection.

In the few samples collected to date, only Pt has been detected. It was found at a concentration of 340 ppt in a stream near the Tulameen deposit, B.C. and at a concentration of 64 ppt in a lake at the Rottenstone deposit, Saskatchewan. These analyses were performed by ICP-MS and confirmed by GFAAS (368 and 65 ppt, respectively). Unfortunately, these samples although clear in color, were not filtered in the field prior to acidification, so it is impossible to ascertain whether Pt was suspended,

colloidal, or in true solution.

Surprisingly, water collected from a tailings pond ($\text{pH} = 4$) at Rottenstone showed no detectable quantities of Pt (or Pd). Water recently collected over a gossan ($\text{pH} = 4.4$) located in the Ferguson/Yathkyed Lakes region, N.W.T., Canada, was found to contain 3 ppt Pt (background of 0.2 ppt), which is a lower limit as a delay of 48 hours occurred between collection and filtration/acidification. A detailed survey of the vegetation in this area is in progress for Pt and Pd contents.

Brines from the Salton Sea geothermal system in California have been analyzed by this procedure. It was necessary to dilute the brine, containing about 24% total dissolved salts, by a factor of 20 to obtain full recovery for Pt and Pd spikes. With a dilution factor of only 2 for the brine, a recovery of about 60% was obtained for each element and this was increased to 75% by using 600 mg of activated charcoal (cf. 300 mg), an amount which begins to hamper efficient filtration.

In summary, Pt and Pd can be determined (together with Au) to a level of 1 ppt in 1-liter water samples by preconcentration on activated charcoal followed by analysis using ICP-MS or GFAAS. Care must be taken to preserve the analytes in solution by adding 10 ml/liter concentrated HCl if analysis is delayed. Alternatively, the preconcentration on activated charcoal can be carried out in the field laboratory and the filtered residues shipped to the analytical laboratory. Brines can also be analyzed by this method with initial dilution by a factor of 20, thus increasing detection limits to 20 ppt.

N.B.: Details of this methodology will be given in a manuscript soon to be submitted to the *Journal of Geochemical Exploration*.

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SPECIAL NOTES

Request for Manuscripts to JGE

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A Safe Heavy Liquid

Geologists who work with heavy liquids should be aware of the toxicity of the various ones in use. There is a new heavy liquid, sodium polytungstate, available that is nontoxic. This heavy liquid can be diluted with distilled water to vary the specific gravity can from 1 to 3.0. It is available in powdered form from Sometu, Falkenried 4, D-1000 Berlin 33, West Germany at DM 130 per kilogram. Even though the cost is approximately 1.6

times more expensive than tetrabromoethane, the safety factor and clean-up with distilled water is worth the difference in price. In addition, I suggest using coffee filters with this liquid as they increase the flow rate, have excellent wet strength, and most importantly, they are cheap. A comparative study using this liquid is available in a recent note by J.E. Callahan published in the *Journal of Sedimentary Petrology* Vol. 57, No. 4, p. 765-766.

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painted on the slide with a small brush, producing almost any color effect. I particularly like the lemon-yellow color but others are available. This process has been written up in several Kodak brochures. One additional point is that your kodalith slides don't fade like the diazochrome technique that I described in the Newsletter several years ago.

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Where is my Journal?

The *Journal of Geochemical Exploration* (JGE) represents one of the main benefits of AEG membership. Our contract with Elsevier Scientific Publishers assures members of receiving at least 800 pages of technical material in JGE annually. Recently, Elsevier has modified our contract to permit publication of up to 1200 pages annually, at no additional cost to the AEG membership for the extra 400 pages.

Unfortunately, delays in publication consequent to the preparation of a large number of special volumes has meant that the first issue of the 1988 year is not scheduled until late November, 1988. This answers the question many new members in 1988 have wondered: when will their JGE issues for 1988 arrive? Long term AEG members received Volumes 28

and 29 in 1987, Volume 30, in March and July, 1988. The last installment of Volume 30 is scheduled for release in late October, 1988.

