



THE ASSOCIATION OF EXPLORATION GEOCHEMISTS

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NEWSLETTER

No. 23

NOVEMBER 1977

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G. J. S. Govett
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J. F. Gilfillan

This is the second Newsletter to be issued in the 1977-78 Association year; once again it is a pleasure to accept this opportunity to communicate with our Members. We trust that all of you have enjoyed a stimulating and profitable field season and we wish you every success for the months ahead.

The primary purposes of this Newsletter are:

- a) to report on certain forthcoming events of interest to exploration geochemists.
- b) to seek expressions of opinion on certain topics pertaining to the future of our Association.
- c) to present reviews of some recent activities of geochemical interest.

1978 INTERNATIONAL GEOCHEMICAL EXPLORATION SYMPOSIUM

Plans for the Seventh Symposium are now well advanced and all indications are that this will be a most successful event. The biennial symposia are the highlights of the Association's calendar, and the organizing committee of the Seventh Symposium looks forward to welcoming as many AEG members as possible to Golden, Colorado, in April 1978.

If anyone desires further information concerning the Symposium, or has not been receiving our publicity mailings please contact the Symposium Secretary:

Dr. M.A. Chaffee
United States Geological Survey,
5946 McIntyre Street
Golden, Colorado, 80401 USA
Phone 303-234-5301

CURRENT COMMODITY TRENDS IN MINERAL EXPLORATION AND EVALUATION Dec. 5-7, 1977

The Australian Mineral Foundation, Adelaide, S.A.

A final reminder of the Symposium co-sponsored by The Geol. Soc. of Australia (SGIGOD) and the A.E.G. to discuss commodities (U, Sn, W, Cr, Mn) which are of current economic interest but have received little attention in recent symposia. Further information can be obtained from Dr. P.G. Moeskops, Australian Mineral Development Labs, Flemington St., Frewville, S.A. 5063 Australia (phone 79-1662).

1980 INTERNATIONAL GEOCHEMICAL EXPLORATION SYMPOSIUM

The Eighth Symposium will be held in Hanover, Germany in April, 1980, in cooperation with the Bundesanstalt für Geowissenschaften und Rohstoffe. Plans for this Symposium are already well in hand and a successful outcome is confidently anticipated. The location of Hanover should certainly appeal to the many beer drinkers among our members - similarly the appeal of the 1978 Symposium should be heightened by proximity to the Adolf Coors brewing establishment.

1979 BASIN AND RANGE "THEME MEETING"

Since the 1980 Symposium will be held outside North America, it is hoped that two "theme meetings" or "mini-symposia" can be organized within the latter continent in 1979 and 1981 respectively. Plans have already been initiated for a meeting to be held, probably in the Spring of 1979, in Tucson, Arizona. Mineral exploration in the Basin and Range province will be stressed at this meeting.

Chairman of the organizing committee for the 1979 Tucson meeting is Ken Lovstrom. At the present time volunteers are being sought to serve on this committee. Anyone wishing to do so, or any person with suggestions to offer concerning the meeting, please contact Ken at:

AMAX Exploration Inc.,
130 South Scott Street
P.O. BOX 1911
Tucson Arizona 85702
Phone (602-624-8171)

COST OF AEG MEMBERSHIP

There has been considerable debate, in recent months, among the AEG Council regarding the cost of membership of our Association. Some concern has been expressed that growth or continuity of membership might be adversely affected by the relative high cost (when compared with some other earth science organizations) of AEG dues. It should be stressed, however, that of our dues of \$42.50 only \$10.00 actually goes to support administrative costs of the Association—the remainder covers the cost of a member's subscription to the Journal of Geochemical Exploration.

Council's objectives is to restrict future membership costs as much as possible; hopefully increases in royalty income accruing from growth in JGE circulation will substantially counteract inflationary cost pressures in the years ahead.

Opinions among Council is, at present, somewhat divided as to whether or not the present cost of AEG membership is a deterrent to membership renewal and growth. It would be helpful if any AEG members who feel particularly strongly on this question one way or another would communicate their feelings to Council: Please write to either Dick Horsnail or Bob Armstrong.

EXPANDING THE SCOPE OF THE AEG

It would be desirable to broaden the areas of applied geochemical activity with which the Association is involved; areas which merit particular attention are;

- a) Geochemistry applied to the detection and evaluation of energy resources
- b) Geochemical studies applied to the environmental impacts of natural resource development.

Papers pertaining to either of these fields will be particularly welcomed by the Editor of the Journal of Geochemical Exploration.

In order to further stimulate interest in the applications of geochemistry to energy resource developments, a committee is being established to review this field and advise on greater AEG involvement. It is hoped that suggestions for workshops and/or "theme meetings", JGE articles, and possibly, further JGE special issues (similar to the recent issue on petroleum geochemistry) will eventually emanate.

The committee will focus on geochemical topics pertaining to radioactive minerals, fossil fuels and geothermal energy; it is likely that subcommittees will be formed to cover the abovementioned fields.

Any members who are in any way interested in participating in the proposed energy committee please write to Dick Horsnail.

R.F. HORSNAIL

FROM THE SECRETARY'S OFFICE

With a busy 1977 exploration field season drawing to a close we now have time to compile and publish the second newsletter of the Association year. Mrs. Ines Filicetti, as before, handles the publication as efficiently as in the past. A meeting of Council was held on October 17 in Ottawa with 12 Councillors in attendance. A number of items were discussed, some of which are reported following:

European Regional Councillor

Nominations for the Association's permanent office of Regional Councillor closed November 1, 1977. One nomination was received, that of Professor G.H.W. Friedrich. Prof. Friedrich is therefore elected to the office and we will look forward to receiving news of geochemical interest in the European geographical area. Professor Friedrich's address is:

Prof. G. H. W. Friedrich
Abt. Angew /Lagerstättenlehre
TH. Aachen
51 Aachen, West Germany

Honorary Membership

It was decided by Council that the Honorary Membership of the Association be restricted to not more than 1% of the total Voting Membership, as taken at the end of the preceding Association year. There are presently 3 Honorary Members of the Association, Drs. H.E.Hawkes, H.E. Lakin, and J.S. Webb. With a present membership of slightly over 500, the Association can have a total of 5 Honorary Members, or an additional 2 to the 3 presently elected. An Honorary Member is elected by the unanimous vote of Councillors of the Association.

