EXPLORE

THE ASSOCIATION OF EXPLORATION GEOCHEMISTS

NUMBER 116 JULY 2002

Newsletter for the Association of Exploration Geochemists

Focus On Geological Survey Updates

Selected Geochemical Studies related to Mineral Deposits by the U.S. Geological Survey (USGS)

Karen D. Kelley, Robert G. Eppinger, and Katherine Walton-Day

Within the USGS, geochemical studies related to mineral deposits can be divided into four broad categories: (1) archival data; (2) national-to-regional-scale geochemistry; (3) geochemistry in support of mineral resource assessments and ore deposit studies; and (4) environmental geochemistry. Provided here is an overview of these activities and highlights of some projects that have recently been completed or are near completion. Studies mentioned herein are those most familiar to the authors, those for which information is most readily available on the web, and those that have produced recent citable reports. The authors assume responsibility for accurate citation of the studies listed, and for the content presented herein. More information about all projects related to mineral deposits is available at the following URL sites: http://minerals.usgs.gov/, http://mine-drainage.usgs.gov/, or http://crustal.usgs.gov/.

Archival Data

The National Geochemical Database (NGDB) contains chemical analyses of approximately 2 million samples of geologic material, including rocks, stream sediments, and soil. For most samples, pulverized splits are also archived in storage facilities in Denver, CO as a physical part of the database. The analyses were generated by various USGS programs over the past 35 years, as well as by the U.S. Department of Energy's National Uranium Resource Assessment (NURE) Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) Program of the 1970s and 1980s.

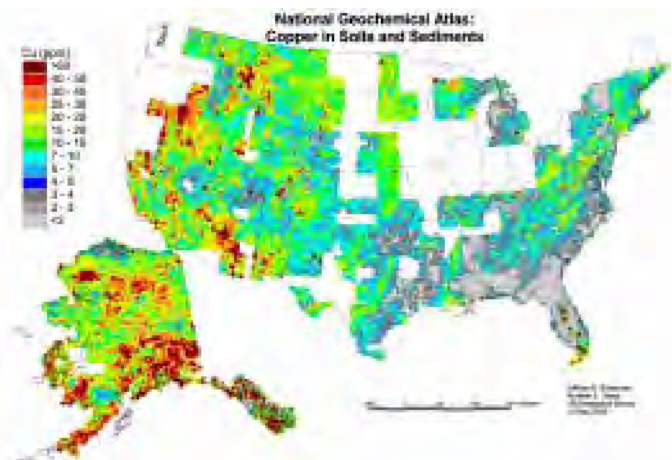


Figure 1. Cu concentrations in soils and sediments for the U.S.

continued on Page 14

Technical Note

Exploration targets outlined by the Geochemical Atlas of West and South Greenland

An atlas of geochemical maps covering all ice-free parts of Greenland (c. 410 000 km^2) is the ultimate goal of the programme 'Reconnaissance geochemical mapping of Greenland' undertaken by the Geological Survey of Denmark and Greenland (GEUS) with financial support from the Bureau of Minerals and Petroleum, Government of Greenland. The first step in achieving this goal is the publication of 'Geochemical atlas of Greenland – West and South Greenland' on CD-ROM (Steenfelt, 2001b). The

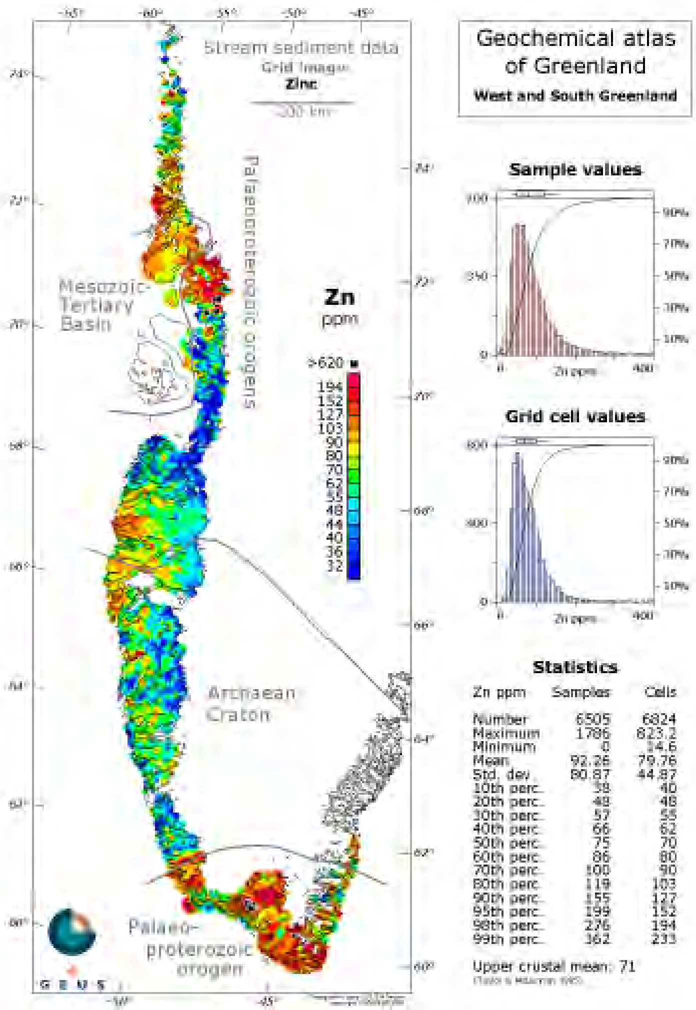


Figure 1. Geochemical stream sediment map of Zn, based on chemical analysis of the <0.1 mm grain size fraction. From (Steenfelt, 2001b).

continued on page 2

Technical Note...

continued from Page 1

atlas presents the result of a compilation of chemical analyses of 7122 stream sediment samples collected from 1977 to 1998 as part of mineral exploration surveys. It contains 43 maps of chemical elements, a map of the volatile contents of stream sediment, a map of gamma radiation and five maps of kimberlite indicator minerals. For comparison, a geological map and an aeromagnetic anomaly map are included. The CD also contains a bibliography and a report describing data handling and presentation.

The geochemical atlas display significant chemical variation over the surveyed area, most of which is attributable to the presence of a variety of lithologies and tectono-stratigraphical domains. Some of the observed features have implications for mineral exploration, and some locally high concentrations of certain elements may be indicative of mineral occurrences. This note describes the atlas and provides some examples of the use of the data to outline new targets for mineral exploration.

As pointed out repeatedly by geochemists of the AEG, among others, regional geochemical data have many application possibilities in addition to mineral exploration. The data from Greenland are no exception. So far they have also assisted geological mapping and environmental baseline documentation.

Data acquisition and handling

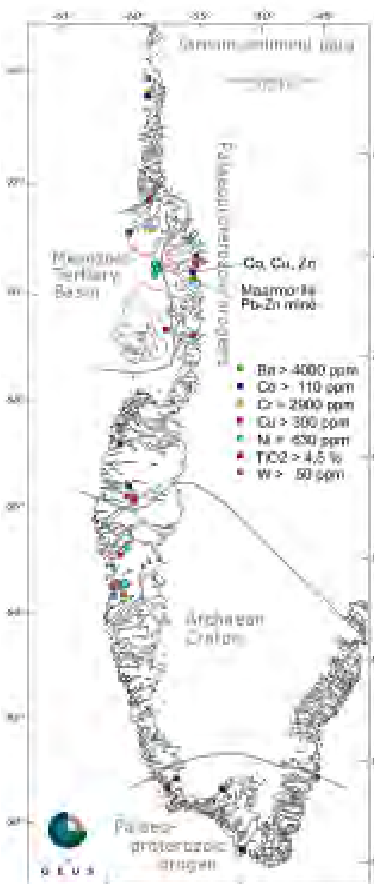


Figure 2. Compilations of anomalies for a selected suite of metals, extracted from maps of the Geochemical Atlas.

Sampling and analysis

In Greenland, the mountainous terrain together with melting snow and ice have created well-developed drainage systems, and streams are ubiquitous contrary to till, soil or vegetation. Thus, stream sediment appeared an obvious *sample medium* for geochemical exploration and mapping. The *sampling density* has varied, but most of West and South Greenland have been sampled at reconnaissance scale, i.e. one sample per 20 to 40 km^2. Sampling was supported by helicopter or rubber boat.

Preferred sampling sites are second or third order streams with catchment areas less than 20 km^2. In the absence of active streams in certain low-relief landscapes, sediment on the shores of small lakes or soil has been sampled instead.

Continued on Page 3

Technical Note...

continued from Page 2

At each sampling site c. 500 g of composite stream sediment was collected in a paper bag. Inadequate sediment occurs in certain streams with high water flow and in some streams within low-relief, vegetated terrain. In such places, a sample was collected from sediment trapped in moss or other vegetation, between stones or along the banks. Additionally, gamma-radiation was measured and a short site description was made. Sample bags were provisionally dried in the field before being packed and shipped to GEUS, Copenhagen. Samples were then oven-dried at 60°C and dry-sieved using two polyethylene screens. The grain size fraction above 1 mm was discarded, the 0.1 to 1 mm fraction stored, and the < 0.1 mm fraction was analysed.

Information on laboratories and analytical methods is given in Steenfelt (2001a). In summary, all atlas samples were analysed for major elements by X-ray fluorescence spectrometry (XRF) at either GGU (GEUS since 1995), or by Activation Laboratories Ltd. (Actlabs), Ontario, Canada. Almost all samples have been analysed for trace elements by Instrumental Neutron Activation at either Bondar-Clegg and Company Ltd. or at Actlabs. Trace element analyses by other methods, such as XRF and inductively coupled plasma emission spectrometry, has been obtained for a proportion of the samples.

The recent interest in diamond exploration encouraged a search for kimberlite indicator minerals in surficial material. They were therefore picked from the 0.25 to 1 mm grain size fraction of about 3000 stream sediment samples from the Archaean Craton of southern West Greenland. Their distribution is presented in the atlas.

Compilation of atlas data

The data set has been compiled from thirty individual stream sediment surveys. While sampling and sample preparation have followed the same procedures over the years, analytical treatment has been less systematic, partly because of progress in analytical methodology and partly because of differences in the aim and analysis budget of individual surveys.

A great challenge in the compilation of the analytical data was the selection of the most reliable data and subsequent levelling of data from different analytical batches. The latter was necessary because variations in analytical accuracy and precision were found to occur both between methods and within specific methods over time. Internal standards have been used to monitor the quality of chemical analyses, and these standards have also been analysed together with international reference material so that the Greenland data can be made consistent with geochemical data from elsewhere in the world. The procedures used in selecting and calibrating the analytical data are documented in Steenfelt (1999; 2001a).

Data presentation

The geochemical and associated maps composing the atlas are made with Geosoft OASIS montaj™ software. The maps may be opened and enlarged, copied and printed using the OASIS montaj 'Free Interface Software' included on the CD.

Each element map, (see Fig. 1, page 1) displays a grid image of the variation in element concentration, a colour scale giving class intervals for the grid colours, histograms showing the frequency distributions of sample values and grid cell values, respectively, and statistical parameters for measured concentrations in samples and for the grid cell values. Details of data presentation may be found in Steenfelt, 2001b.

Targets for mineral exploration

Single element anomalies

Defining anomalies is a research field of its own. In practice, the data application decides how anomalies are best defined. Therefore, the black squares in the geochemical maps simply show the location of samples with the highest concentrations of the mapped element, as a matter of interest for a variety of users. For many elements the anomalies of the present data set are often clear outliers in the frequency distribution of element concentrations. In other cases anomalies are defined as values above the 98th or 99th percentile. A comparison of the anomaly threshold, indicated in the colour scale, with the values for the percentiles in the tables of statistics, shown on each map, allows the user to judge the significance of the highest values.

Some anomalies reflect known mineral occurrences, but many are not readily explained and warrant follow-up. Figure 2 (page 2) shows a compilation of anomalies for a suite of elements relevant to mineral exploration. Clusters of anomalies are regarded as the most interesting. Within the Archaean, a small cluster of W anomalies suggests scheelite mineralisation (perhaps similar to the kind discussed by Appel, 1994). A couple of Ni anomalies are seen, one of which is associated with a known dunite body and the other is unexplained.

continued on page 17

TABLE OF CONTENTS

President's Message

Philippe Freyssinet

Dear Colleagues,

As you can see, the **EXPLORE** format has changed; our Newsletter is evolving and is becoming more comprehensive, with a number of new features. I wish to express my deepest thanks to Lloyd James who has ended his mandate as **EXPLORE**'s Editor-in-Chief. He has accomplished the remarkable task of keeping the Newsletter interesting and varied over these last years. Mary Doherty will now be heading the ship, and we are particularly grateful that she has accepted this heavy duty, tedious at times, for it is our Association's true quarterly rendezvous.

I am taking the opportunity provided by **EXPLORE**'s 3rd issue in 2002 to discuss with you some ongoing evolutions within AEG, some of which might lead to profound transformations for our Association. I believe this deserves a broad debate amongst all members before any decision is made. Thanks to Nigel Radford and Dave Garnett's work, our association statutes have been updated. These had not been revised in over ten years and they required a broadened definition of the fields covered by AEG: more specifically, towards Environmental Geochemistry, as I already suggested in the last **EXPLORE** issue.