Members in good standing in 1988 will receive Volumes 31, 32 and 33. Members in 1988 have received a copy of a 1988 update of our geochemical bibliography, 1988 *Membership Listing and Directory of Geochemical Services* and issues 62 and 63 of EXPLORE (in addition to this number 64). Please wait until you see an announcement of JGE publication of Volume 31 in *Notes from the Editor* before writing to the AEG office to enquire about the status of your 1988 membership. The address label on this issue reveals your membership status for 1988.

The effect of the delay in

publication schedule of the JGE on new members of the association represents a new problem for the AEG council and actions are being taken to return to a reasonably un-

derstandable schedule of publication. Rest assured members in good standing in 1988 will receive all of their issues of JGE, albeit publication will carry into mid 1989.

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 USA.

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

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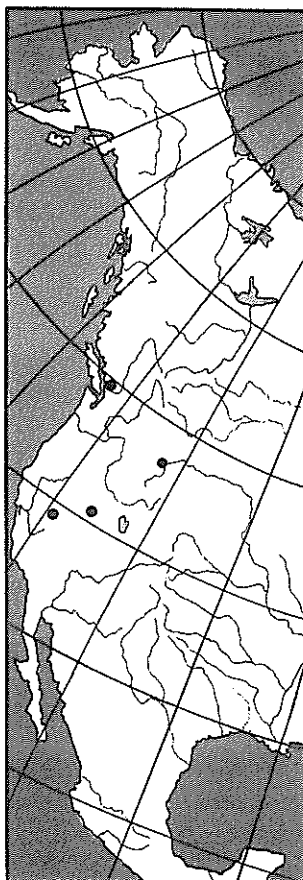
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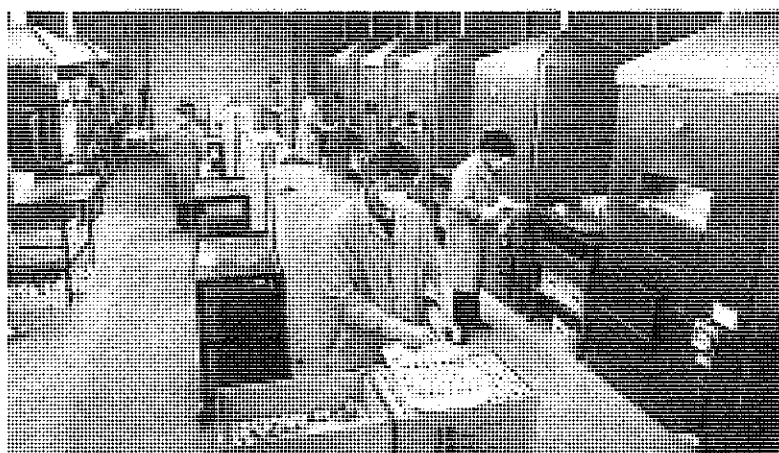
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- Shallow (1" - 6") soil samples
- Separation of mineralogical clays (the long-term collectors)
- Thermal desorption of adsorbed gases
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- Sulfur oxides and hydrides
- Organic sulfurs
- C₁ - C₇ hydrocarbons
- Organohalides
- Nitriles
- CO₂

RESULTING MAP FEATURES

- Area partitions or zones
- Linear and/or areal halos
- "Anomalies"

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Exploration Geochemistry

This list comprises titles that have appeared in major publications since the compilation in Newsletter No. 63. Journals routinely covered and abbreviations used are as follows: Economic Geology (EG); *Geochimica et Cosmochimica Acta* (GCA); United States Geological Survey Circular (USGS CIR); and Open File Report (USGS OFR); Geological Survey of Canada Papers (GSC Paper) and Open File Report (GSC OFR); Bulletin of the Canadian Institute of Mining and Metallurgy (CIM Bull.); Transactions of Institute of Mining and Metallurgy, B: Section Applied Earth Science (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. Please send submittals or contributions to Dr. Closs, not to EXPLORE.