Advertising in the Newsletter

The Council reaffirmed their agreement that advertisements should be allowed in the Newsletter, to partially offset the ever-increasing publications costs. With this, preliminary rates for advertising space were set at \$10.00/issue of the Newsletter for a business card-size advertisement. At this reasonably-priced rate and the knowledge that the publication reaches over 500 geochemically-interested persons, it is hoped that businesses will take this opportunity to advertise their wares and services. Inquiries should be directed to the Secretary's office.

1978 DUES NOTICE - SECOND CALL

Attention is directed once again to the 1978 Dues Notice included in this Newsletter. This is the second call. Subscriptions are due January 1, 1978. Failure to pay prior to this date results in a termination of your subscription as well as the exclusion of your name from the mailing list. Elsevier mailing lists are revised in January of each year.

Change of Address

A Change of address form is attached for those members who plan to change residence for periods of more than 12 months. For lesser periods, it is preferable that the members make their own arrangements for the redistribution of their Journal copy. This assists in reducing the administrative costs of the permanent office.

Back Issues of the Journal

Lately, the permanent office had received a number of requests for back issues of the Journal. The permanent office does not carry back issues and members should contact Elsevier directly with their requests.

INDUSTRY SUPPORT FOR UNIVERSITY RESEARCH IN APPLIED GEOCHEMISTRY

A letter from Professor D.D. Runnels of the University of Colorado is reproduced below. This should be of considerable interest to AEG members employed by U.S.-based industrial organizations.

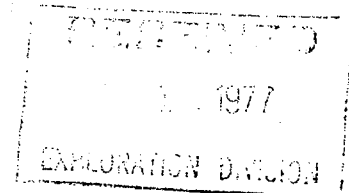
UNIVERSITY OF COLORADO

BOULDER, COLORADO 80309

DEPARTMENT OF GEOLOGICAL SCIENCES

(303) 492-8141

July 5, 1977



Dr. R. F. Horsnail
President of the S.E.G.
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4704 Harlan Street
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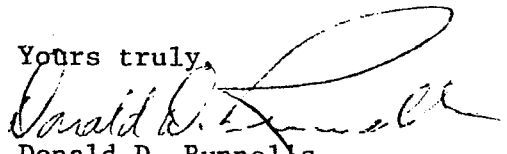
Dear Dr. Horsnail:

In the recent Newsletter No. 22 of our Society, a number of comments are made concerning the role of universities in training future exploration geochemists. In particular, Dr. Govett states that: "...the mining industry--and the public--that pays the taxes to support universities have a right to expect those universities to undertake the fundamental research necessary to improve the capability of mineral exploration...."

Although the situation may be different in Canada, the amount of tax money paid by the minerals industry in most states in the United States is trivial in comparison to the overall tax support of the universities. There may be some exceptions to this in the U.S., such as Utah, Idaho, Montana, and Arizona, but not many. If the minerals industry wishes to have better training of future geochemists, the industry should be willing to offer some financial support directly to the universities for this purpose. Along this line, I thought it might be of interest to the members of the S.E.G. to learn of the results of a campaign that I launched about five years ago to raise money from industry to inaugurate a modest program in the fundamentals of exploration geochemistry here at the University of Colorado. I contacted 71 mining companies and oil companies that have a mining department. In a three-page letter I described my hopes and aspirations for initiating instruction and research in this field, and I asked for contributions of either money or new or used equipment. In response, I received 69 rejections. One company did contribute some used tubes for atomic absorption, but they would not fit our instrument. And Gulf Minerals Corp. gave us \$3000; we used that money to buy a student-model emission spectroscope. Needless to say, this overwhelmingly negative response from industry killed any hopes that I had of convincing my colleagues and administration of the desirability of teaching and conducting research in exploration geochemistry.

It is also important to point out that the financial health of the universities in the United States has deteriorated significantly since I made my plea to industry. We are less able to initiate new programs now than ever before. Without direct and substantial support from industry, education and research in exploration geochemistry cannot be improved.

Yours truly,



Donald D. Runnells
Professor of Geochemistry

DDR:pf



PAST SYMPOSIAPROSPECTING IN GLACIAL TERRAIN

The third symposium on "Prospecting in Areas of Glaciated Terrain", organized by the Institution of Mining and Metallurgy with the cooperation of the Geological Survey of Finland, was held in Helsinki, Finland on the 15th, 16th and 17th of August. The meeting was attended by 115 participants and was followed by a field trip to Finnish Lapland.

The following is a list of the nineteen papers presented:

- | | |
|---|--|
| Application of humus analysis to geochemical prospecting: some case histories
<i>J. Nuutilainen and V. Peuraniemi</i> 1 | Case history of discovery and exploration of Pleutajokk uranium deposit, northern Sweden
<i>B. Gustafsson and H. Minell</i> 72 |
| Exploration in the northwest region of the Koitelainen gabbro complex, Sodankylä, Finnish Lapland
<i>K. Puustinen</i> 6 | Glacial dispersal of uranium in the District of Keewatin, Canada
<i>R. A. Klassen and W. W. Shilts</i> 80 |
| Prospecting for lithium and tungsten in Ireland
<i>R. Steiger</i> 14 | Conductive bedrock and overburden effects on airborne electromagnetic methods used by the Geological Survey of Finland
<i>M. Peltoniemi</i> 89 |
| Aspects of photogeological interpretation of Sokli carbonatite massif
<i>H. Paarma, H. Vartiainen and J. Penninkilampi</i> 25 | Application of humus to exploration
<i>M. Kokkola</i> 104 |
| Kola peninsula till stratigraphy
<i>V. Ya. Evzerov and B. I. Koshechkin</i> 30 | Magnetic susceptibility and its anisotropy in the study of glacial transport in northern Finland
<i>R. Puranen</i> 111 |
| Problems of geochemical contrast in Finnish soils
<i>K. Kauranne, R. Salminen and M. Äyräs</i> 34 | Geophysical methods in thick overburden, Kolari, Finland
<i>A. Hattula</i> 120 |
| Till-sampling methods used in exploration for scheelite in Kaustinen, Finland
<i>B. Lindmark</i> 45 | Glacial transport in Finnish Lapland
<i>H. Hirvas</i> 128 |
| Detection of deeply-buried sulphide deposits by measurement of organic carbon, hydrogen ion and conductance in surface soils
<i>G. J. S. Govett and C. Y. Chork</i> 49 | Synopses |
| Re-evaluation of ore potential at Korsnäs, Finland, by means of geochemistry
<i>A. Björklund</i> 56 | Case history of copper mineralization with naturally copper-poisoned areas at Raitevarre, Karasjok, Finnmark county, Norway
<i>B. Røsholt</i> 138 |
| Litho-geochemistry as an aid in massive sulphide exploration
<i>J. Nichol, E. W. Bogle, O. P. Lavin, J. W. McConnell and V. J. Sopuck</i> 63 | Base-metal concentration in recent lake sediments and peat in Radnejaure area, Arjeplog, Swedish Lapland
<i>R. Friedli, J. Ek and F. C. Jaffé</i> 139 |