In the process of revising AEG's by-laws, propositions for amendments were made under "Purpose" (see N. Radford's paper in **EXPLORE** N°111, April, 2001) by replacing "exploration geochemistry" with "geochemistry of natural resources". These statutory modifications reflect the profound evolutions our scientific discipline has seen over the past 15 to 20 years.

Our steadily-declining number of members speaks for the evolution of exploration geochemistry. From 653 members in 1980, numbers increased to 1200 in 1990, then 1165 in 1995 and only 798 in 2000. In 2002, our member count is down to 722. When I first joined AEG in 1987, following the 12th IGES held in Orléans, Exploration Geochemistry was powered by the fact that this discipline stood at the crossroads between scientific developments and industrial applications. Major analytical and computing achievements have made our discipline one of the most effective, if not the most cost-effective exploration tool. At the same time, the boom in exploration for gold and related deposits ideally suited exploration geochemistry and allowed it to take over from conventional techniques.

This fertile context promoted a rich variety of fields of research (analytical chemistry, data analysis, soil, rock and sediment geochemistry, hydrogeochemistry, biogeochemistry, etc). As we look back at this situation, we realise the formidable synergy that AEG's publications created, through its scientific journal and the Exploration Geochemistry Handbooks series. The evolution of geochemistry as one of the major mining exploration techniques is now universally accepted throughout the mining industry. Exploration geochemistry has become a structured market with large private operators, particularly in the analytical field, and a myriad of consultants. It is now widely used, in some form, by most exploration geologists.

These profound evolutions explain the significant number of geologists and mining companies who joined AEG in the early 1990's. Exploration Geochemistry progressively evolved from a research field to a science applied on a technical basis like an "engineering discipline", which is undoubtedly one of the most significant applications of geochemistry. As Exploration Geochemistry became an applied science, the scientific community, particularly the proportion of young scientists, gradually decreased in the AEG, this trend being the strongest in Europe. Today, it is clear that the significant questions about dispersion and detection of trace elements in soils and sediments have been largely solved. It seems to me that the main scientific and technical stakes in exploration geochemistry are about such topics as:

- Detection of hidden and buried deposits at shallow to middle depths,
- Analysis of weak or indirect geochemical signals (gas, organometallic compounds, etc),
- In-situ trace element analysis.

There are of course, many other fields of applications where exploration geochemistry can improve its field of knowledge. Examples of this may include extracting residual benefit from previously-existing data sets, defining international standards for sample collection, and sample preparation. These would all work to improve the global quality of geochemical results.

The mining industry has become global with world-leading companies in four centres (USA, Canada, South Africa and Australia). With the gradual withdrawal of Europe, new mining zones have emerged (i.e. Indonesia-PNG, Western Africa, etc). The concept of sustainable development in the mining industry, which is illustrated by the Global Mining Initiative (www.globalmining.com), has triggered a period of reflection as to the future of this industry. The official press release from the last GMI conference in Toronto in May 2002 states that "industry leaders said it is imperative to improve social and environmental(?) performance, negotiate agreement on protected areas off-limits to mining, and develop protocols with verification mechanisms."

Emerging needs for knowledge about anthropogenic impacts on our planet, mainly industrial, have led to a wide spectrum of scientific research whose applications have only begun to turn into significant disciplines. A large proportion of the scientific geochemical community is now working in this sector. In my opinion, this trend represents a new development opportunity for AEG. As I wrote in the previous EXPLORE issue, it seems to me that AEG can play a key role in a number of areas of environmental geochemistry, as our knowledge of exploration and mineralisation geochemistry can contribute significantly to the management of several current environmental issues (i.e. mine water management, mining residues, contaminated land management, etc). It is appropriate, therefore, that AEG will be one of the sponsors of the 6th International Symposium on Environmental Geochemistry immediately following the Dublin IGES (www.iseg2003.com) where it will probably host two sessions, one on the management of geochemical databases and the other on the environmental geochemistry of mine sites.

It also seems to me that we must unequivocally advertise that our vocation encompasses certain areas of environmental geochemistry. The explicit inclusion of the word "Environment" in the title of our journal, "Geochemistry: Exploration, Environment, Analysis", and the regular inclusion of environmental articles in recent editions of the journal, already reflect this orientation. This represents a real development opportunity for the Association, given the promising scientific synergy between exploration and environmental geochemistry.

If we want to embrace fully the concept of an Association dedicated to the geochemistry of all aspects of natural resources,

continued on Page 5

President's Message

continued from Page 4

we should consider changing our name to The Association of Exploration and Environmental Geochemists. A name change goes hand in hand with a new image, even though the impact of such a change is difficult to forecast. I feel personally such a change could represent for the AEG a good opportunity to attract new members, particularly young scientists, and to consider our discipline from different points of view.

However I am conscious that changes of name and image have to be carefully considered, and represent more than just a slight alteration in the by-laws of the Association. It requires a debate to consider all of the aspects that such an evolution may induce. That is why I invite you to send your comments and opinions on this proposal. I urge you all to think about these issues and take part in the discussion forum on our web site. A synthesis of the debate will be published in the columns of forthcoming **EXPLORE** issues.

Philippe Freyssinet
President AEG
BRGM
Environment & Process Division
BP6009, F-45060 Orléans, France
Tel : 33-238.64.3005
Fax : 33-238.64.3680
Email : p.freyssinet@brgm.fr

Readers' Forum

In **EXPLORE** 115 there is a report from Becquerel Labs on their testing of two Reference Materials (RM). One of these appears to be of poor quality. It was not named because it was no longer available. I am concerned about this decision. I telephoned one of the Authors and was assured that it was not a Rocklabs Reference Material, but no other Members of the Association (AEG) know this.

Looking at the results for the poor quality RM, we presumed that it could not be one of ours, but even if it had been, it would be better for everyone if it was named. People who had used it might be very interested to know of these test results. Maybe they answer some puzzling results in completed studies. Maybe the results are part of a long-term program which is continuing. The manufacturer needs to be warned that all was not well. Procedures for RM manufacture need to be changed. Maybe they have already been changed, but users need to know that.

The need for ensuring high standards of analysis has never been higher. The investment world has turned away from the dot.com phenomenon and money is coming back into the mining industry. But, it will not continue to come back if investors cannot be assured that everything is being done to ensure the reliability of information. The days of "winging it" are over. The mining industry took decades to understand that the pressure for a better environmental outcome from mining was never going to go away. We tried to keep our heads down and hope it would turn out alright. We must not allow that type of action to occur again. If figures for ore reserves are published, they must be "squeaky" clean. We must not be embarrassed if an aware reporter questions any company's accounts. The numbers must be justifiable to a high degree. Improvements are occurring but at a rate that is far too slow. New rules are being proposed world-wide but their application is only slowly being taken up. Our Association can show the way by setting the highest professional standards.

Yours sincerely,

Ian Devereux FAEG
Rocklabs Ltd
i.devereux.rocklabs@clear.net.nz

The Uranium Lady

Late in the year 2000, a woman near Greenville, South Carolina (S.C.), USA visited a series of doctors. One of these finally suspected that she suffered from some sort of mineral imbalance. Analysis of tissue samples revealed radium and uranium at alarming levels. A consulting geologist who lived nearby recommended taking well water samples at her home. Results indicated uranium and radium significantly above drinking water standards (DWS).

Since that time two studies have been done. One of well water, and another of uranium in urine. The S.C. Dept of Health and Environmental Control (DHEC) sampled over 150 domestic water wells in an area of about four square miles near the original discovery. Of these, 50 exceeded the DWS of 30 ppb U. Testing of 105 residents revealed that 94 exceeded the expected 90th percentile for uranium in urine samples. (See DHEC press release, July 12, 2001.) Subsequent re-testing indicated that uranium, believed to be a very transient nephrotoxin, was not being removed from bodies at nearly the rate expected. DHEC's well testing revealed uranium up to 10,000 ppb, radium up to 43 pCi/l, radon to nearly 50,000 pCi/l and arsenic to 38 ppb as compared to actual or proposed DWSs of 30, 4, 300, and 10 respectively. The presence of As may suggest polymetallic veins such as the five-element veins described by Lefebure.

Data from the U.S. National Uranium Reconnaissance Evaluation (NURE) program have been available since the late 1970s. While some of the information developed in this program has been used in exploration, it doesn't seem to have found its way into the mainstream of environmental and regulatory agency consideration. Cursory examination of NURE ground water data from the Greenville 1X2-degree quadrangle (34-35N; 82-84W) suggest an anomaly/background break at about 0.1 ppb for uranium. Values (N=667) range from a detection limit of 0.002 ppb to a high of 419 ppb. Twenty percent of the samples exceed 0.1 ppb. NURE sampling was carried out at a nominal sampling density of one site per ten square miles. It was anticipated that this would result in capturing 70 percent of the available information content or more. The Greenville anomaly area was bracketed by two samples only slightly above background - 0.15 and 0.25 ppb. DHEC sampling of 150 wells in close proximity suggests that well depth plays a key role. Adjacent wells may vary greatly in U (and associated element)

continued on Page 6

Readers' Forum

continued from Page 5

content. Deeper (rock) wells tend to have higher uranium than more shallow (saprolite) wells.

Since the incidents at Three Mile Island and Chernobyl, and discoveries like Jabiluca, there has not been a big demand in the US for uranium exploration geologists. Yet a few of us survive and are preparing to assist in locating families or communities at risk from natural contaminants in their drinking water, or indoor air. We are working with SC-DHEC as they continue to deal with the initial discovery (largely resolved by running water lines from the county system). The SC State Geologist has developed detailed geologic maps which look amazingly like maps from Pleutajok, Sweden (Gustaffson, 1980). A proposal to develop exploration models based on the initial discovery area and other high-U wells of the NURE dataset and then to apply these models as an efficient way to locate at-risk families has been submitted for federal funding. If funded, the project will be a joint effort of USC, Clemson, Furman, SC-DHEC, and the SC Geol. Survey. An advisory committee including Colin Dunn, Art Rose, and Bob Carpenter - all with a long history in uranium exploration - will provide guidance to the effort.

Van Price
vprice@esri.sc.edu

The Role of the Association of Exploration Geochemistry (AEG) in Environmental Geochemistry

Today, the AEG has an urgent need to resolve the question of its interfacing with environmental geochemistry. As our professional colleagues have repeatedly pointed out, in theory, there is no real schism between exploration and environmental geochemistry. Rather, the two terms are "market orientated" one towards mineral exploration and the other to environmental studies. Because we are a part of a market orientated world we are forced to recognise at present that as mineral exploration declines, the need for fulltime exploration geochemists will gradually diminish. This may be only a temporary setback, because money may be again invested in mineral exploration when it is realised that minerals are required to maintain a high standard of living worldwide. At present, the AEG is facing a reduction in membership. On the other hand, the current market demand for experienced environmental geochemists is increasing. This provides the AEG with an opportunity to reorganize now to allow the recruitment of environmental geochemists to increase in the future.

For several years, members of the Association of Exploration Geochemists (AEG) have discussed the future relationship between Exploration Geochemistry and Environmental Geochemistry. Recently, Demetriades (2001), and Taylor (2001) have separately commented on this problem as it relates to a proposed revision of the AEG By-Laws. In this paper I share with members of the Association my thoughts for rewriting the AEG constitution.

Hopefully, this update would bring the Association into line with current changes taking place in other environmental sciences. These thoughts may help to redefine the mission of the AEG as a whole and suggest new membership criteria that will attract ecologists and other environmental scientists into environmental geochemistry. Although this dilution may be considered dangerous to our profession, the integrity of the AEG may be safeguarded by stipulating the conditions of membership status.

The current reformulation of Ecology and Environmental Science

The current AEG predicament is not unique. For example, the book edited by Sala et al (2000), needed 26 chapters and 421 pages to update Methods in Ecosystem Science. Also, Jensen and Bourgeron (2001)'s book Guidelines for Integrated Ecological Assessments includes 35 chapters on 'interdisciplinary approaches' to the biological study of the environment. From the viewpoint of the AEG, it is important and disappointing that neither book's index references 'geochemistry' or 'environmental geochemistry'. Turner, Gardner and O'Neill (2001) provide a comprehensive description of a new environmental science in their book Landscape Ecology: Theory and Practice (11 chapters, 401 pages, plus a data disc). The text of this book makes only passing reference to the 'geochemical substrate' underlying landscapes and incidentally, its index has no heading for 'geochemistry'. These books, and others like them, suggest the current trend towards the reformulation of holistic biological and interdisciplinary environmental sciences lacks reference to the environmental geochemistry perspective.

The development of 'Landscape Ecology' is an example of

continued on Page 7

Readers' Forum

continued from Page 6

just how fast a new environmental science can develop. As Turner et. al. (2001) put it: "As ecologists embraced the challenges of understanding spatial complexity, landscape ecology moved from being a tangential sub-discipline in the early 1980s to one that is now mainstream. Indeed the landscape approach, or landscape level, is now considered routinely in all types of ecological studies." (p.vi).

In my opinion, in order to survive and prosper, the AEG must make available its vast database of geochemical experience to both old and new environmental disciplines. The AEG must now try to attract recruits from these biological disciplines to become members.