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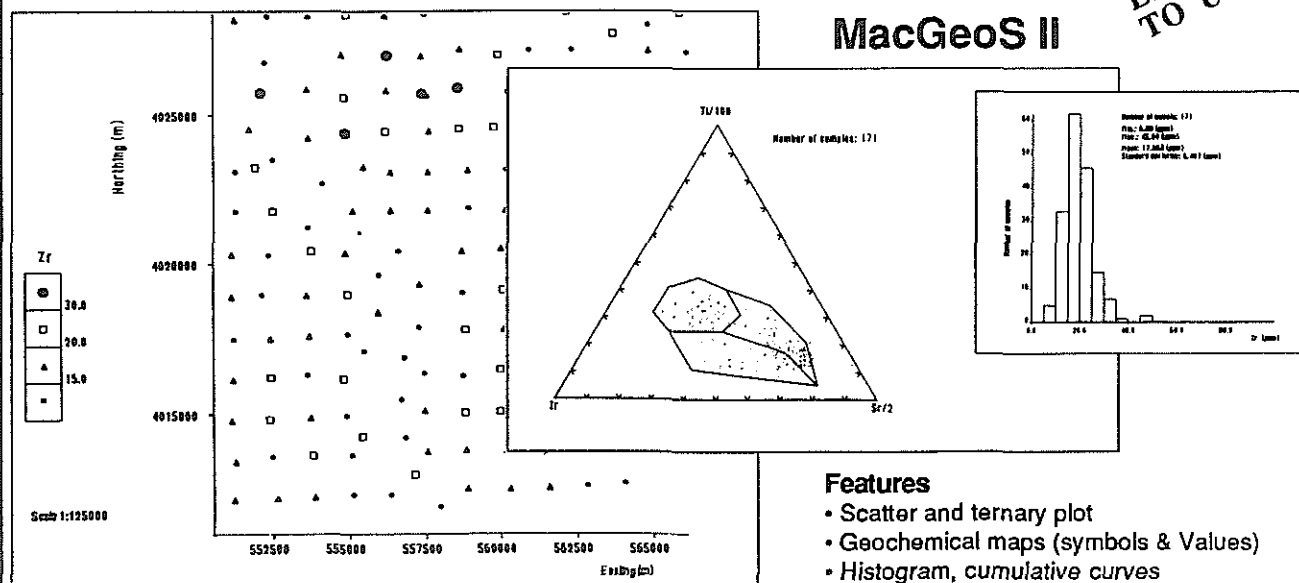
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Recent Papers on Analytical Geochemistry

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 4, "et al." is used. This list covers those issues received by the author since those listed in EXPLORE No. 63.

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.

Berrow, M.L. 1988. Sampling of soils and plants for trace element analysis. *Anal. Proc.*, **25**: 116-118.

Brooks, R.R. and Lee, B.S. 1988. The determination of Platinum and palladium in rocks and soils by electrothermal atomic absorption spectrometry of extracts of their iodo complexes. *Anal. Chim. Acta*, **204**: 333-337.

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Kvasov, A.I. 1988. Determination of Pd, Pt, Ir and Au in rocks by concentrating them in a nickel sulfide matte and subsequent neutron activation analysis. *Geochem. Intern.* **25**(2): 122-124.

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Geochemistry of Peatlands

I wish to briefly summarize my interest in the geochemistry of peatlands and establish contact with others working with peat.

My Ph.D. thesis (University of Western Ontario, 1986) is concerned with the inorganic geochemistry of peats and the physical chemistry of peatland waters. I am particularly interested in the frequent anomalous accumulations of Cu and U in peatlands (mires), and the possible use of mires in geochemical exploration. I am having a difficult time finding people in Canada and the United States who share this interest (except for Dr. R. E. W. Lett at Barringer Magenta!)

I have worked with the Geological Survey of Finland where peatlands are used in exploration. In addition, mires are used as sampling media by industry in Finland (Outokumpu) and Sweden (Boliden and LKAB), but I am not well informed of work here at home.