The above papers have been published in "Prospecting in Areas of Glaciated Terrain, 1977", available from the Institution of Mining and Metallurgy, 44 Portland Place, London, W1N 4BR, ENGLAND.

EXPLORATION '77

The above meeting, sponsored by the Canadian Geoscience Council, was recently held in Ottawa and, as widely predicted, was a resounding success. Summaries of the geochemical contributions follow:

BOYLE, R.W.

Geological Survey of Canada, Ottawa

Geochemistry Overview

(Paper 3 presented at 11:10-12:00 a.m., Monday, October 17)

The earth is characterized by five distinct spheres – lithosphere, pedosphere, hydrosphere, atmosphere, and biosphere – the various materials of which provide sampling media for geochemical surveys carried out in the search for mineral deposits, coal, oil, and natural gases. In reconnaissance and detailed prospecting for mineral deposits, the best results have been achieved with hydrogeochemical (particularly stream sediment) and soil surveys. Lithochemical (rock), atmochemical (gas), and biogeochemical surveys have not been extensively employed, but where applied judiciously have yielded a modicum of success. In the search for hydrocarbons, analyses of various hydrocarbon gases and other associated compounds in soils, waters, and rocks have produced some significant results.

The modern methods of geochemical exploration owe their rapid growth in the 20th century to the following circumstances:

1. Elucidation of the nature of primary and secondary dispersion halos and trains that are associated with all mineral deposits and accumulations of hydrocarbons.
2. Development of accurate and rapid analytical methods utilizing the spectrograph and various specific sensitive colorimetric reagents (viz. dithizone).
3. Development of resins and plastic (polyethylene) laboratory ware of all types.
4. Development of atomic absorption spectroscopy.
5. Development of gas chromatography and other precise methods of trace analyses of hydrocarbon compounds and various gaseous inorganic substances.
6. Development of radioactive methods of detection of the radioelements, particularly uranium and thorium and their daughter elements. These have included the electroscope, electrometer, ionization chamber, Geiger tube, Geiger-Müller tube, scintillometer, and gamma-ray spectrometer in about that order of development.
7. Development of rapid and precise methods of analyses of various volatile elements such as mercury, sulphur compounds, and radon.
8. Development of rapid and precise methods of analysis of various types of both organic and inorganic particulates in the atmosphere.
9. Refinement of field techniques in carrying out reconnaissance and detailed geochemical surveys of all types but especially those based on stream sediments, lake bottom sediments, heavy minerals, stream and lake waters, groundwaters, springs and their precipitates, and biological materials. In recent years the use of helicopters has revolutionized sample collection in reconnaissance surveys in practically all terrains.
10. Development and refinement of methods of detailed geochemical prospecting using overburden drilling techniques in permafrost terranes, glacial terranes, and deeply weathered and lateritized terranes.
11. Development and refinement of methods using ore boulder, gangue boulder, and heavy mineral trains and fans for prospecting in glacial terranes and in deeply weathered and lateritized terranes.
12. Research and development of efficient methods in the processing and assessment of geochemical prospecting data by statistical and computer techniques.

Future research in geochemical prospecting should be focused on the following:

1. Definition of geochemical provinces and their relationship to metallogenic provinces.
2. Development of methods for discovering mineral deposits and concentrations of hydrocarbons deeply buried in bedrocks.
3. Development of methods for discovering mineral deposits deeply buried below glacial deposits, recent sediments, lateritized deposits, and other types of surficial debris.
4. Elucidation and formulation of techniques to relate the size and intensity of trace element halos and dispersion trains to the estimated size and grade of mineral deposits.

5. Further development and refinement of biogeochemical and atmogeochemical methods in the search for mineral deposits and accumulations of hydrocarbons.
6. Delineation of the nature and extent of lithogeochemical, pedogeochemical, hydrogeochemical, biogeochemical, and atmogeochemical halos associated with oil and gas fields.
7. A better understanding of the factors controlling the migration of the elements in endogene and exogene environments.
8. Production of standardized regional geochemical maps on a national grid based on analyses for the principal elements in the periodic table of materials of the lithosphere (rocks), pedosphere (soils), hydrosphere (waters, stream sediments, lake sediments), and biosphere (vegetation, etc.). For most countries such a program may require a concerted effort for a century or more.

BOLVIKEN, B.

Geological Survey of Norway, Trondheim, Norway

GLEESON, C.F.

C.F. Gleeson and Associates Ltd., Ottawa, Canada

Focus on the use of Glacial Soils in
Geochemical Exploration

(Paper 13 presented at 2:00-2:30 p.m., Tuesday, October 18)

Large portions of the Earth's surface have been glaciated several times during the last 2 million years. These glaciated regions include much of North America north of latitude 40°N (New York), most of Europe north of latitude 50°N (London) and extensive regions in Asia, particularly the area north of latitude 60°N (Leningrad).

The overburden in these areas is made up of till and other glaciogenic deposits which have been laid down by the action of glaciers and their melt waters. The material has been derived from fresh or weathered bedrock and preglacial soils over which the glaciers advanced.

The use of glacially-transported overburden in geochemical exploration creates special problems distinct from those in terrain covered by residual soils. Types of geochemical dispersion found in glacial terrain can be divided into two main classes, 1) syngenetic dispersion, i.e. principally mechanical or particulate dispersion which took place during glaciation and 2) epigenetic dispersion, i.e. mechanical and chemical dispersion which has taken place during the post-glacial period.