The Future of Environmental Geoscience

Environmental geoscientists in general are also concerned with the reformulation of environmental geology for the future. For example, USGS Geoscientist Mary Lou Zoback, in her Presidential Address to the 2000 Annual Meeting of the Geological Society of America, titled her paper "Grand Challenges in Earth and Environmental Sciences: Science, Stewardship, and Service for the Twenty-First Century" (Zoback, 2001). This interesting paper provides geoscientists (including the AEG) with 6 general guidelines for the future development of environmental earth science. As Zoback (2001) puts it:

> "Fifty years ago, the concept of having daily global snapshots of direct measurements of a variety of earth properties freely available on home computers was unthinkable. These advances will enable increasingly sophisticated numerical modelling of natural systems, but in many cases, our scientific understanding of the interconnected physics, geology, chemistry, and biology of these natural systems is still at the infancy stage." (p.41)

From the viewpoint of the AEG, it is important and useful that Dr Zoback characterized her six guidelines on a broad 'process level' rather than on narrow 'discipline' or 'theme' criteria. What follows I have shortened and edited Dr Zoback's six guidelines, and added brief explanations. Examples are given for each one. The first five guidelines are probably familiar to AEG members. For the sixth, a hypothetical example is included to focus attention on an aspect of environmental science, which is of growing importance today.

Guideline (1) Geochemical mapping of environmental systems

After noting that natural variability is important in both spatial and temporal scales, Dr. Zoback quotes the geochemical mapping described by Davenport et al (1993) from Eastern Canada. Dr Davenport's group reported multi-element geochemical data for 40,000 lake sediments collected from Newfoundland and Labrador. They concluded that background levels of arsenic were not affected by urban St John's. In contrast, lead patterns in the same urban area were above the 99th percentile of values for the entire area surveyed, which included areas of lead mineralization. This suggested an anthropogenic input of lead near St John's.

Dr. Zoback commented that regional geochemical baseline data can provide an important approach to the discovery of environmental change. In the future, the AEG could provide many examples of environmental geochemistry of this type at the global, regional, and local scale (A.G., Darnley et al, 1995).

Guideline (2) Mass/energy balances: geochemical cycling in environmental systems

Dr Zoback notes that an understanding of the quantitative aspect of the physics, chemistry, geology, and biology of biogeochemical cycles is fundamental to understanding of how larger natural systems (e.g. global climate) function. It is interesting that the concept of 'biogeochemical cycles' originated in geochemistry and is now a part of environmental geochemistry.

Thirty years ago a Russian geochemist, F.I.Kozlovskiy (1972), stressed concepts of various kinds of geochemical flows in landscapes (Fortescue 1980 p.96). Today, environmental scientists and ecologists are very familiar with such transfers of matter and energy in ecosystems of all kinds using the modern equivalents of Kozlovskiy's concepts. Clearly, the AEG could include studies of the mass flux and energy balance in natural systems as a component of environmental geochemistry.

Dr. Zoback cites the critical need to understand in detail the flows of water in the unsaturated (vadose) zone of arid areas (E.G., Yucca Mt., Nevada, and the Hanford Reserve in Washington State), where high-level radioactive waste is being, or will be, stored. She points out that detailed study of the hydrology of these systems revealed many surprises.

Guideline (3) Geochemical feedback between natural and perturbed environmental systems

This guideline is linked to the previous one, but includes the recognition of man's actions that have perturbed the natural system. Short and/or long term geochemical effects of man's actions which have deliberately (or inadvertently) perturbed the natural environment have often been studied by members of the AEG . Examples here include effects of acid mine drainage and accumulation of atmospheric fallout from smelter stacks. Members of the AEG are familiar with these effects derived from point source, or non-point source polluters.

For example, at Wawa, in Northern Ontario, Canada, regional geochemical maps showing copper patterns in surface (0-10cm) lake sediment (downwind from a smelter point source) were found to be different from copper patterns in sediment taken lower down (14cm+) in the same cores. Because there in no significant vertical movement of copper in the cores, this

continued on page 8

Readers' Forum

continued from Page 7

material, which was laid down prior to the commencement of smelter operations in 1914, exhibited background copper patterns derived from underlying rocks (Fortescue and Vida 1990).

Members of the AEG could provide many examples of general and detailed environmental experience of this kind discovered in the course of geochemical mapping.

Guideline (4) Geochemical proxies for biodiversity and/or ecosystem health

Many members of the AEG are aware of ways in which geochemistry affects the nutrition and health of plants, animals and man. Recently, Finkelman et al (2001), have provided a geological update of the role geology plays in environmental human health. In the future, environmental scientists who are members of the AEG will probably contribute much information to the broad spectrum of biodiversity and ecosystem health. Dr. Zoback(2001) takes another view of this guideline:

> "Identifying geologic, chemical or biological parameters or a suite of parameters that can indicate the health, or biodiversity of an ecosystem represents a substantial challenge to all practitioners of environmental science. The challenge gets at the crux of solving environmental problems. Once we think we have found solutions for environmental problems, how do we monitor or measure (one hopes remotely) parameters that indicate the effectiveness of or our corrective actions or efforts at restoration or remediation ?" (P. 44)

This suggests that members of the AEG now have an opportunity to discover to what extent geochemistry can be used to assist in the solution of these problems.

Guideline (5) Quantifying consequences of geochemical impacts and effects

Agricultural geochemistry already includes many examples of the impacts and effects of adding fertilizers and other chemicals to croplands in the short and/or the long term. The geochemical impact of the addition of fertilizers to agricultural or forest crops provides the AEG with another possible application for its accumulated geochemical expertise within the environment. This type of expertise can also be applied to forecast effects of chemical fertilizers from crop to crop and from season to season.

Guideline (6) Geochemistry for communicating uncertainty and relative risk within environments

Alternative risk and social uncertainty are usually implicated in proposed geochemical impacts during future open cast mining, or other major landscape disturbances. For example, educating the public of uncertainties and trade-offs, always present in geochemical modelling of future environmental changes (based on case history data) could develop into another important role for the AEG expertise.

Comments

It is important to remember that Dr. Zoback aimed these 6 environmental guidelines at geologists and geoscientists in general, and not specifically at geochemists. For this reason some of them may appeal to the membership of the AEG to the exclusion of others. The principal contribution that Dr Zoback has made at the present time is to provide a conceptual bridge to the AEG, between environmental science and environmental geochemistry. It is also important to remember that Dr. Zoback's guidelines are only one way along which the AEG might develop environmental expertise. Either way, I believe that Dr. Zoback's 6 guidelines suggest a way forward for the AEG at this time. One result of serious consideration of the Zoback paper is that it forces the reader to reflect on general conceptual models of environmental geochemistry in relation to other environmental sciences.

Other suggestions for the future of the Association of Exploration Geochemists

In the Concise Oxford Dictionary 'association', is defined as 'act of coming together for a common purpose'. Broadly, the 'common purpose' of the AEG is to study the geochemistry of the environment at, or near, the surface of the earth for mineral exploration including reference to the environment as required. By building on this foundation, the By-Laws of the Association might establish not one, but two, AEG divisions in the near future. One division would include the searchers for mineral deposits (as now), and the other would provide a forum for environmental geochemistry The By-Law rules for admission of geochemical practitioners into either of the divisions must be fair and equal. Successful applicants for either division should have qualifications sufficient to satisfy the Councillors of the AEG. Initially, the AEG Environmental Division could be organized around Dr. Zoback's 6 guidelines (discussed above) after rewriting them to encompass most aspects of environmental geochemistry. Papers describing the objectives and organization of this new AEG 'Environmental Division' might appear in EXPLORE for consideration and approval by the entire AEG membership.

Supposing these changes are approved in principle. The next step would be to organize an 'AEG Environmental Division Workshop' as part of some future AEG meeting. The proceedings of the workshop might be published in a new section of "Geochemistry: Exploration Environment Analysis."

Discussion and Conclusions

The future of the AEG is currently being challenged by a gradual decline in membership due to the gradual decrease in mining worldwide. A current positive factor in environmental science is the move to redefine biological and geological sciences to meet the challenges of a rapid developing science.

continued on Page 9

Reader's Forum

continued from Page 8

To meet these changes I suggest to split the activity of the AEG into two divisions. Some members will argue what I am about to propose is that we are accepting a schism between exploration and environmental geochemistry. The AEG members will have to face the hard reality that the only way to bridge the gap which is rapidly developing between the two market oriented disciplines is to embrace environmental geochemistry. I am, therefore, proposing that the AEG has two divisions. One division would be traditional and the exploration activity of the Association and the other division is environmental and be concerned with all aspects of environmental geochemistry. To begin with, the proposed AEG environmental division could be based on the six geoscience guidelines described by Dr. Zoback. This change in emphasis should allow the AEG to fully participate in the current holistic reformation of the environmental sciences, without disturbing its traditional mineral exploration activity.

If the AEG's two divisions were to survive and prosper side by side, in time, the new AEG division could equal - or even surpass - the importance of the other in the Association. One way to signal to environmental geochemists everywhere the change in emphasis of the AEG would be to change its name to the Association of Exploration and Environmental geochemists (AEEG). This would more accurately describe the activity of its entire membership. It would also save the AEG from gradually becoming ineffective and irrelevant in both disciplines.

Acknowledgements

Dr Charles Butt, Environmental Regolith and Environmental Geoscience Research Leader, CSIRO Exploration and Mining, PO Box 1130, Bentley, WA6102 read initial drafts of this paper and offered several constructive suggestions. Also, I acknowledge the help of Dr Alecos Demetrides, Institute of Geology and Mineral Exploration, 70 Messoghian Avenue 11527, Athens, Greece, who provided useful ideas on the presentation of the information within the paper. Finally, Professor Nigel Radforth, C/O CSIRO Exploration and Mining PO Box 1130, Bentley, WA6102 read the paper in draft and suggested that it should be published when convenient to do so.

References

Darnley, A.G., A.Bjorkland,, B. Bolviken, N.Gustavsson, P.V.Koval, J.A.Plant, A.Steenfelt, M.Tauchid and Xi Xuejing with contributions by R.A. Garrett and G.E.M.Hall (1995). A Global Geochemical Database for Environmental and Resource Management: Final Report of IGCP Project 259 Recomendations for International Mapping. Earth Sciences Report No 19 124pp. UNESCO Publishing, Paris.

Demetriades,A. (2001). "By-Laws" may appear boring, but they are important comments on the AEG identity. **EXPLORE** Newsletter, No 113 (October 2001) p.19-21.

Finkelman,R.B., H.Catharine W.Skinner, G.S.Plumlee and J.E.Bunnell (2001). Medical Geology Geotimes, November 2001 p-21.

Fortescue,J.A.C. (1980). Environmental Geochemistry : A Holistic Approach. Springer Verlag, New York, 347pp.

Fortescue J.A.C. and E.A.Vida (1990). The use of lake sediment cores to map environmental change in Ontario, Canada. In 'Exploration 1990' Proceedings of the Third International Joint Symposium of IAGC and AEG, Prague, Czechoslovakia, p. 92-107.

Gergel S.E, and M.G.Turner Eds. (2002). Learning Landscape Ecology. Springer Verlag, Now York, 316 pp.

Jensen, M.E. and P.C. Bourgeron Eds. (2001). A Guidebook for Integrated Ecological Assessments. Springer Verlag, New York, 536 pp.

Kozlovskiy,F.I. (1972). Structural function and migrational landscape geochemical processes (trans.) Pochvovedeniye 4 p. 122-138.

Sala, O.E., R.B. Jackson, H.A. Mooney, and R.W. Howarth Eds. (2000). Methods in Ecosystem Science. Springer Verlag, New York, 421pp.

Taylor, G.E. (2001). The Bye-Laws and the Environment. EXPLORE Newsletter, No 113, p.21.

Turner, M.G., R.H. Gardner, and R.V. O'Neill (2001). Landscape Ecology in Theory and Practice. Springer Verlag, New York, 401pp.

Zoback, M.L. (2001). Grand Challenges in Earth and Environmental Sciences; Science, Stewardship, and Service for the Twenty-First Century. GSA Today, December 2001 p. 41-47.

John A. Fortescue
Geochemistry Consultant
2960 Solar Lane, San Marcos, CA, USA, 92069
Phone: (760) 744-6815
email: ffortes@cts.com

Exploration Technology Workshop: *Discovery* Thru *Innovation*

A two-day workshop was held in conjunction with the SEG2002 meeting in Denver, Colorado USA in April 2002. The workshop was co-sponsored by the Association of Exploration Geochemists. Two student attendees were provided with scholarships by the AEG. The workshop was intended to evaluate current exploration technologies and their role in integrated exploration programs, with perspectives from the large, small and junior companies. The state-of-the-art for exploration geophysics, geochemistry, remote sensing and information technology was reviewed; successful discoveries based upon integrated exploration were presented; and a panel discussed strategies for effective implementation and integration of these technologies into the exploration environment. The workshop was organized by Graham Closs, Mary Doherty, and Ken Witherly.

Geochemical exploration methods, from conventional to leading-edge technology, were summarized in one afternoon by geochemists active in the exploration industry. Many thanks to the geochemists who willingly participated by giving overviews of the current state of the application of exploration geochemistry and actively participated in the discussion of new technology, and integration of the geosciences in exploration companies today. Special thanks are owed to the geochemistry presenters: Chris Benn, Lynda Bloom, William Coker, Patrick Highsmith, Dave Kelley, Clark Smith, Paul Taufen, and Steve Walters. An additional 14 speakers represented geophysics, computer development, remote sensing and GIS applications. A brief summary of the geochemistry talks from the workshop is in progress, to be included as a technical note in the next issue of the Explore newsletter.

The following summaries were provided by the two students sponsored at the workshop by AEG: Gustavo Rodreguez from Argentina, and Andrew Dacey from Australia.