I have published several small review papers on peatland geochemistry, and a detailed review (200 MS pages) is now in press at *Earth-Science Reviews*. In addition, I am now preparing a monograph for Elsevier on the geochemistry of peat and peatlands, and a part of one

chapter will address the possible use of peatlands in exploration geochemistry.

With almost 15% of Canada covered by peatlands, I would like to hear from exploration people who either have used peat samples as part of the exploration programs (and details of problems, successes, failures, etc.) or would like to use peat, but are not sure where to begin. I think the monograph would benefit from this kind of feedback because it may help me to focus on specific problems. Even if I cannot help, at least I will have a better appreciation of the problems involved.

In addition, I am sure that there must be a great volume of peat geochemical data out there which has not been published. If this is the case, I am always looking for good data which would strengthen the book, and would appreciate use of such data where possible, with appropriate credit to be given to the source of the information.

William Shotyk, Ph.D.
Visiting Postdoctoral
Researcher
Geology Department
University of Western Ontario
London, Ontario
NGA 5B7 Canada

Student Paper Competition

The Association of Exploration Geochemists will hold its fifth annual Student Paper Competition in 1988. Papers eligible for the competition must have been published in a refereed scientific journal within the last five years and less than five years since the graduation of the student author. Multiple authors are allowed, although the student must be the senior author. The award will be announced in January, 1989 and the prize will consist of a

two-year membership at the appropriate level in the Association of Exploration Geochemists, including receipt of all publications. Please send nominations with three copies of the paper and the current address of the nominee to:

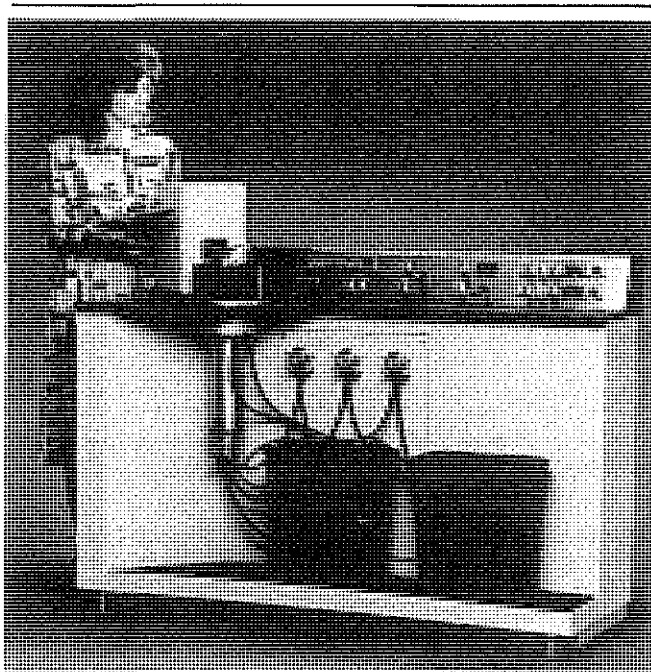
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Lithogeochemistry

Reviews in Economic Geology, Volume 3: *Design and Interpretation of Soil Surveys* has been enthusiastically accepted by the profession as indicated by sales. We are considering a proposal to the Society of Economic Geologists that a future companion volume on lithogeochemistry be prepared. At this time, I am requesting input on what you would like to see in such

a volume. Please suggest concepts, novel ideas, case histories, and methodologies along with contact individuals prepared to contribute and perhaps participate as instructor in a future short course. Send your correspondence to:

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Technical Advertisement

ADVERTISE IN EXPLORE

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JGE Issues in Progress

Editing the proceedings of the 12th International Geochemical Exploration Symposium was completed in September. Eleven AEG members kindly agreed to this task on short notice. Publication by the *Journal of Geochemical Exploration* is expected on schedule, approximately one calendar year after receipt of the manuscripts from the organizers of the symposium in January-February, 1988. Final editing to ensure consistency was by **Stuart Jenness**, a past editor of the *Canadian Journal of Earth Sciences*. Selected abstracts from the meeting will be published in addition to papers.