There are many physical as well as chemical processes which alone or in combination may result in anomalies with intricate dispersion patterns; these anomalies may be difficult to trace back to their sources. To facilitate interpretation of results from soil surveys in glacial terrain the sampling and analytical methods used should be those which will disclose anomalous patterns that are genetically not too complex.

Ideally methods applicable to defining syngenetic patterns presupposes a thorough knowledge of the glacial history of the area, frequently this requirement is not fulfilled. Where this is the case or where the glacial history is very complicated till samples taken close to the bedrock surface might be the only way of obtaining interpretable results. Overburden sampling at depth may require heavy drilling equipment, such equipment together with various types of light soil-sampling equipment have been developed and successfully used in North America and Europe. Syngenetic dispersion patterns are caused by unoxidized mineral particles and the analytical methods used should employ rigorous digestion techniques, X-ray fluorescence or optical spectrographical methods. Also mineralogical analyses of heavy minerals in glacial tills is a method which has a great potential for defining and explaining syngenetic dispersion patterns.

In outlining epigenetic dispersion patterns, experience has shown that strong anomalies can be produced in glacial till due to down-slope metal dispersion in groundwater. Anomalies can also be produced directly over the bedrock source due to gaseous movement of elements such as radon and mercury and various compounds of sulphur. The permeability of the overburden as well as the ability of humus to bind heavy metals are important factors in creating these types of epigenetic dispersion patterns. Sulphide metal deposits can be good electrical conductors, together with the pore water of the country rock they may act as galvanic cells in which chemical elements move under electromotive forces. Recent work seems to indicate that electrochemical processes of this kind might cause characteristic epigenetic dispersion patterns in glacial soils.

Normally epigenetic dispersion patterns can be detected in surface soils; this means that sampling costs are relatively inexpensive when compared to sampling at depth. Also analytical methods using relatively simple extraction techniques generally are sufficient for most elements sought.

Throughout the short history of geochemical exploration in glaciated terrain, soils have been used extensively as a sampling medium. In the past our approach has been somewhat empirical; in the future, if we are to advance our knowledge of geochemical processes and applicability of geochemical soil sampling in glaciated environments, more research into dispersion mechanisms will be required.

BRADSHAW, P.M.D. and THOMSON, I.
Barringer Research Ltd., Rexdale, Ontario

**The Application of Soil Sampling to Geochemical Exploration
in Non-glaciated Regions of the World**

(Paper 14 presented at 2:30-3:00 p.m., Tuesday, October 18)

Early work in the application of geochemistry to mineral exploration revealed evidence of a simple and direct relationship between geochemical patterns in residual soils and those in the underlying bedrock. Many geochemical features are common to soils developed under a wide range of physical and climatic conditions and thus permit the widespread use of geochemistry in exploration. A simple model, based on the ideal pattern, can be applied extensively in the unglaciated regions of the world, provided attention is given to the well understood and documented distortions caused by mechanical movement and hydromorphic dispersion. Significant differences are, however, noted in various places and the prime objective of the exploration geochemist is to correctly recognize these situations and to select techniques of sampling, analysis and interpretation to accommodate them or to identify environments where geochemistry is not effective and so avoid its use completely.

In this paper a review is presented of the application of geochemistry in non-glaciated soil environments. The basic geochemical characteristics of these soils are illustrated by the use of idealized models and case histories from around the world. Particular attention is given to climatic and physical effects which create conditions that differ markedly from the idealized situation, including the effects of lateritization and caliche development, desert soils and the effects of transported overburden such as alluvium, blown sand, landslides and volcanic ash. In all of these cases, field experience has demonstrated that a reliable reflection of both lithology and mineralization can be obtained in the overlying soil by the correct selection of techniques. In establishing methods, careful consideration must be given to variables such as optimum grain size, soil horizon to be sampled, analytical extraction employed, choice of elements to be analyzed and the interpretation of the various parameters measured and observed.

GOVETT, G.J.S.
*University of New Brunswick,
Fredericton, New Brunswick*

NICHOL, IAN
Queen's University, Kingston, Ontario

Lithochemistry in Mineral Exploration

(Paper 15 presented at 3:00-3:40 p.m., Tuesday, October 18)

Lithochemistry, as used in this presentation, is defined as the determination of the chemical composition of bedrock material with the objective of detecting distribution patterns of elements that are spatially related to mineralization.

Mineralogical alteration zones in host rocks around mineral deposits have long been recognized and used as indicators of ore. Such alteration zones are the visible manifestations of physical and chemical changes in the host rocks resulting from either primary reactions associated with ore formation or subsequent secondary reactions between the ore and the host rocks. Chemical alteration halos may be more intense, and therefore detectable, over greater distances than mineralogical halos, since the lattice substitution of elements may be detected chemically without having any mineralogical representation. The scale and intensity of changes in the chemistry of the host rock is a function of the genesis of the ore, the chemistry of the host rock, and the nature of the secondary processes. Appreciation of these factors is fundamental to the successful application of lithochemistry to mineral exploration.

Lithochemistry has application at three levels of exploration: identification of geochemical provinces, favourable ore horizons, plutons or volcanic horizons on a regional reconnaissance scale; recognition of local halos related to individual deposits on a local reconnaissance or follow-up scale; and wall-rock anomalies related to particular ore-shoots on a mine scale.

Lithogeochemistry has been applied on a regional scale to the identification of mineralized areas in granitic and gneissic terrane (Sn, W, Mo, Cu, and U); in areas of basic intrusions (Ni, Cr, and Pt metals) and basic volcanic rocks (Cu); and in areas of sedimentary rocks (Cu, Pb-Zn, and Au-U). In other cases favourable geological environments have been recognized on the basis of some diagnostic geochemical parameter of lithological units spatially, and probably genetically, associated with mineralization. For example, productive greenstone belts can be distinguished from non-productive greenstone belts, and cycles of volcanism containing significant massive sulphide deposits can be distinguished from equivalent non-productive cycles on the basis of enhanced background contents of certain elements; areas of black shale horizons enriched in chalcophile elements may be readily identified, and these horizons may be spatially associated with more favourable horizons – such as quartzites and limestones – for the emplacement of mineralization.