"The workshop was directed to evaluate exploration technologies and how these can be integrated in exploration programs. Since the global minerals exploration environment is becoming mature and funding for mineral exploration is being reduced, technical integration is a critical issue. Exploration technologies in geoscience-related disciplines have been revised including geophysics, geochemistry and remote sensing as well as their integration into geological models for mineral exploration. In addition to these, the increasing need for innovation

continued on Page 10

Exploration Technology Workshop...

continued from Page 9

and integration was addressed, while technology is being applied. Recent advances in specific disciplines have revised concepts and methodologies as illustrated by successful discoveries based on integrated exploration around the world.

This workshop allowed me to know what kind of available exploration technology would be applied for exploration within the highly-endowed, very immature Andean Paleozoic terrane of Argentina, where I am conducting my studies. Gold deposits in the northernmost part of Argentina bear many similarities to orogenic gold deposits in Phanerozoic fold belts elsewhere, in terms of host rocks, structural framework and mineralization style. Deposit-scale studies allowed the understanding of the main controls on gold mineralization, but the way these controls can be integrated, for predictive geological targeting in a regional scale, remains poorly understood. A predictive geological targeting for orogenic gold mineralization within the Ordovician fold belt should include the integration of structural analysis and stratigraphic studies, coupled with geochemical dispersion pattern data. First-order anticlinal structures developed on well-bedded lithologies and areas of high As enrichment (more than 100 ppm) may be the considered as the most favorable areas. Recent lithogeochemical studies have shown an enrichment of K2O within the mineralized areas (up to 30% of enrichment compared to background). This suggests that K may be used as a pathfinder element at a regional exploration scale, enabling the use of radiometric aerial surveys.

The significance of these controls should be tested by interrogation of digital maps and geologic databases within a GIS. However, the availability of such direct and indirect geological knowledge is poor in the Paleozoic belt of Argentina making difficult the application of integrated methods at the present.

Gustavo A. Rodríguez
PhD Candidate
Universidad Nacional de Córdoba, Argentina
CONICET, Instituto de Geología y Minería, Universidad Nacional de Jujuy
Avda. Bolivia 1661, (4600) San Salvador de Jujuy, Argentina
grod@idgym.unju.edu.ar

A Successful Integration of Technologies

Held in Denver on the 12th and 13th of April, the "Exploration Technology" short course preceded the "Global Exploration: Integrated Methods of Discovery" conference. I was fortunate to be sponsored by the Association of Exploration Geochemists to attend this meeting as well as receiving a grant to assist with travel costs. As I am currently a student at the University of Tasmania, Australia and studying for a Master's in Economic Geology, the short course was beneficial in ensuring I was up to date with the latest exploration techniques within our industry.

Recent advances in the exploration field have been rapid and in addition to reinforcing several pre-existing ideas and data interpretation methods, the course highlighted many new developments, particularly in the fields of remote sensing and virtual-reality interrogation of 3-D geophysical data. A lot was covered in the two days with the end result quite clear: that, through the successful integration of today's technologies and subsequent developments, we can be assured that our exploration efforts will result in the discovery of future ore bodies.

My sincere thanks to the AEG whose sponsorship made it all the more possible to attend both the short course and conference and with the recent and continuing upsurge in exploration activity, I hope soon to put to use some of the knowledge gained from my time in Denver.

Andrew Dacey
CODES, University of Tasmania
Australia
hm_explore@yahoo.com

2002 Distinguished Lecturer Series

Clemens Reimann has been tirelessly on the road as the AEG Distinguished Lecturer for 2001 - 2002. Clemens Reimann holds a Diplom-Mineraloge (M.Sc.) in Mineralogy and Petrology from the University of Hamburg (Germany), a Dr. mont. (Ph.D.) in Geosciences from Leoben Mining University (Austria), and a Univ. Doz. (D.Sc.) in Applied Geochemistry from the same university.

He has worked as a Lecturer in Mineralogy and Petrology at Leoben Mining University, as an exploration geochemist in Eastern Canada for three years, in contract research in environmental sciences in Austria for six years, and as Chief of Laboratory in a cement company for almost 4 years. He has worked for the Geological Survey of Norway for 9 years, first as Section Leader -- Geochemistry and Hydrogeology, and later leading the international Kola Ecogeochemistry project. He was on leave of absence during 2001.

Clemens' research interests focus on all aspects of regional geochemistry. He has published more than 50 articles in international journals, and 2 books. The following lectures are offered in his Distinguished Lecture tours.

1. *The Baltic Soil Survey*
2. *Geochemical Mapping -- Technique or Art?*
3. *Geochemical Provinces - Do They Exist and What is Their Relation to Regional Geology?*
4. *The Kola Ecogeochemistry Project*
5. *The Kola Project - Environmental Geochemical Mapping of the Central Barents Region*

Abstracts for these talks are available on the AEG web site (http://www.aeg.org). The two talks presented at Colorado School of Mines were videotaped and will be available for distribution.

To date Clemens has presented these lectures at the Austrian Geological Survey, the University of Vienna, University of Las Vegas, University of Reno, Geological Society of Nevada (Elko), Geological Society of Nevada (Reno), Colorado School of Mines, The Geological Survey of Canada and the University of British Columbia.

Clemens has provided the following comments describing his travels:

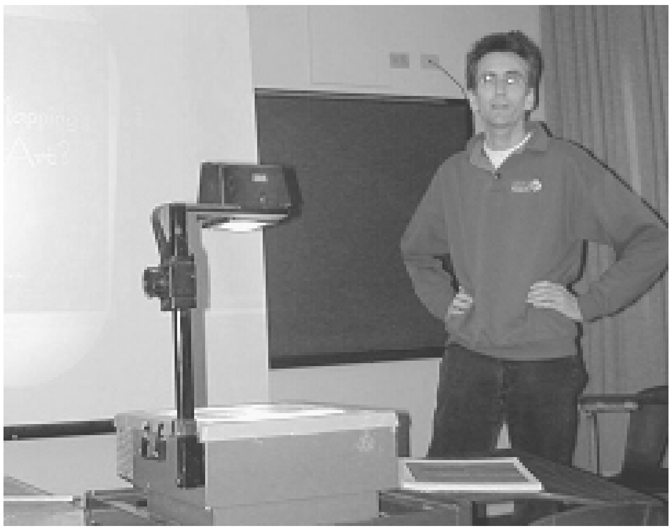
"The trip to the USA was interesting and quite some stress; eight talks in ten days on three different topics were not easy to handle. I am no longer sure that it really was one of my brighter

continued on Page 11

Distinguished Lecturer Series...

continued from Page 10

ideas to offer four different topics. Two of the talks were videotaped at the Colorado School of Mines, which was a remarkable experience in itself. The trip resulted in many good new contacts, some new friends and many interesting meetings and discussions. It may even cause new follow-up projects to the Kola Project. Notable, very lively discussions followed all talks - a pleasant reward for the lecturer. In practical terms it turned out to be quite difficult these days to organize a good overhead



Clemens lecturing at the Colorado School of Mines,. Photo: P. Taufen

projector that can accommodate European A4-size overheads of both "landscape" and "upright" format. For the next trip I will take a CD-ROM with PowerPoint® presentations along.

"The talk at Vienna University of Technology was remarkable because most of the listeners were statisticians and students of mathematics. The emerging discussion after the talks showed that the audience found applied examples of the use of statistics very refreshing. The lecturer learned to appreciate some new statistical aspects hidden in the talk.

"I hope that the "American" audience enjoyed my talks as much as I enjoyed presenting them (well, most of them). Thanks to all the people that made this trip possible and enjoyable, just to name some: Clark, David, Greg, who managed to put up a lot of the funds, Gwendy, Jean, Leslie, Mary, Owen; and, of course my hosts in Denver, Paul Taufen and Jean and Paul Theobald. Everything was extremely well organized. Thanks also to NGU, my employer, for paying for the flight to the USA and my time. And: in case I have promised to send something to somebody and it has not arrived yet: please make contact and remind me."

Clemens Reimann
Geological Survey of Norway (NGU)
N-7491 TRONDHEIM / NORWAY
phone (office): +47 73 904 307
phone (home): +47 73 931 767
e-mail: clemens.reimann@ngu.no

Call for Papers

Special Issue of the AEG Journal Geochemistry: Exploration, Environment, Analysis

Our friend and colleague at the Geological Survey of Canada, Dan R. Boyle, passed away in the summer of 2000 after a courageous battle with cancer. We, together with Gwendy Hall, editor-in-chief of the AEG Journal "Geochemistry: Exploration, Environment, Analysis" or GEEA, thought it would be a fitting tribute to honour Dan's many contributions to geoscience with a special issue of the journal.

Dan's interests and specialties were diverse, covering the general fields of economic geology and low-temperature geochemical processes. This gives us fairly wide latitude in the types of papers that might be suitable for this volume. We have decided to divide the issue into two general sections along the lines of Dan's interests:

1) low-temperature geochemistry and weathering studies, and
2) ore deposits and hard-rock geochemistry.

Dan published on many topics, including: groundwater sampling and monitoring; fluoride in drinking water; mine tailings geochemistry; basal-type uranium deposits; surficial uranium deposits; copper porphyry deposits, exploration geochemistry of copper porphyries; volcanogenic massive sulfides and uranium; mineral exploration using groundwaters; gossan geochemistry; trace element geochemistry of ores; and magmatic Sn and W, and Ti mineralization.

To date, we have informally approached our immediate colleagues and have secured firm commitments for five papers in the first section, and two in the second. We need more papers, however, for a full special issue. Please consider contributing a paper to this special issue. We would be looking for a submission by September 30, 2002.

Matthew will handle the geochemistry and non-ore deposits papers, and Jan will handle the ore deposits/hard rock submissions. If you have any questions, or would like further information, please do not hesitate to contact the co-editors:

Matthew I. Leybourne, *Geosciences Department*
University of Texas at Dallas
Box 830688
Richardson, Texas, 75083-0688 USA
Phone (972) 883-2403 Fax (972) 883-2537
Email: mleybo@utdallas.edu

Jan M. Peter, *Mineral Resources Division*
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario K1A 0E8 Canada
Phone (613) 992-2376 Fax (613) 996-3726
Email: jpeter@nrcan.gc.ca

RECENT PAPERS

This list comprises titles that have appeared in major publications since the compilation in EXPLORE Number 115. Journals routinely covered and abbreviations used are as follows: Economic Geology (EG); Geochimica et Cosmochimica Acta (GCA); the USGS Circular (USGS Cir); and Open File Report (USGS OFR); Geological Survey of Canada papers (GSC paper) and Open File Report (GSC OFR); Bulletin of the Canadian Institute of Mining and Metallurgy (CIM Bull.): Transactions of Institute of Mining and Metallurgy, Section B: Applied Earth Sciences (Trans. IMM). Publications less frequently cited are identified in full. Compiled by L. Graham Closs, Department of Geology and Geological Engineering, Colorado School of Mines, Golden, CO 80401-1887, Chairman AEG Bibliography Committee. Please send new references to Dr. Closs, not to **EXPLORE.**

Anand, R.R. and Paine, M., 2002. Regolith geology of the Yilgarn Craton, Western Australia: implications for exploration. Aust. J. Earth Sci. 49: 3-162.

Banfield, J.F. and Navrotsky, A. (eds.), 2001. Nanoparticles and the Environment. Min. Assoc. Am., Rev. Min. and Geochem. V. 44. 349 p.

Bechtel, A., Gratzer, R., Puttmann, W., and Oszczepalski, S., 2002. Geochemical characteristics across the oxic/anoxic interface (Rote Faule front) within the Kupferschiefer of the Lubin-Sieroszowice mining district (SW Poland). Chem. Geol. 185(1/2): 9-31.

Bi, X., Cornell, D.H., and Hu, R., 2002. REE composition of primary and altered feldspar from the mineralized alteration zone of alkaline intrusive rocks, western Yunnan Province, China. Ore Geol. Rev. 19(1/2): 69-78.

Bish, D.L. and Ming, D.W. (eds.), 2001. Natural Zeolites: Occurrence, Properties, Applications. Min. Assoc. Am., Rev. Min. and Geochem. V. 45. 654 p.

Blakeman, R.J., Ashton, J.H., Boyce, A.J., Fallick, A.E., and Russell, M.J., 2002. Timing and Interplay between Hydrothermal and Surface Fluids in the Navan Zn + Pb Orebody, Ireland: Evidence for Metal Distribution Trends, Mineral Textures, and delta 34 S Analyses. EG 97(1): 73-91.

Blevin, P.L., 2002. The petrographic and compositional character of variably K-enriched magmatic suites associated with Ordovician porphyry Cu-Au mineralization in the Lachlan Fold Belt, Australia. Min. Deposita. 37(1): 87-99.

Brand, N.W. and Butt, C.R.M., 2002. Weathering, element distribution, and geochemical dispersion at Mt. Keith, Western Australia: implication for nickel sulphide exploration. Geochemistry: Exploration, Environment, Analysis. 1(4): 391-407.

Brown, G.E., Jr. and Parks, G.A., 2001. Sorption of Trace Elements on Mineral Surfaces: Modern Perspectives from Spectroscopic Studies, and Comments on Sorption in the Marine Environment. Intern. Geol. Rev. 43(11): 963-1073.

Butt, C.R.M., 2002. Dispersion of gold and associated elements in the lateritic regolith, Mystery Zone, Mt. Percy, Kalgoorlie, Western Australia. Geochemistry: Exploration, Environment, Analysis. 1(4): 291-306.