The Chinese special issue, being edited by **Xie Xuejing** and **Stuart Jenness**, is nearing completion. This has been a difficult exercise, both for the authors and the editors, to communicate knowledge in such a different language. Considering the enthusiasm of the geochemists and the amount of work being carried out in that country, China is likely to play a major part in the further development of exploration geochemistry.

The special issue *Epithermal Gold Mineralization of the Circum-Pacific: Geology, Geochemistry, Origin and Exploration* is planned for publication in late 1989. It is being edited by **Jeffrey Hedenquist**, **Noel White**, and **Gordon Siddeley**. Jeff Hedenquist has sent me a provisional list of the papers offered. At twenty eight, this is well above original expectations. Regions covered will include Japan, Kamchatka, Philippines, Papua New Guinea, Indonesia, Australia, New Zealand, Fiji, Chile, Caribbean, Western United States, and the Yukon. In addition to papers on deposits, there will be general papers discussing the geology of epithermal mineralization, and geochemical and geophysical methods of exploration.

Eion M. Cameron
Editor-in-Chief, JGE
University of Ottawa

AEG 1989 GENERAL MEETING



13TH INTERNATIONAL GEOCHEMICAL EXPLORATION SYMPOSIUM 2nd BRAZILIAN NATIONAL GEOCHEMICAL CONGRESS Rio de Janeiro, Brazil • October 1-6, 1989

Excursions will be planned for the pre-symposium and post-symposium periods. 1) Carajas Mineral Belt: The Carajas iron ore and manganese deposits; The Salobo copper/gold deposit. 2) Gold deposits and iron ore deposits of the Iron Quadrangle: Sao Bento, Morro Velho, Moeda Formation Witswatersrand-type gold. 3) Deposits in carbonatites and in alkaline complexes; niobium, phosphate, bauxite, uranium and titanium ores of southwestern Minas Gerais. 4) Precious-metal deposits and chromite/emerald mines of Bahia: The Weber greenstone belt and the Fazenda Brasileiro gold deposit; The Witswatersrand-type Jacobina gold deposit; The Campo Formosa chromite and emerald mines. 5) Base-metal and uranium deposits of Bahia: the Caraiba copper deposit; the Boquira iron formation-hosted lead deposit. 6) The Taquari/Vassouras potassium deposit in the Sergipe Basin. 7) Petroleum geochemistry excursion to the Campos oil field, Rio de Janeiro, emphasizing applied organic geochemistry. 8) The Crixas gold deposit and Niquelandia garnierite lateritic nickel deposits of Goias. 9) The Paracatu gold deposit, the Vazante Zinc silicate (willemite) deposit, and the Mississippi Valley-type lead/zinc deposits of northwestern Minas Gerais. 10) A one-day excursion to visit analytical laboratories and research centers in the Rio area.

Languages: English will be the official language of the International Symposium. Portuguese will be the official language of the National Congress. In accordance with the interest shown, simultaneous translation will be made available.

Technical Program: The event will comprise five days of technical sessions and workshops. The symposium and congress will be structured as follows:

October 1 (eve.) Opening of the 2nd Brazilian Geochemical Congress
October 2-3 2nd Brazilian Geochemical Congress and Workshops of the 13th International Geochemical Exploration Symposium
October 3 (eve.) Opening of the 13th IGES
October 4-6 13th International Geochemical Exploration Symposium

Themes for the meeting are: 1) enrichment and formation of ore deposits by geochemical processes; 2) petroleum exploration geochemistry; 3) applied geochemistry in humid tropical terrains; 4) applied geochemistry in arid terrains; 5) exploration geochemistry for precious metals, strategic metals (Cr, V, Mn, etc.) and high-technology metals (Ga, Y, In, etc.); 6) recent developments in analytical chemistry techniques appropriate to exploration geochemistry; 7) geochemistry of carbonatites and rare earth metals; 8) applications of lead isotope geochemistry; 9) environmental geochemistry; 10) other subjects.