On a more local scale, geochemical dispersion halos of both major and minor elements have been shown to be associated with porphyry copper deposits. Similarly, depletion of Na and Ca, and enhancement of Fe, Mg, and K – together with characteristic distribution patterns of a wide range of trace elements – appear to be a general local-scale feature associated with volcanogenic massive sulphide deposits. Wallrock dispersion halos have proved useful in detailed exploration, although their nature is very much dependent on local geological conditions.

Various techniques have been employed to detect bedrock anomalies related to mineralization; these include whole rock analysis, measurement of water-soluble elements (especially halogens), and analysis of mineral separates. In some cases multivariate statistical techniques have been used to identify otherwise unrecognized, subtle features of the data or as a means of enhancing very weak anomalies.

The results cited are examples where lithogeochemistry has been or could have been used successfully for the location of particular types of mineralization. They are also indications of the diversified role lithogeochemistry could have in mineral exploration.

Exploration requirements in the future will demand techniques to find mineral deposits in situations where current methods have failed. In particular, presently available routine geochemical methods are unsuitable, or have limited application, for the location of deeply-buried or blind deposits – and these are the types of deposits that probably will become common targets for mineral exploration as the more easily detected near-surface targets are exhausted. The subtle lithogeochemical anomalies and element zoning found in the cap-rocks of some types of blind deposits offer scope for their detection, and may also be useful in drill-hole control.

The application of lithogeochemistry is largely a function of the availability of adequate samples either from suitable bedrock exposure or drill core; obviously, it must have limited potential in areas of deep weathering and areas of extensive overburden or soil cover. However, within these constraints, recent developments offer convincing evidence of the potential power of lithogeochemistry as an exploration method.

BARRINGER, A.R.

Barringer Research Ltd., Rexdale, Ontario

**The Application of Atmospheric
Particulate Geochemistry in Mineral Exploration**

(Paper 16 presented at 3:40-4:20 p.m., Tuesday, October 18)

The atmospheric layer close to the earth's surface carries extensive geochemical information relating to the composition of the underlying terrain. During active mixing, there is an upward flux of both gaseous and particulate material from the surface. Gaseous forms of atmospheric geochemical interest include mercury vapour, halogen vapours, sulphur compounds, and radon. These gases diffuse rapidly and need to be measured very close to the surface to be of value. In general, experiments on the atmospheric geochemical measurement of trace gases have been mainly confined to mercury and radon, and have not led to the development of techniques that have been widely applied. This is due to the inherent problems relating to sensitivity requirements and the effects of rapid dilution.

In the case of atmospheric particulates, comparatively large fluxes of material rise into the atmosphere when mixing conditions are good and with appropriate instrumentation it has been shown feasible to carry out atmospheric geochemical surveys using this material. If it is desired, however, to collect particulate material that relates closely to the underlying terrain, it is important to separate material carried in parcels of rapidly rising air from particulates associated with neutral or sinking conditions. It is also advantageous to use coarse particulate fractions in size ranges larger than 30 microns to minimize the effects of lateral migration and the re-entrainment of particles that have been previously translocated by wind.

Atmospheric particles can be of both inorganic and organic origin, much of the later arising from vegetation. It has been established both in the laboratory and in the field that there can be movement of elements through vegetation to leaf surfaces followed by dispersion of these elements into the atmosphere as particulate material. Particulates derived from vegetation are, therefore, related geochemically to the composition of the underlying soils. In practice, material arising from both vegetation and residual soil surfaces can be utilized for geochemical exploration purposes.

Several types of airborne equipment have been developed for carrying out systematic atmospheric geochemical surveys. The spatial resolution of these systems varies according to design between 100 metres and several kilometers. Analytical methods employed have included conventional emission spectroscopy, laser vapourization coupled with emission spectroscopy, x-ray fluorescence spectroscopy, and fission track-etch counting. The spectroscopic measurements provide analyses for 20 or more elements, including all of the base metals while fission track-etch methods give exceptionally high sensitivity and specificity for uranium alone, and are insensitive to radon and bismuth 214.

Optical monitoring and fluidic switching devices have been used to provide for separation of upwelling particulates from material in stagnant and sinking air.

Atmospheric airborne geochemical prospecting appears to offer important potential as a complementary tool to a variety of airborne geophysical methods. In the case of uranium exploration, it can provide information that is unaffected by surface disequilibrium effects and the fine size aerosol interference that can considerably modify airborne gamma-ray spectrometer results.

WARD, F.N.

US Geological Survey, Denver, Colorado

BONDAR, W.F.

*Bondar-Clegg and Company Ltd.,
Ottawa, Canada*

Analytical Methodology in the Search for Metallic Ores

(Paper 17 presented at 4:20-5:00 p.m., Tuesday, October 18)

Atomic absorption and emission spectrography are the methods of analysis most widely used in geochemical exploration. Development of nonflame atomizers, particularly electrothermal devices and reduction cells for atom and metal-hydride generation, has expanded the application of atomic absorption spectrometry by pushing detection limits of many elements well into the parts per billion range and by reducing detection limits for others, such as As, Se, Te, and Sn, to levels useful in litho-geochemical surveys. The recent introduction of inductively-coupled plasma sources for excitation, as well as other variations such as use of echelle gratings, has increased the number of available spectrographic methods for multi-element surveys and has simplified the application of partial extraction techniques in emission spectrography.

Other methods that require mass spectrometers and gas chromatographs are being used to measure volatile indicator elements and compounds such as helium and sulfur gases. Analytical techniques including those based on voltammetry, ion-selective electrodes, and the use of partial or selective extractions are finding increased application as analytical tools and as aids in determining metal speciation so as to better understand geochemical processes of dispersion and concentration.

Current interest in uranium exploration has sparked a major effort to develop new or improve existing analytical methods for the determination of uranium and related radionuclides. Exploration geologists may now choose conventional fluorimetry, delayed neutron activation, X-ray fluorescence, laser-induced fluorescence, and nuclear-fission track techniques for the determination of uranium. The choice will depend on sensitivity required, sample media being analyzed, chemical species of the uranium to be determined, turnaround time required, and cost considerations. Two of the methods described, conventional fluorimetry and laser-induced fluorescence, can be adapted for use in the field.