Craig, M.A., 2002. Regolith mapping for geochemical exploration in the Yilgarn Craton, Western Australia. Geochemistry: Exploration, Environment, Analysis. 1(4): 383-390.

Davies, R.M., O'Reilly, S.Y., and Griffin, W.L., 2002. Multiple Origins of Alluvial Diamonds from New South Wales, Australia. EG 97(1): 109-123.

Deming, D., 2001. Introduction to Hydrogeology. McGraw Hill. 480 p.

Filella, M., Belzile, N., and Chen, Y.W., 2002. Antimony in the environment: a review focused on natural waters. 1. Occurrence. Earth-Sci. Rev. 57(1/2): 125-176.

Frost, B.R., Mavrogenes, J.A., and Tomkins, A.G., 2002. Partial melting of sulfide deposits during medium- and high-grade metamorphism. Can. Mineralogist 40(1): 1-18.

Gascoyne, M. and Peterman, Z.E. (eds.), 2002. Geochemistry of Yucca Mountain, Nevada: A Potential Site for a High-level Nuclear Waste Repository. Applied Geochem. 17(6): 657-853.

Grabezhev, A.I., Moloshag, V.P., and Purtov, V.K., 2002. Behavior of Al and Ti during Acid Metasomatism at Massive-Sulfide Deposits of the Ural. Geochem. Intern. 40(2): 141-154.

Hill, R.E.T., 2002. Komatiite volcanology, volcanological setting and primary geochemical properties of komatiite-associated nickel deposits. Geochemistry: Exploration, Environment, Analysis. 1(4): 365-381.

Hinrichs, J., Dellwig, O., and Brumsack, H.J., 2002. Lead in sediments and suspended particulate matter of the German Bight: natural versus anthropogenic origin. Applied Geochem. 17(5): 621-632.

Holliday, J.R., Wilson, A.J., Blevin, P.L., Tedder, I.J., Dunham, P.D., and Pfitzner, M., 2002. Porphyry gold-copper mineralization in the Cadia district, eastern Lachlan Fold Belt, New South Wales, and its relationship to shoshonitic magmatism. Min. Deposita. 37(1): 100-116.

Kroll, T., Muller, D., Seifert, T., Herzig, P.M., and Schneider, A., 2002. Petrology and geochemistry of the shoshonite-hosted Skouries porphyry Cu-Au deposit, Chalkidiki, Greece. Min. Deposita. 37(1): 137-144.

Kurchavov, A.M., Grankin, M.S., Mal'chenko, E.G., Khamzin, B.S., and Zhukovskii, V.I., 2002. Metallogenic Zonality of the Devonian Volcanoplutonic Belt in Central Kazakhstan. Geol. of Ore Deposits 44(1): 18-25.

Larocque, A.C.L., Stimac, J.A., McMahon, G., Jackman, J.A., Chartrand, V.P., Hickmott, D., and Gauerke, E., 2002. Ion-microprobe analysis of FeTi Oxides: Optimization for the Determination of Invisible Gold. EG 97(1): 159-164.

Larsen, R.B., 2002. The distribution of rare-earth elements in K-feldspar as an indicator of petrogenetic processes in granitic pegmatites: examples from two pegmatite fields in southern Norway. Can. Mineralogist 40(1): 137-151.

Lawrance, L.M., 2002. Multi-element dispersion within salt-lake environments: case study of the buried Hannan South gold deposit, Western Australia. Geochemistry: Exploration, Environment, Analysis. 1(4): 323-339.

Lee, G., Bigham, J.M., and Faure, G., 2002. Removal of trace metals by coprecipitation with Fe, Al, and Mn from natural waters contaminated with acid mine drainage in the Ducktown Mining District, Tennessee. Applied Geochem. 17(5): 569-581.

Lorenga, J.A., 2002. Butte, Montana: Minerals, mines, and history. The Mineralogical Record 33(1): 5.

continued on Page 13

RECENT PAPERS

continued from Page 12

Lydon, J., Roy, T., Slack, J.F., and Knapp, M.E. (eds.), 2001. The Geological Environment of the Sullivan Deposit, British Columbia. Geol. Assoc. of Canada GAC-MDD Spec. V. 1. 635 p. + CD-Rom.

Muller, D., 2002. Gold-Copper mineralization in alkaline rocks. Min. Deposita. 37(1): 1-3.

Ohlander, B., Friese, K., and Fritz, P. (eds.), 2001. Special Issue: Geochemical studies of mining and the environment. J. Geochem. Explor. 74(1-3): 1-231.

Pawlowsky-Glahn, V. and Egozcue, J.J., 2002. BLU Estimators and Compositional Data. Math. Geol. 34(3): 359-274.

Peng, Q.M. and Palmer, M.R., 2002. The Paleoproterozic Mg and Mg-Fe Borate Deposits of Liaoning and Jilin Provinces, Northeast China. EG 97(1): 93-108.

Qing, M. and Han, X.J., 2001. The auriferous difference and its appraisal criteria for magnetite series granite in the Western Henan Province. Kuangwu Yaushi 21(4): 23-27.

Ran, Y., Fu, J., Rate, A.W., and Gilkes, R.J., 2002. Adsorption of Au (I, III) complexes on Fe, Mn oxides and humic acid. Chem. Geol. 185(1/2): 33-49.

Robertson, I.D.M., King, J.D., and Anand, R.R., 2002. Regolith geology and geochemical exploration around the Stellar and Quasar gold deposits, Mt. Magnet, Western Australia. Geochemistry: Exploration, Environment, Analysis. 1(4): 353-364.

Ruiz, C., Arribas, A., and Arabas, A., Jr., 2002. Mineralogy and geochemistry of the Mesa Valverde blind massive sulphide deposit, Iberian pyrite belt (Spain). Ore Geol. Rev. 19(1/2): 1-22.

Ryan, P.C., Wall, A.J., Hillier, S., and Clark, L., 2002. Insights into sequential chemical extraction procedures from quantitative XRD: a study of trace metal partitioning in sediments related to frog malformities. Chem. Geol. 184(3/4): 337-357.

Sangster, D.F., 2002. The role of dense brines in the formation of vent-distal sedimentary-exhalative (SEDEX) lead-zinc deposits: field and laboratory evidence. Min. Deposita. 37(2): 149-157.

Scott, K.M., 2002. Weathering in the Parkinson Pit and its implications for exploration in the Mt. Magnet Mining District, Western Australia. Geochemistry: Exploration, Environment, Analysis. 1(4): 341-352.

Scott, K.M. and Howard, R.W., 2002. Hydrothermal alteration and geochemical dispersion in the regolith at Panglo, Eastern Goldfields, Western Australia. Geochemistry: Exploration, Environment, Analysis. 1(4): 313-339.

Semenov, E.I., 2001. Ores and Minerals of Rare Earths, Thorium and Uranium (Lanthanides and Actinides). GEOS Moscow, Russia (in Russian). 307 p.

Sergeev, N.B. and Gray, D.J., 2002. Gold mass balance in the regolith, Mystery Zone, Mt. Percy, Kalgoorlie, Western Australia. Geochemistry: Exploration, Environment, Analysis. 1(4): 307-312.

Settmann, R. and Jenchuraeva, R. (eds.), 2001. Paleozoic geodynamics and gold deposits in the Kyrgyz Tien Shan, International Geological Correlation Programme Excursion Guidebook. 182 p.

Shcherbakov, Y.G., 2002. Review - The Theory of Placers by N.A. Shilo: A Geochemical Aspect in the Classification of Ore Associations. Geochem. Intern. 40(3): 350-352.

Sherlock, R. and Logan, A. (eds.), 2000. VMS Deposits of Latin America. Geol. Assoc. of Canada. 641 p.

Shilo, N.A., 2000. The Theory of Placers. Akad. Gorn. Nauk (Moscow).

Sillitoe, R.H., 2002. Some metallogenic features of gold and copper deposits related to alkaline rocks and consequences for exploration. Min. Deposita. 37(1): 100-116.

Smedley, P.L., and Kinniburgh, D.G., 2002. A review of the source, behavior and distribution of arsenic in natural waters. Applied Geochem. 17(5): 517-568.

Som, S.K. and Joshi, R., 2002. Chemical Weathering of Serpentinite and Ni Enrichment in Fe Oxide at Sukinda Area, Jajpur District, Orissa, India. EG 97(1): 165-172.

Spencer, R.M., Montenegro, J.L., Gaibor, A., Perez, E.P., Mantilla, G., Viera, F., and Spencer, C.E., 2002. The Portovelo-Zaruma Mining Camp, Southwest Ecuador: Porphyry and Epithermal Environments. SEG Newsletter No. 49: 1, 8-15.

Stein, H.J., Markey, R.J., Morgan, J.W., Hannah, J.L., and Schersten, A., 2001. The remarkable Re-Os chronometer in molybdenite: How and why it works. Terra Nova. 13(6): 479.

Sylvester, P. (ed.), 2001. Laser-Ablation-ICPMS in the Earth Sciences. Min. Assoc. Canada Short Course Series 29.

Wilburn, D.R., 2002. Annual Review 2001 - Exploration Overview. Min. Eng. 54(5): 26-36.

Wilson, A.M., Sanford, W., Whitaker, F., and Smart, P., 2001. Spatial patterns of diagenesis during geothermal circulation in carbonate platforms. Am. J. Sci. 301(8): 727.

Yang, X.Y., Wang, K., Sun, L., Yang, X., Li, Y., and Shi, K., 2002. Geochemische und geophysikalische Erkundung einer potentiellen Porphyry (A prospecting porphyry Cu-Au deposit in Changpushan area by geochemical). Chemie der Erde. 61(4): 254-276.

Zanker, H., Moll, H., Richter, W., Brendler, V., Hennig, C., Reich, T., Kluge, A., and Hutlig, G., 2002. The colloid chemistry of acid rock drainage solution from an abandoned Zn-Pb-Ag mine. Applied Geochem 17(5): 649-656.

Zhong, H., Zhou, Z.H., Zhou, M.F., Sun, M., and Liu, B.G., 2002. Platinum-group element geochemistry of the Hongge Fe-V-Ti deposit in the Pan-Xi area, southwestern China. Min. Deposita. 37(2): 226-239.

THANK YOU!

Lloyd James has faithfully served as Editor of the AEG **EXPLORE** newsletter. His contributions to the newsletter are acknowledged and greatly appreciated. Lloyd will continue to assist Mary Doherty with her new duties as Editor of the newsletter.

Gratitude is also extended to the past Assistant Editors who have served for some time and were ready for a break: Elizabeth Bailey, Robert Eppinger, David Gray, Geoff Murphy, David Turner, and Marian Skwarnecki. Thank you all for your contributions.

Geological Survey Updates

continued from Page 1

Ongoing efforts involve upgrading and standardizing the information in the database concerning sample type, sample location, and analytical methodology. As these upgrades are completed, the data are being released to the public via the Internet. Reformatted data from the NURE HSSR program for most of the U.S. are available at the following URL: http://greenwood.cr.usgs.gov/pub/open-file-reports/ofr-97-0492/index.html. Upgraded data for Alaska are available at: http://geopubs.wr.usgs.gov/open-file/of99-433/. In addition, major portions of the PLUTO database (a subset of the NGDB) are available on CD-ROM. (USGS Digital Data Series DDS-47). For more information, contact David Smith (dsmith@usgs.gov).

National-to-Regional-Scale Geochemistry

The USGS, in cooperation with state governments, private industry, and native corporations, is conducting a National Geochemical Survey (NGS) to establish a national-scale data set using minus-150-micrometer (μm) stream sediments as the primary sample medium. The early impetus for the NGS was to complete coverage of areas where surface sediment sampling was incomplete or nonexistent. In particular a set baseline of values for arsenic abundances was a need expressed by many collaborating agencies. Thus, the NGS is driven in part by environmental concerns. Through a combination of new sample collection and re-analysis of archival samples, the goal of the NGS is to provide surface-sediment-based coverage for the nation on a 17 x 17 kilometer (km) grid (or denser). Analyses comprise a wide variety of chemical elements, including As, Se, Hg, and Pb. To date, more than 50,000 samples, both new and archival, have been analyzed. National coverage is presently about 75%, with completion expected in three years. Figure 1 shows a map of copper concentrations for the U.S. based on currently available data from this project.

For information about the NGS, contact Andrew Grosz (agrosz@usgs.gov) or Jeff Grossman (jgrossman@usgs.gov).

Geochemistry in Support of Mineral Resource Assessments and Ore Deposit Studies

Assessment studies

USGS mineral resource assessment studies of Federal lands provide land management agencies with earth science data and interpretations, applicable at both local and regional scales. Geochemical data, in combination with other earth science information, are used to assess the potential for undiscovered mineral deposits. As part of a worldwide trend, land managing agencies and the public have become more concerned with the environmental consequences of development of mineral resources, and as a result, the USGS has undertaken a greater role in collecting and including environmental data in mineral assessments. In the past, the USGS conducted 1° X 2° quadrangle-based assessment studies; however, with reduced staff and diverse needs, USGS assessment studies are now more limited in number, cover larger areas, and are typically bounded by large drainage basins, rather than political or quadrangle limits.