Workshops: 1) applied rare earth element geochemistry; 2) design and interpretation of geochemical surveys including advances in statistical methods; 3) microcomputer applications in geochemistry; 4) geochemistry of precious metals in laterite; 5) applied biogeochemistry; 6) carbonatite geochemistry; 7) analytical techniques for the determination of gold and PGE's; selective extractions used in exploration geochemistry; 8) geochemical exploration techniques for petroleum; 9) others.

Call for Papers: Proposals for papers covering the listed topics must be submitted in English as extended abstracts up to 1000 words or as completed papers. For the 2nd Brazilian Geochemical Congress, either Portuguese or English will be accepted, but the contributions must be completed papers. It is the aim of the symposium committee to do as much as possible to overcome any possible language-barrier difficulties for visitors and local participants alike. Therefore, completed written texts and figures of the oral presentations are requested and must be submitted by May 1, 1989, and these must be suitable for copying and binding for use by those attending the symposium. The symposium committee requests that manuscripts be submitted whenever possible on diskette as unformatted ASCII files to facilitate their review in word processor programs.

The format used for manuscripts for the 13th IGES must be that specified in the Guide to Authors found in the first issue of the Journal of Geochemical Exploration to appear each year. The format used for the 2nd Brazilian Geochemical Congress must be that specified in the "Revista Brasileira de Geociencias", furnished upon request. Please indicate the intended destination of the paper as either the 13th IGES or the 2nd Brazilian Geochemical Congress.

Publications: Invited lectures and other selected contributions will be published in the proceedings of the 13th IGES. Proceedings will be published as a special issue of the Journal of Exploration Geochemistry. The annals of the 2nd Brazilian Geochemical Congress will be published in an annals volume available at the event. A guide to the field excursions will be published, and publication will be planned for a summary of the Workshop sessions.

Social Program consists of sightseeing in Rio, samba show, boat excursion to tropical islands, shopping in Rio, and a bus tour to mountain towns surrounding Rio.

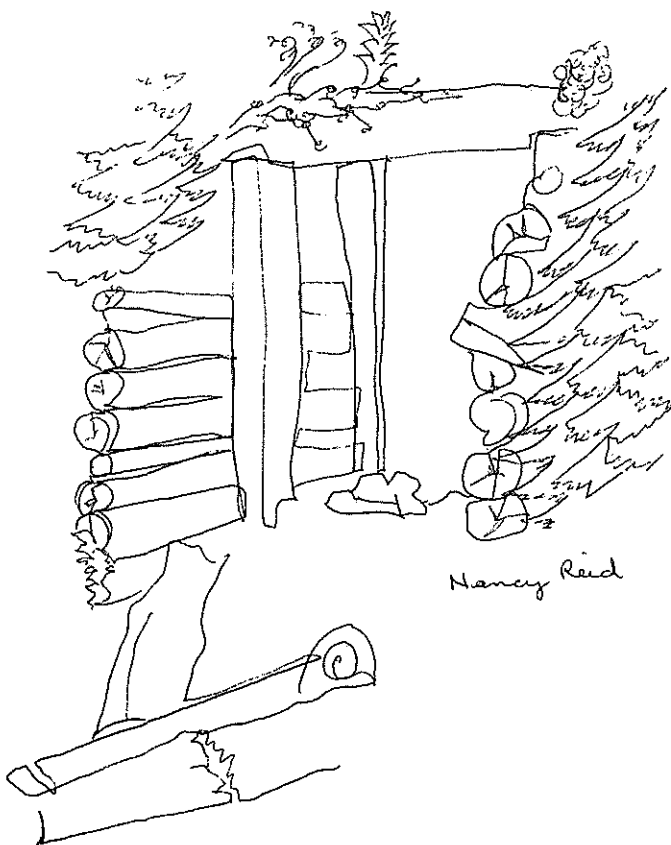
Exhibits, Advertising, Sponsorship: Any organization interested in booth space during the symposium for exhibiting equipment or services, in sponsoring a symposium function (coffee breaks, wine and cheese reception, printing of abstracts volume, etc.), or in advertising in the volume of abstracts is asked to contact the following address, indicating the nature of its interest.

Contact for a copy of the First Circular or for further details:

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