While recent developments of exotic techniques and apparatus have greatly expanded the number of useful analytical techniques in exploration geochemistry, each one has its own problems and limitations as well as its applications. A panacea for analytical problems does not yet exist-except perhaps in the skilled analyst, whose ingenuity in developing and applying new methods augments the diligent application of tried and true procedures.

CANNON, Helen L.
US Geological Survey, Denver, Colorado

BROOKS, R.R.
Massey University, Palmerston North, New Zealand

Botanical Methods of Prospecting

(Paper 18 presented at 9:00-9:35 a.m., Wednesday, October 19)

PART 1 — Advances in Geobotanical Methods
(presented by H.L. Cannon)

PART 2 — Advances in Biogeochemical methods
(presented by R.R. Brooks)

The presence or absence of particular species or varieties of plants in mineralized areas, and the effects of metals on plant growth have been observed and used in the search for concealed ore bodies since the 8th century. In the last ten years, studies of sparsely vegetated areas in wooded country have led to the discovery of lead in Norway and copper in the United States. Botanists have recently observed the actual evolution under stress conditions of new subspecies in mineralized or metal-contaminated ground, and there is now a growing understanding of metal-tolerance mechanisms in various plants. The development of new, highly tolerant races of plants in metal-poisoned ground is much more rapid than was previously supposed. Plants also may rid themselves of metal by dying to the ground each year or by concentrating metal in root cell walls and subsequently growing new adventitious roots. In widely separated areas of Europe, distinctive plant communities have been found to characterize terrane that has an anomalously high content of specific metals. New nickel accumulators have been identified in many countries, and a study by R.R. Brooks of herbarium specimens of previously reported indicator plants has shown many to be true accumulators of specific metals. These and other advances indicate the continuing usefulness of geobotanical methods of prospecting.

MEYER, W.T.
CITCO International Minerals Co., Tulsa, Oklahoma

THEOBALD, P.K.
US Geological Survey, Denver, Colorado

BLOOM, HAROLD
Colorado School of Mines, Golden, Colorado

Stream Sediment Geochemistry

(Paper 19 presented at 9:35-10:20 a.m., Wednesday, October 19)

Stream sediments are characterized by their variability, rather than by their uniformity, in composition, grain size, sorting, or color. Their variability is a function of the geology, terrain, and climate of the catchment area sampled by the stream; and variability is essential to the success of stream-sediment surveys. Prospectors have always made use of stream sediments, initially through observation of mineralized boulders and panning of heavy minerals from the stream bed, and more recently by chemical analysis of the fine fractions of stream sediments. Over the past twenty-five years, stream-sediment geochemistry has become accepted by government and intergovernment agencies and by the mining industry as the principal method of low-cost reconnaissance exploration in areas that are favored by the combination of adequate relief, adequate precipitation, and a suitable drainage system.

Today, surveys that make use of trace analysis of the fine fraction (normally - 80 mesh) of active sediments, the most common approach, are increasingly being questioned. In areas having extreme climates or for which information from the fine sediment is not adequate, enhancement of anomalies may require sampling of organic material, specific coarse fractions of inorganic sediment, selected mineral groups within the sediment that may be isolated mechanically or chemically, or a combination of these media. A variety of sampling and analytical methods have been developed to accommodate regional geologic and climatic variations, and these are further modified to suit the aim of the survey, whether it be multi-purpose or strictly for prospecting.

This review outlines the present state-of-the-art in terms of broad climatic zones and presents selected examples from surveys by both government and industry. The largest expense in a geochemical survey is that of sample collection, particularly the transportation cost to or between sample sites. Thus, the current tendency is toward multiple samples at a site and multi-element analyses. Mathematical and graphical interrelation of all of these components with the geology, geophysics, and physiography of the area under study, which usually requires computer technology, is more useful in determining exploration targets than is the single-sample, single-element approach that was successful in the past.

CAMERON, E.M., COKER, W.B. and HORN BROOK, E.H.W.
Geological Survey of Canada, Ottawa

Lake Sediment Geochemistry Applied to Mineral Exploration

(Paper 20 presented at 10:40-11:25 a.m., Wednesday, October 19)

In recent years considerable attention has been focused on investigating the role of lake sediment geochemistry as a guide to mineralization mostly within the Shield regions of the northern hemisphere. Investigations have developed because conventional geochemical exploration techniques, involving the sampling and analyses of stream sediments, soils and bedrock, have found limited application in many areas of the Shield. These regions contain extensive glacial overburden and, being of low relief, are characterized by indefinite and disorganized drainage systems.

Studies of the relationships between lake sediment geochemistry and various types of mineralization have been performed by government agencies, the mining industry and university groups. Under the auspices of the Uranium Program the Geological Survey of Canada is carrying out large scale reconnaissance surveys to outline areas deserving more detailed exploration for mineral deposits and also to assist in resource appraisal. Features which have contributed to the effectiveness of lake sediment geochemistry for reconnaissance mineral exploration within Shield areas include: the great abundance of lakes; that centre-lake bottom sediments provide a homogeneous sample medium for trace metal accumulation; the amenability of this procedure to rapid helicopter sampling techniques, which allows large areas to be covered rapidly and relatively cheaply.

The use of lake sediment geochemistry for regional reconnaissance has been fairly well established in the northern permafrost regions of the Shield. However, the problems appear to be somewhat more complex in regions of the southern Shield, south of the zone of discontinuous permafrost, where only limited work has been done, although some success has been achieved. The problems here include increased biologic activity; widely varying limnological environments; and an apparently less intense rate of weathering compared to northern Shield regions. Over the Shield as a whole it is clear that the effectiveness of the method varies with the element and type of deposit sought and with local terrain and overburden conditions. Because of all these considerations a great deal of information is required on a number of fundamental fronts, for example: on the transport and accumulation of metals within organic-rich environments, on the rates of weathering of various types of mineralization in different regions of the Shield, and on the physical and chemical processes which operate during and after glacial activity.

The techniques of lake sediment geochemistry are currently at a stage where they are being refined and evaluated and are being tested in different regions. The main application of lake sediment geochemistry for mineral exploration has been within the Canadian Shield and adjoining areas. But the problems that originally caused its application in these regions are also apparent in other regions. In Canada these include parts of the Cordillera and Appalachians, and abroad the Scandinavian Shield.