As an example, the Humboldt River basin in northern Nevada covers 43,500 km^2 and includes many of the nation's largest gold deposits. In 1995, the Bureau of Land Management identified several elements for investigation that are important because of their role as pathfinder elements or as potential toxins in the environment. Recently completed geochemical landscape maps (Fig. 2) of select elements in soils and stream sediments (Folger and Ludington, unpublished data), when combined with information about the geology, topography, and mining districts, provide a visual aid to interpreting geochemical anomalies. Many of the historic and still productive silver mining districts in Nevada (including the largest Ag producers: McCoy-Cove, Coeur Rochester, and Ken Snyder mines) are prominent features on this map. For example, anomalous silver concentrations delineate all of the mining districts in the Humboldt Range along the western arm of the basin, the districts that follow the northwest-trending Battle Mountain-Eureka Trend in the central basin, and the north-south trending Independence district along the northern boundary of the basin. The Snake Mountain district on the northeastern boundary is known for barite resources but not silver; therefore, the anomalous silver in sediments in that area is interesting, as it suggests the area is enriched in silver in addition to barite. The soil and sediment geochemical data are also important for mineral deposit-related environmental studies. Due to the large amount of historical and recent mining in the Humboldt River Basin, the soil and sediment data, along with water and mine waste materials (Nash, 2000; 2001) were used to determine natural background abundances of these materials and how mining activities may have changed these abundances. A summary of all investigations in the Humboldt River basin will be contained in an upcoming USGS Bulletin entitled "Geoenvironmental Investigations of the Humboldt River Basin, northern Nevada". For more information about Humboldt geochemical studies, contact Helen Folger (hfolger@usgs.gov).

Similar assessment studies are ongoing in northern Idaho and western Montana, covering the uppermost major tributaries of the Columbia and Missouri Rivers known as the Headwaters region. Ongoing studies include re-interpretation of existing regional stream sediment geochemistry, production of geochemical landscape maps, upgrading and standardizing approximately 150,000 existing geochemical records, and environmental geochemical studies of historic mining districts. For example, mining districts in the upper Salmon River drainage basin of central Idaho are being investigated to support salmon habitat restoration efforts by other Federal agencies. Most of the historic mines and associated deposit types studied do not appear to be degrading water quality because they typically have neutral or higher pH and moderate alkalinities which inhibit dissolved aqueous transport of many metal species (Hammarstrom et al., 2002; Van Gosen et al., 2000).

continued on Page 15

Geological Survey Updates

continued from Page 14

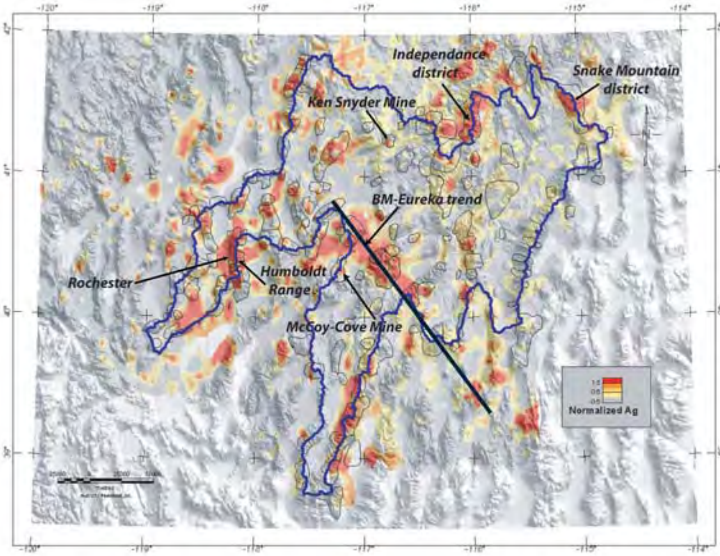


Figure 2. Normalized silver geochemical data from the Humboldt River basin. The data are ranked and colored by standard deviation. The normalized scores were processed using a minimum curvature algorithm to produce the grids. Sample density within the basin is approximately one sample per 17 km². The most anomalous values are in red and all values below the mean are in medium gray. The Humboldt River basin is outlined in blue on a DEM base map. Select mining districts are outlined as black polygons. Bold italics are specific names referred to in text. BM-Eureka=Battle Mountain-Eureka.

Nontraditional uses of geochemistry in the Headwaters assessment study include on-going forest nutrition studies and a before-and-after comparison study of stream sediment and stream-water chemistries in a large area of central Idaho impacted by intense wildfires in 2000. The severe wildfires burned an area of approximately 140,000 hectares (340,000 acres), much of which had been sampled in a 1996 stream sediment and water baseline study (Eppinger et al., 2001). The area was re-sampled in 2001. Preliminary results indicate that the stream waters quickly returned to baseline conditions, but the 2001 stream sediments have higher concentration of selected metals in mineralized areas, probably due to an increase in landslides, debris flows, and slumping of naturally metal-rich soils where vegetation has been stripped away by the wildfires.

For information on Headwaters geochemistry, contact Bob Eppinger (eppinger@usgs.gov).

Ore deposit studies

An important aspect of resource assessments is the understanding of the essential ore-forming processes and large-scale events that led to the development of mineral deposits. Several USGS ore genesis research studies heavily utilize geochemistry. Ongoing USGS work at Red Dog, a sediment-hosted massive sulfide deposit in Alaska and currently the largest zinc deposit in the world, has advanced the understanding of many fundamental geochemical and geological attributes of the ore deposit and other key parameters that led to the formation of this important resource. In situ trace element geochemical data obtained using laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) for sulfides from the Red Dog deposits provide a tool for unraveling stages of sulfide deposition and for determining the evolution of trace element compositions of the fluid(s) through time. At least four stages or types of texturally and compositionally distinct sphalerite are recognized. The geochemical differences (primarily in the elements Fe, Mn, Co, Tl, and Ge) among these four stages suggest a possibly long-lived complex hydrothermal system, involving multiple metal-bearing fluids (Kelley et al., 2001) that may have contributed to the giant size of the deposits at Red Dog. Unlike the sphalerite chemistry, in situ data for pyrite from Red Dog are not as useful

continued on Page 16

Geological Survey Updates

continued from Page 15

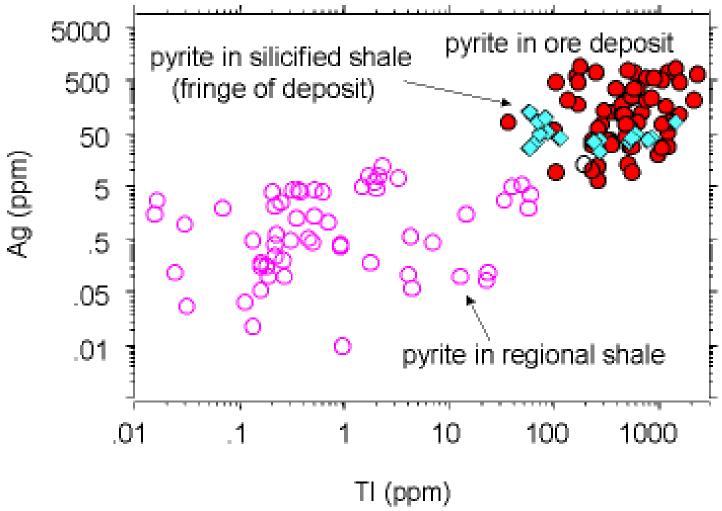


Figure 3. Concentrations of Tl and Ag in pyrite from Red Dog compared with pyrite in stratigraphically equivalent units distal to mineralization. Analyses by in situ Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS). Red dots - pyrite from mineralized zones; blue diamonds – pyrite in silicified shales on the fringe of the deposit; purple open circles – pyrite in host shales distal to mineralization.

in terms of distinguishing various mineralizing stages. However, pyrite from the ore deposits is distinct from pyrite in stratigraphically equivalent units distal from mineralization; pyrite from the ore deposits has much higher concentrations of Tl and Ag (Fig. 3). Whole-rock geochemical data for altered rocks in and around the deposits also show distinct differences when compared to unaltered and unmineralized rocks away from the deposits (Slack et al., 2001). In particular, altered rocks near the deposits have high As, Sb, Tl, and Ge, and positive Eu anomalies compared to rocks distal from the deposit. The observed geochemical trends provide useful vectors to mineralization and are a potential exploration tool. For more information, contact Karen Kelley (kdkelley@usgs.gov).

Recent USGS work on Mississippi Valley-type (MVT) deposits (Leach et al., 2001) has similarly contributed to a growing understanding of the many fundamental geochemical and geological attributes that led to the formation of these deposits. New age dating techniques provide evidence that MVT deposits form in direct response to global scale tectonic events. In addition, geochemical data from fluid inclusions (Cl/Br data) support the notion that most of the salinity in hydrothermal ore-related fluids was derived from evaporated seawater, rather than dissolution of evaporites. This implies that paleoclimate may have been an important control on the formation of MVT deposits, and therefore suggests that exploration programs for MVT ore districts in frontier areas perhaps should include evaluations of paleogeographical and paleoclimate history of the areas of interest. For more information, contact David Leach (dleach@usgs.gov).

Geochemical signatures of sedimentary rock hosted disseminated gold (SRHDG) deposits in Nevada have recently been used in combination with age constraints and geology to sort them into four major types: Devonian sedex; Jurassic, Cretaceous and Tertiary pluton-related; Late Eocene Carlin–type; and Neogene low-sulfidation epithermal (Hofstra and Cline, 2000). Many of these deposits are aligned along crustal faults inherited from Proterozoic rifting. In the Carlin trend, basement faults are manifest by (1) abrupt facies changes and syngenetic ore deposits, (2) anomalous fold orientations and translational fault systems, (3) igneous intrusions of Jurassic, Cretaceous, and Tertiary age, and (4) Au-bearing ore deposits of different types and ages that are locally superimposed. These observations suggest that crustal structures localized deformation, magmatism, and hydrothermal activity repeatedly over the complex Phanerozoic tectonic history of the region. Current research seeks to improve our understanding of the evolutionary history of these mineral belts and roles of structural and geochemical inheritance in the formation of the economically most important Carlin-type gold deposits. For more information, contact Al Hofstra (ahofstra@usgs,gov).

Gold deposit research has also recently focused on the important characteristics of and differences between orogenic and intrusion-related gold deposits. Studies of the latter group of deposits have been particularly focused in the Tintina gold province of interior Alaska and western Yukon; studies have stressed important trace element associations, fluid inclusion characteristics, and stable isotope signatures of the ores (Mair et al., 2000; Goldfarb et al., 2000; Hart et al., 2002). The space-time characteristics of these various epigenetic precious metal systems have been evaluated relative to patterns of global distribution of these deposits (Goldfarb et al., 2001a), providing improved targeting of areas most favorable for future geochemical and other exploration programs. Also important in terms of exploration for gold deposits are recent collaborative studies between the USGS and Chinese government and university geoscientists that have produced new geochemical and geological information summarizing China's most significant gold resources (Goldfarb et al., 2001b; Zhou et al., 2002). For more information, contact Rich Goldfarb (goldfarb@usgs.gov).

continued on page 17

Geological Survey Updates

continued from Page 16

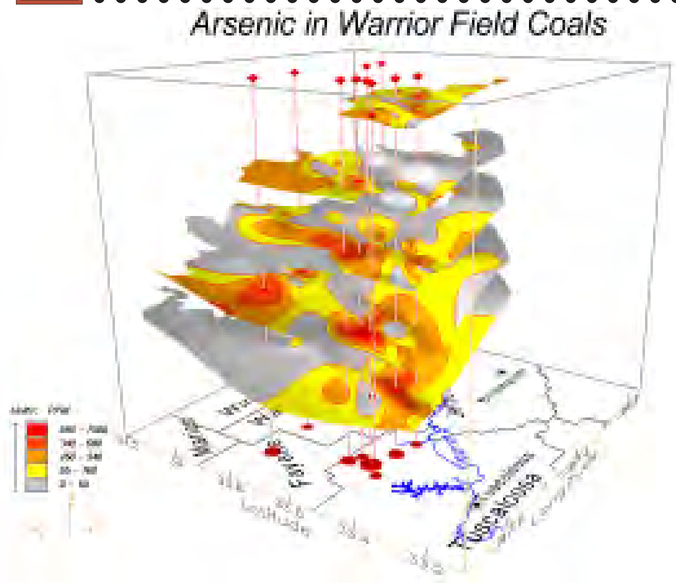


Figure 4. Arsenic in the Warrior coal field. The 3-D view shows contoured concentrations of arsenic in ppm for 5 different coal groups. View looking northeast. Vertical dimension is not drawn to scale. The vertical lines are drawn through areas with exceptionally high arsenic. The downward projection of the lines shows the geographic locations of these high values. The lower intercept of these drop lines has an associated circle whose diameter is roughly proportional to the extent of the associated arsenic enrichment.

Environmental Geochemistry

In the last decade, the USGS has focused much research on understanding the environmental aspects of mineral deposits, and has expanded traditional uses of trace element, stable isotope, and fluid inclusion data to studies that not only include ore genesis research, but also the entire life cycle of mineral deposits, including natural and anthropogenic modification, ore processing, remediation and reclamation. The knowledge gained in these studies is not specific to mineral resources, but can be applied to other societally relevant issues (e.g., volcanic landslide hazards and cyanide degradation) and to the preservation and restoration of major ecosystems (e.g., web site: http://crustal.usgs.gov/projects/isotopes/). Many recent USGS studies related to mineral deposits have focused primarily on the environmental impact of historic mining activities on water quality and biota. A relatively new arena for USGS research is the application of geochemistry to human health. Below are a few examples of recent environmental geochemistry studies.