DYCK, W.

Geological Survey of Canada, Ottawa, Canada

MILLER, W.R.

US Geological Survey, Golden, Colorado

Application of Hydrogeochemistry to the Search for
Uranium and Base Metals

(Paper 21 presented at 11:25-12:00 a.m., Wednesday, October 19)

As the world's surficial mineral deposits become depleted new methods of search for subsurface deposits will have to be developed. Hydrogeochemical techniques were of interest during the early 1950's, but analytical techniques were not available for routine analyses with the required sensitivity. Recently, equipment and techniques have become available for rapid analyses of water with the required sensitivity.

A literature search reveals that by far the greatest amount of work on hydrogeochemical prospecting is published in Russian journals. While few prospectors outside Russia can use these publications directly, several translation services have translated numerous major works.

Generally chemical analyses of water are more difficult to interpret than analyses of other common sampling media. Techniques for interpretation of water chemistry for exploration can be divided into the use of raw data and the use of statistical techniques. The first technique involves the plotting of the element of interest (e.g. Cu to locate Cu-mineralization) or associated elements (e.g. Mo to locate Cu-porphry mineralization or F to locate Pb-Zn mineralization). Ratios can be used for normalization (e.g. SO_4/Cl^- or Cu/SO_4 to eliminate compositional differences). A few of the statistical techniques used include the use of moving averages (Gleeson and Boyle, 1976), multiple regression, and factor analysis (Miller and Ficklin, 1976).

Water chemistry used in conjunction with thermodynamic data can also be used for interpretation of geochemical data and to gain a better understanding of the geochemical cycles of selected elements in the weathering environment.

The elements of interest in hydrogeochemical exploration for uranium are uranium and its decay products—radium, radon, and helium.

Uranium is easily oxidized to the water soluble hexavalent state. Its mobility is also enhanced by the complexing action of carbonates in neutral and basic waters, of sulfates in acid waters, and of silicates in neutral waters. Organic matter adsorbs uranium strongly and can be responsible for decreasing migration of the uranyl ion.

The hydrogeochemical techniques employing radium and/or radon are best suited to detailed or semi-detailed investigations of radioactive occurrences. Their ease of detection and short range make them good tracers for pin pointing uranium occurrences or outlining radioactivity too weak for the gamma-ray spectrometer or the fluorimeter.

Helium, because of its inertness and great mobility has the potential of revealing uranium ore bodies through greater thickness of cover than conventional techniques, but the exact same attributes can cause false anomalies.

The use of water as a medium for geochemical exploration has increased in the last decade. Water is one of the more important sample media for locating concealed mineralization. Springs have served man since the dawn of history as guides to buried minerals. In inhabited areas wells can do the same for 20th century man. In uninhabited areas systematic drilling and testing of aquifers will become one of the methods of search in the future.

MARTIN, LUCIANO

*Computer Applications and Systems Engineering,
Rexdale, Ontario*

HOWARTH, RICHARD J.

Imperial College, London, England

Use of Computer-based Numerical and Mapping Techniques
in the Compilation and Interpretation of
Exploration Geochemical Data

(Paper 24 presented 3:45-4:15 p.m., Wednesday, October 19)

The computer methods used for the planning, quality control, presentation and interpretation of exploration geochemical data are classified in the two general categories of purely numerical, whereby the sample location is not a factor, and mapping in which position is considered. Elementary statistical techniques are widely used. Laboratory reliability tests are based on the evaluation of duplicate and standard sample analyses. The basic statistical parameters, means, variances, deviations and the frequency distributions are often the extent of the data treatment. Single element, rather than multivariate methods are predominant. The latter are used in assessing correlation, in correcting for scavenging effects of iron and manganese and less frequently in discriminant and cluster analysis. The mapping methods combine numerical treatment with cartographic output. Single element measured value maps, using symbol grading based on the statistical analysis, are the most frequent practice. The next step for interpretation is usually the separation of regional (usually contoured) and local effects; some form of moving average method has been found most useful. While in some countries lack of suitable computer hardware has limited the application of these methods, in others the restraining factor is the lack of appreciation of the powers of the methods and equipment when used intelligently. However geochemists are gaining a better understanding of the usefulness of mathematics and computer equipment.

COOPE, J.A.

*Newmont Exploration of Canada Ltd.
Toronto, Ontario*

DAVIDSON, M.J.

Newmont Exploration Ltd., Tucson, Arizona

Some Aspects of Integrated Exploration

(Paper 25 presented at 4:15-5:00 p.m., Wednesday, October 19)

For many years, regional techniques of mineral exploration incorporating airborne geophysical methods and other remote sensing techniques applied to identify broad geological parameters have been used under a variety of geological and geophysical conditions. Such use of disciplines has served to broadly classify areas based primarily on physical properties and prospective mineral potential.

The better understanding of the geological processes leading to the formation of mineral deposits, together with the enterprising development of geophysical, geochemical and other types of exploration tools during recent years, has provided a basic framework for an integrated application of techniques on a more detailed scale with the potential of improved cost and exploration effectiveness.

Observance of variations in geophysical and geochemical backgrounds can provide critical data which serves to elucidate geological interpretation and the evaluation of anomalous conditions. These variations are commonly related to primary geological features or larger-scale ore-forming processes and can yield critical information when the connection is recognized and properly interpreted. Magnetic, resistivity, lithochemical and other selected techniques are particularly adaptable in this more detailed integrated application.

Different disciplines and data-gathering methods within disciplines can yield the same or equivalent information interpretable in a geological context. However, recognition of the physio-chemical fingerprint of an ore environment requires a multidisciplinary, integrated approach when signatures observed from any one discipline are too subtle to generate adequate confidence levels by themselves. In any particular situation there is a sequence of applications and areal coverage which will define targets at a minimum cost.

WEBSTER, S.S.

Abminco N.L., Wayville, South Australia

SKEY, E.H.

Abminco N.L., Kalgoorlie, W. Australia

Geophysical and Geochemical Case History of
the Que River Deposit, Tasmania

(Paper 33 presented at 2:00-2:20 p.m., Thursday, October 20)

The Que River massive sulphide deposit, discovered in 1974, comprises several separate lenses located within an area 800 metres by 100 metres. The lenses occur within a sequence of pyritic dacites and andesites approximately 4 kilometres long and up to 300 metres wide. The lenses are vertical with average width 9 metres. One lens is predominantly chalcopyrite and pyrite, the others being predominantly galena, sphalerite and pyrite. Outcrop of massive sulphides is minimal.

The exploration area was selected within a well mineralized belt of Cambrian calc-alkaline volcanics marking the eastern edge of the Dundas Trough in Tasmania. Initial reconnaissance surveys covered an area of 60 square kilometres, with geological traverses and stream sediment sampling. Several areas of anomalous geochemistry were located in favourable rock types.

Progress of the reconnaissance programme and follow-up investigation was impeded by dense rainforest and rugged terrain. Accordingly an airborne electromagnetic survey was flown. Though the technique had not been an ore-finder in Australia, the geophysical environment in Tasmania was such that application of the technique was warranted. A conductor was immediately identified in one area of anomalous stream sediment geochemistry.

The target was subsequently delineated by soil geochemistry and ground electromagnetic techniques. Initial drilling proved the conductor to be a single lens of predominantly copper and iron sulphides. Additional drilling intersected a comparatively major zone of zinc, lead and iron sulphides which was not detected by the electromagnetic surveys, but was expressed by soil geochemistry. An integrated orientation survey showed that the induced polarization technique, combined with soil geochemistry, optimised drill target definition.

COOLBAUGH, D.F.

Consultant Industrias Penoles, Mexico

Geochemistry and Geophysics in the Discovery and Development
of the La Caridad Porphyry Copper Deposit, Sonora, Mexico

(Paper 34 presented at 2:20-2:45 p.m., Thursday, October 20)

The discovery of La Caridad, which is a major porphyry copper deposit, in Sonora, Mexico was the result of planned mineral exploration which was carried out over a large potential area employing reconnaissance exploration methods of photo-geology and geochemistry followed by semi-detailed and detailed exploration methods of geophysics, geochemistry and geology.

Intense hydrothermal alteration exposures in the district were observed from flying aircraft but before this area could be field-checked, anomalous copper and molybdenum values in stream sediments were found 18 kilometers downstream in the drainage from the deposit. These anomalous values were followed upstream to the area of the La Caridad deposit. The stream sediment sampling was followed by more detailed soil and rock-chip sampling and reconnaissance geologic mapping.

Induced polarization surveys, geochemical studies and geologic mapping were used to delimit the La Caridad deposit. Very low induced polarization and geochemical values were noted over the central part of the deposit due to deep leaching. Alteration and mineralization exhibit classic porphyry copper patterns.

HAUSEN, D.M.

Newmont Exploration Ltd., Danbury, Connecticut

**Application of X-ray Diffraction Alteration and
Geochemical Techniques at San Manuel, Arizona**

(Paper 36 presented at 3:05-3:30 p.m., Thursday, October 20)

Alteration zoning at the San Manuel-Kalamazoo porphyry deposit near San Manuel, Arizona has been evaluated by the x-ray diffraction method of monomineralic contouring. Over 350 drill and drift samples from the San Manuel segment have been analyzed by x-ray diffraction for major alteration minerals, including sericite, quartz, pyrite, K-feldspar, plagioclase, chlorite, etc., followed by plotting and contouring of XRD data.

Contouring of alteration data indicates that the San Manuel ore body is bound by concentric zones of alteration assemblages that outline the general shape of the ore zone. Alteration zones include: (a) external zones that surround the ore body as concentric outer envelopes of sericitization, silicification and pyritization, and (b) internal zones of high plagioclase-low K-feldspar (locally high biotite) that make up the porphyry "core" of the deposit, and (c) K-feldspar-rich zones that usually coincide with the ore body, but are occasionally discordant to the ore and alteration zones.

Monomineralic contouring for each type of alteration corroborates the general conclusion that the San Manuel ore body is terminated circumferentially and at the east end by closed contours, but remains open to the west and on top, where the Kalamazoo segment is believed to have been removed.

MIDDLETON, R.S. and CAMPBELL, E.E.

Rosairo Resources (Canada) Ltd., Toronto, Ontario

**Geophysical and Geochemical Methods for
mapping Gold-Bearing Structures in Nicaragua**

(Paper 39 presented 4:10-4:30 p.m., Thursday, October 20)

Gold deposits in northeastern Nicaragua which are associated with Tertiary volcanic centres occur as fracture-controlled epithermal vein systems or disseminated sulphide zones within volcanic breccias. VLF electromagnetic surveys were carried out to delineate the fractures and alteration zones associated with two quartz vein deposits. Tropical weathering appears to enhance the conductivity of the controlling fractures, making them ideal VLF-EM targets. By filtering the in-phase response, the veins are delineated by the resultant contoured data. Soil geochemical surveys over the vein deposits revealed anomalous gold values (0.3-.5 ppm), in disconnected patterns along the trend of the veins, however, the VLF-EM results put the geochemical patterns into perspective and when taken together define much better the various veins in the system.

Induced polarization and magnetic surveys were used to outline a gold-bearing disseminated pyrite-sphalerite deposit hosted in a volcanic breccia. This deposit, known as Coco Mino, is located near the Honduras-Nicaragua border. Anomalous gold, copper, zinc, lead and silver geochemistry over the volcanic breccia defined the main portion of the zinc-bearing volcanic breccia, however, a broader gold anomaly at threshold levels (0.3 ppm) outlined a much larger area which subsequently was defined by IP as an extensive disseminated pyrite-kaolinite-sericite alteration zone. The dispersion of zinc was greater than lead or copper, and the geochemical patterns for Cu, Pb, Zn appeared to be highly affected by drainage patterns and water courses along faults whereas the gold patterns were controlled by the lithology and the alteration zone, and correlated best with the IP - resistivity and magnetic anomalies.

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NEW MEMBERS

The following individuals have been accepted for Membership in the Association by Council on October 17, 1977. The Association is pleased to welcome the new Members.

VOTING MEMBERS

Armstrong, D.R.M.	Assistant chief geologist-RCM Geological Services, Zambia
Baum, L.F.	Consulting Exploration geochemist/geologist, Kirkland Wash, USA
Cox, R.	Senior Geologist Placer Exploration Ltd., Westleigh, Australia
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