As- and Hg-specific studies

The Warrior bituminous coal field in Alabama contains arsenic concentrations that are three times higher than the average for all U.S. coal; some local areas contain arsenic concentrations greater than 200 ppm (Fig. 4). The coal field is also enriched in numerous other elements (Goldhaber et al., 2000). The metal enrichment is interpreted to be related to post or syn-coalification hydrothermal fluids that

continued on Page 19

Technical Note...

continued from Page 3

The northern part of the Palaeoproterozoic orogens features a cluster of samples with very unusual chemistry. The cluster lies north of the carbonate hosted, now exhausted, Pb-Zn deposit at Maarmorilik in greywacke metasediments. The sediments are anomalous in Co, Cu and Zn (see also Fig. 1) but also have high concentrations of Ni and REE (Steenfelt et al., 1998). Zinc mineralisation is known from the area (Coppard et al., 1992), but that does not explain the other anomalies. Hence, some other mineralisation or unknown lithology is indicated. A small cluster of presently unexplained Cu anomalies is tied to Palaeoproterozoic supracrustal rocks, just north of the Archaean Craton. The southerly Palaeoproterozoic Ketilidian orogen has scattered anomalies for Ba, Co, Ti, W and Zn, of which only the latter has a known source, namely alkaline syenites of Mesoproterozoic intrusions, further discussed below.

The Cr, Ni and Ti anomalies within the Mesozoic-Tertiary Basin are associated with plateau basalts and may reflect unusual compositions of certain lava flows. Thus, high Ni is associated with known occurrences of picritic lavas. However, the possibility that the anomalies indicate deposits of chromite, pentlandite or ilmenite should not be entirely excluded.

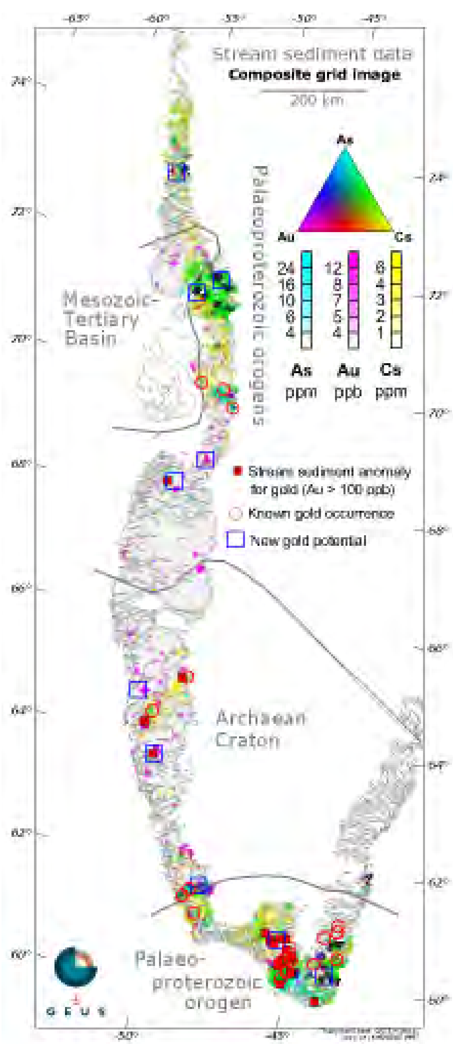


Fig. 3. Gold potential map based on stream sediment data

Mineral potential maps

The geochemical maps reflect lithological changes and may be used to outline lithologies associated with ore formation. The chemical characteristics are more clearly expressed when elements are combined using, for example, three-colour composite grids. The technique is illustrated in the gold potential map Fig. 3 showing a composite grid of As, Au and Cs together with Au anomalies and known gold occurrences. The intensity of the colours increases with concentration, and the indicator triangle shows the result of adding components. Thus, high concentrations of all three components result in dark or black coloration (centre of triangle). Such areas are consid-

continued on Page 18

Technical Note...

continued from Page 17

ered having the highest gold mineralisation potential.

The idea behind the choice of elements is that epigenetic gold mineralisation may form where granitic magmas penetrate source rocks for gold at a high crustal level. Supracrustal rocks enriched in As are often a source of Au, and high-level granitic magmatism (pegmatites and aplites) are characterised by high concentrations of Cs. Thus, favourable areas for gold mineralisation are indicated by coinciding high As and Cs, i.e. green to black grid cells. The resultant targets, marked by blue squares, include Au anomalies (Au>100 ppb), high grid values for gold based on more than on sample, and areas of coinciding high As and Cs (with or without high Au). The known occurrences of gold mineralisation lie within green areas (combined high As and Cs) supporting the validity of the model. The gold mineralisation model was first developed and applied to South Greenland (Steenfelt, 2000), but seems to work elsewhere in the Precambrian of Greenland.

A different kind of mineral potential is illustrated in Fig. 4, showing the use of Nb as a pathfinder for kimberlites together with the distribution of pyrope identified in stream sediments and kimberlite occurrences. Kimberlite pipes have not been encountered and sheets and dykes are rarely more than 0.5 m wide. However, kimberlites have Nb concentrations in the range of 150-300 ppm that contrasts with the 5-10 ppm of the surrounding gneisses. In addition, kimberlites decompose more readily than the gneisses during weathering so that their signal in the stream sediment is enhanced relative to their volume proportion of the bedrock. Regional Nb anomalies are spatially associated with known kimberlite fields, S-S (Sisimiut-Sarfartoq), M (Maniitsoq), and P (Pyramidefjeld) in West Greenland, whereas the Nb-anomalous areas in South Greenland reflect alkaline intrusive complexes and dyke swarms. The shape of the northern Nb anomaly suggests that the S-S kimberlite field extends to the north, south-east and east of the presently known occurrences.

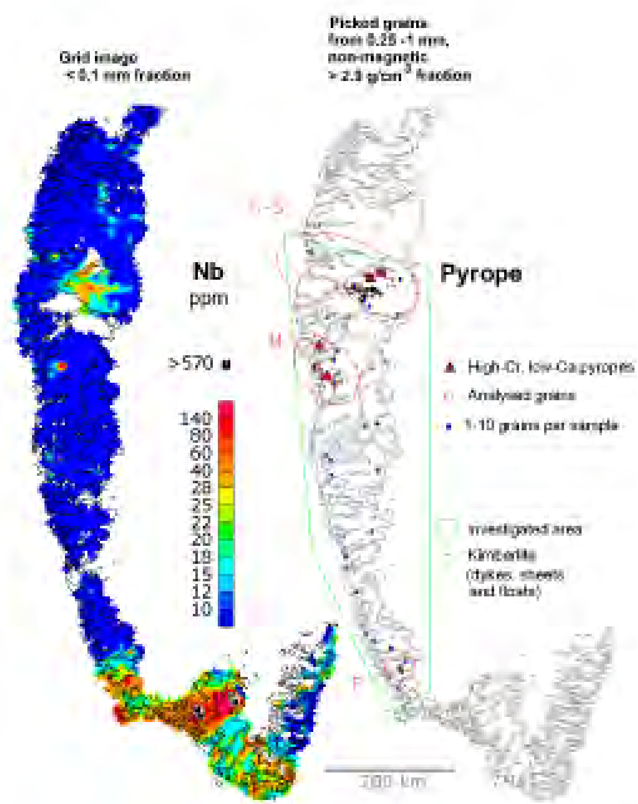


Fig. 4. Nb-provinces and distribution of pyrope in relation to kimberlite fields in West Greenland, S-S (Sisimiut-Sarfartoq), M (Maniitsoq) and P (Pyramidefjeld). Kimberlite occurrences from Larsen (1991).

In South Greenland, high Nb outlines the Mesoproterozoic Gardar alkaline igneous province (Fig. 5). The most evolved magmas of the intrusive complexes have very high concentrations of incompatible elements such as Be, Li, Ga, K, Rb, Zn, Y, Zr, Nb, Ta, REE, U, Th. Accordingly, stream sediment anomalies for Ga, Hf, Nb, Ta, Th, Zn, Zr and REE are located in drainages of some Gardar intrusions. Exploration geochemical data for some of the speciality metals are compiled in Fig. 5b indicating a potential for additional deposits outside the known Nb-Ta prospect at Motzfeldt Sø (Thomassen, 1989).

Final remarks

The geochemical atlas and the data set behind it are invaluable in assessing the mineral potential of West and South Greenland, not only because they show the location of high concentrations of elements associated with ores or

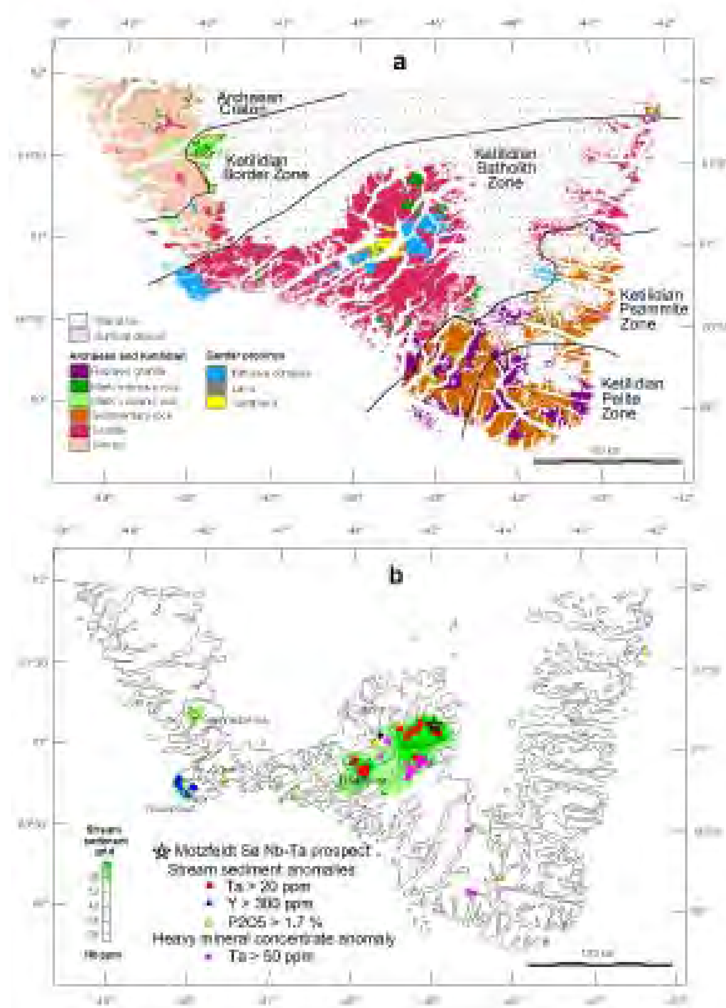


Fig. 5. (a) Simplified geology of South Greenland; (b) mineral potential map for some specialty metals. From Steenfelt et al. (2000).

continued on Page 19

Technical Note...

continued from Page 18

ore formation, but also because the data provide much information on lithochemistry. The latter is particularly useful because large areas of Greenland are poorly known geologically and rock chemical data are scarce. Interpretation of combined element grids together with other relevant information outline new targets for mineral exploration. Further possibilities lie in the integration of the geochemical data with more kinds of data, such as lithological, geophysical, structural and stratigraphical, as they become digitally available, and use of statistical tools and modelling to detect new settings favourable for ore formation.

The Geochemical Atlas of West and South Greenland is available from GEUS, see www.geus.dk. This note is published with the permission of the Geological Survey of Denmark and Greenland.

Agnete Steenfelt
Geological Survey of Denmark and Greenland
Øster Voldgade 10
DK 1250 Copenhagen K
ast@geus.dk

References:

Appel, P.W.U., 1994. Stratabound scheelite in altered Archaean komatiites, West Greenland. Mineralium Deposita, 29: 341–352.

Coppard, J., Swatton, S. and Harris, C.J., 1992. Karrat exclusive exploration licence. 1992 year end report, 19 pp. Unpublished report, RTZ Mining and Exploration Ltd.

Journel, A.G. and Huijbregts, C.J., 1978. Mining Geostatistics. Academic Press, London, 600 pp.

Larsen, L.M., 1991. Occurrences of kimberlite, lamproite and ultramafic lamprophyre in Greenland. Open File Series Grønlands Geologiske Undersøgelse, 91/2: 1–36.

Steenfelt, A., 1999. Compilation of data sets for a geochemical atlas of West and South Greenland based on stream sediment surveys 1977 to 1997. Danmarks og Grønlands Geologiske Undersøgelse Rapport, 1999/41: 1–33.

Steenfelt, A., 2000. Geochemical signatures of gold provinces in South Greenland. Transactions of the Institution of Mining and Metallurgy (Section B: Applied earth science), 109: B14–B22.

Steenfelt, A., 2001a. Calibration of stream sediment data from West and South Greenland. A supplement to GEUS Report 1999/41. Danmarks og Grønlands Geologiske Undersøgelse Rapport, 2001/47: 1–43.

Steenfelt, A., 2001b. Geochemical atlas of Greenland - West and South Greenland. Danmarks og Grønlands Geologiske Undersøgelse Rapport, 2001/46: 39 pp., 1 CD-ROM.

Steenfelt, A., Dam, E. and Kyed, J., 1998. Geochemical mapping of the Uummannaq region (70º30' to 72º30'N, 50º to 56º W), central West Greenland. Danmarks og Grønlands Geologiske Undersøgelse Rapport, 1998/40: 25 pp., 41 maps.

Steenfelt, A., Nielsen, T.F.D. and Stendal, H., 2000. Mineral resource potential of South Greenland: review of new digital data sets. Danmarks og Grønlands Geologiske Undersøgelse Rapport 2000/50: 47 pp.

Thomassen, B., 1989. Evaluation of the niobium-tantalum potential of the Motzfeldt Centre, South Greenland. Rapport Grønlands Geologiske Undersøgelse, 145: 66-73.

Geological Survey Updates

continued from Page 17

were expelled during Alleghanian thrust faulting in the southern Appalachians. Arsenic enrichment in stream sediments from the region is linked to arsenic-bearing pyrite that presently resides locally in coal beds and in mine waste material. However, dissolved arsenic in associated stream waters in these coal-bearing areas is not elevated, suggesting that there is presently no reason to believe that human health will be impacted from enrichment of arsenic in northern Alabama (Goldhaber et al., 2001). For more information, contact Marty Goldhaber (mgold@usgs.gov).

A recent concern of national importance is environmental impact of arsenic and mercury distributed in ores, mine wastes, soils, waters, and vegetation surrounding mineral deposits, and geologic environments that contain naturally elevated arsenic and mercury abundances. The USGS has been conducting studies in areas of particular concern including (1) the low-sulfide gold quartz deposits and placers in the Sierra Nevada Foothills, CA, and similar deposits in east-central Alaska; (2) mercury deposits in the CA Coast Range and in the southwest AK mercury mineral belt; (3) Fairbanks, AK, where significant abundances of naturally-occurring As in ground waters have been observed; (4) naturally occurring As in ground waters in New England; (5) areas in the Humboldt basin with locally high As and Hg; and (6) areas outside the U.S. in Surinam and the Philippines that are Hg contaminated.

Fairbanks is the second largest population center in the State of Alaska, and the majority of homes in Fairbanks rely on wells or water storage tanks for their domestic water needs. Geochemical studies by the USGS have included seasonal collection of ground water samples from 17 residential wells. The As concentrations in ground waters range up to about 30 times the current Alaska state drinking water Maximum Contaminant Level (MCL) of 50 μg/l (the MCL will soon be lowered to 10 μg/l). The source of the arsenic is gold-bearing quartz vein deposits in the region; it is contained in sulfide minerals (arsenopyrite, pyrite, and stibnite), or it is remobilized from iron- and manganese-oxides that formed during weathering of these primary sulfide minerals (Mueller et al., 2001). Ongoing studies are designed to better understand how naturally occurring arsenic enters the ground water, and how it can be removed. For more information, contact Seth Mueller (shmuelle@usgs.gov).

Concerns about arsenic-bearing ground water are also the driving force for ongoing USGS studies in New England that involve detailed examination of possible sources and pathways for arsenic in bedrock (Ayuso et al., 2002; Foley et al., 2002). Detailed mineralogical analyses of iron-sulfides and rock samples from the regionally extensive and sulfide-rich Penobscot Formation and mineral deposits from coastal New Hampshire and Maine, coupled with data from drill core, have established a diversity of primary and secondary mineralogical hosts for arsenic. The Pb isotopic and trace element concentrations show that there is a genetic

continued on Page 20

Geological Survey Updates

continued from Page 19

link between arsenic-rich sulfide minerals in sulfidic schists and mineralized samples and secondary oxy-hydroxides presently forming along rock surfaces, joints, crevices, and fractures. Weathering of arsenic-rich and arsenic-poor iron sulfide generates acid and releases metals (e.g., Pb, Cu, As, Co, Ni) that are then sequestered in a number of identified secondary minerals (e.g., ferrihydrite, goethite, scorodite, jarosite, and natrojarosite, rosenite, and melanterite). For more information, contact Robert Ayuso (rayuso@usgs.gov).

Mercury deposits in southwest Alaska occur in a broad belt, primarily along the Kuskokwim River basin. The dominant environmental concern is inorganic mercury in cinnabar ore and elemental mercury remaining at the mines that erodes into streams and rivers (Bailey et al., in press; Gray et al., 2000). Under some conditions, part of this inorganic mercury is converted to organic forms of mercury, which are highly toxic, water and lipid soluble, and capable of bioaccumulation in the food chain. Mercury contents in fish are particularly important because this is the primary pathway of mercury to humans who consume fish. Although sediment, water, soil, and vegetation samples collected from the mines contain highly elevated mercury, all fish collected downstream from the mines contain mercury contents below the 1.0 μg/g safe level recommended by the U.S. Food and Drug Administration. The USGS is presently conducting international studies of mercury mines in Palawan, Philippines (Gray et al., 2001), as well as environmental studies of small-scale Au mining in Suriname where elemental Hg has been used extensively in the recovery of Au (Gray et al., 2002). For more information, contact John Gray (jgray@usgs.gov).

Other

Other studies (nonspecific to particular elements) of the effects of mining and mineral deposits on the environment can be grouped into four primary areas of interest: abandoned mine lands, mine waste characterization, toxic substances hydrology, and geoenvironmental modeling. Specific information can be found at the following web sites: http://mine-drainage.usgs.gov/ or http://minerals.usgs.gov/environment.html.

The USGS conducted the Abandoned Mine Lands (AML) Initiative from 1997 through 2001 to provide technical assistance in support of Federal Land Management Agency (FLMA) actions to remediate contamination associated with abandoned hard rock mining activities. AML has employed a watershed approach, in which contaminated sites are identified based on their effect on the water and ecosystem quality of a targeted watershed. The initiative has been implemented on a pilot scale in the Boulder River basin in southwestern Montana and the Upper Animas River basin in southwestern Colorado. The AML studies have emphasized development and integration of geologic, biologic, hydrologic, and geospatial studies. Some interim results are available in U.S. Geological Survey (2000). Noteworthy results include: (1) studies that integrate hydrologic and biologic data to better understand toxicity of elevated metal concentrations in streams to aquatic biota (Besser et al., 2001); (2) studies to delineate premining conditions (Church et al., 2000); and (3) studies of the effects of natural-acid drainage on the environment (Bove et al., 2000; Mast et al., 2000; Yager et al., 2000). More detailed information can be found at the following website: http://amli.usgs.gov/amli.

The characterization of mine wastes uses a multidisciplinary approach to assemble, develop, and refine methods and tools for characterizing and screening weathered solid-mine wastes. Researchers from a variety of disciplines, including geophysics, geochemistry, geology, mineralogy, remote sensing, and spatial modeling, have worked together at metal mining waste sites to develop an integrated "toolkit" for the rapid screening and characterization of historical mine-waste piles. An overview is available at: http://crustal.usgs.gov/minewaste/. The Coeur d'Alene district in northern Idaho and western Montana is an example of a mining district where historic mining and ore processing methods and periodic flooding of rivers have resulted in the dispersion of metal-enriched sediment at least 240 km downstream of the mining district. USGS studies in the district are specifically designed to understand the distribution, fate, transport, and availability of metals associated with the historic mining activities (Balistrieri et al., 1999; 2000).

Toxic substance studies have been focused within the AML study basins, the Pinal Creek basin in Arizona, and the upper Arkansas River basin in Colorado (http://toxics.usgs.gov). Studies in Pinal Creek have focused on the geochemical evolution of an acidic ground water plume and interactions between shallow ground water and surface water (http://az.water.usgs.gov/pinal/index.html). Tracer injection synoptic sampling techniques have been developed within the upper Arkansas River basin (http://co.water.usgs.gov/toxics/). These techniques have been used to help locate the primary sources of metal loading to streams by surface and ground water. These studies have been conducted in the two AML study basins, the Boulder River Basin in Montana (Nimick and Cleasby, 2001) and the Animas River in Colorado (Kimball et al., in press), as well as in other historic mining areas throughout the western U.S. (Kimball et al., 2001; Ortiz and Bencala, 2001). The data from these studies are also used to calibrate the solute transport models OTIS (One dimensional Transport with Inflow and Storage: Runkel, 1998), and OTEQ (One dimensional Transport with Equilibrium chemistry: Runkel and Kimball, 2002). Once calibrated, the models can be manipulated to simulate the effects of various remediation scenarios on water quality in a stream (Runkel and Kimball, 2002; Walton-Day et al., 2000). One important result from such modeling indicates that remedial plans that remove too much iron from the stream without considering removal of all trace metal sources may result in higher instream trace-metal concentrations following remediation (Runkel and Kimball, 2002). Results such as these emphasize that remediation must consider the integrated response of the

continued on Page 21

Geological Survey Updates

continued from Page 20

stream to changes that might result from remedial actions.

In recent years, the USGS has been involved in the development of geoenvironmental models. The primary objective is to gain a better understanding of the environmental behavior of selected mineral deposit types at deposit-scale to more regional watershed-scales (http://crustal.usgs.gov/projects/gem/). For example, recent work on massive sulfide deposits in the eastern U.S. has shown that variable water chemistry results from Kuroko versus Besshi-type massive sulfide deposits (Seal et al., 2001). Water from massive sulfide deposits can have extreme acidity and metal concentrations. In fact, studies of the Iron Mountain site in California led to the development of methods to measure and document negative pH values (Nordstrom et al., 2000; web site: http://ca.water.usgs.gov/acid/).

In summary, the USGS is involved in conducting geochemical studies at a variety of spatial scales with objectives ranging from accumulation of baseline data to ore deposit genesis to environmental remediation. This overview summarizes some of the highlights from selected studies. Additional information on these and other studies may be obtained through the references, individuals, and websites listed herein.

References

Ayuso, R., Foley, N., Ayotte, J., Lyon, A., Burns, J., Marvinney, R., Reeve, A., and Robinson, G., 2002, Pb isotopes, arsenic sources and enrichment pathways linking sulfides from mines and unmineralized rocks to secondary iron oxides, coastal New England: Arsenic in New England: A multidisciplinary scientific conference (May 28-31, 2002), Manchester, New Hampshire.

Bailey, E.A., Gray, J.E., and Theodorakos, P.M., in press, Mercury in vegetation and soils at abandoned mercury mines in southwestern Alaska, USA: *Geochemistry: Exploration, Environment, and Analysis.*

Balistrieri, Laurie S., Box, Stephen E., Bookstrom, Arthur A., Ikramuddin, Mohammed, 1999, Assessing the influence of reacting pyrite and carbonate minerals on the geochemistry of drainage in the Coeur d'Alene mining district: Environmental Science and Technology, v. 33, p. 3347-3353.

Balistrieri, Laurie S., Box, Stephen E., Ikramuddin, Mohammed, Horowitz, Arthur J., and Elrick, Kent A., 2000, A study of porewater in water saturated sediments of levee banks and marshes in the lower Coeur d'Alene River valley, Idaho: sampling, analytical methods, and results, http://geopubs.wr.usgs.gov/open-file/of00-126/.

Besser, J.M., Brumbaugh, W.G., May, T.W., Church, S.E., and Kimball, B.A., 2001, Bioavailability of metals in stream food webs and hazards to brook trout (Salvelinus fontinalis) in the Upper Animas River Watershed, Colorado: Archive of Environmental Contamination and Toxicology, v. 40, p. 48-59.

Bove, D.J., Mast, M.A., Wright, W.G., Verplanck, P.L., Meeker, G.P., and Yager, D.B., 2000, Geologic control on acidic and metal-rich waters in the southeast Red Mountains area, near Silverton, Colorado: Proceedings from the Fifth International Conference on Acid Rock Drainage, Denver, Colorado, May 21-24, 2000: Littleton, Colorado, Society for Mining, Metallurgy, and Exploration, p. 523-533.

Church, S.E., Fey, D.L., and Blair, R., 2000, Pre-mining bed sediment geochemical baseline in the Animas River watershed, southwestern Colorado: Proceedings from the Fifth International Conference on Acid Rock Drainage, Denver, Colorado, May 21-24, 2000: Littleton, Colorado, Society for Mining, Metallurgy, and Exploration, p. 499-512.

Eppinger, R.G., Briggs, P.H., Brown, Z.A., Crock, J.G., Meier, A.L. Theodorakos, P.M., and Wilson, S.A., 2001, Baseline geochemical data for stream sediment and surface water samples from Panther Creek, the Middle Fork of the Salmon River, and the Main Salmon River from North Fork to Corn Creek, collected prior to the severe wildfires of 2000 in central Idaho: U.S. Geological Survey Open-File Report 01-0161, http://pubs.usgs.gov/openfile/of01-0161/.

Foley, N., Ayuso, R., Ayotte, J., Marvinney, R., Reeve, A., and Robinson, G., 2002, Mineralogical pathways for arsenic in weathering meta-shales: An analysis of regional and site studies in the Northern Appalachians: Arsenic in New England: A multidisciplinary scientific conference (May 28-31, 2002), Manchester New Hampshire.

Goldfarb, R.J., Hart, C.J.R., Miller, M.L., Miller, L.D., Farmer, G.L., and Groves, D.I., 2000, The Tintina gold belt—A global perspective: in The Tintina Gold Belt—Concepts, Exploration, and Discoveries, British Columbia and Yukon Chamber of Mines, Special Volume 2, p. 5-34.

Goldfarb, R.J., Groves, D.I., and Gardoll, S., 2001a, Orogenic gold and geologic time: A global synthesis: *Ore Geology Reviews*, v. 18, p. 1-75.

Goldfarb, R.J., Zhou, T., Garwin, S.L., Mao, J., and Qiu, Y., 2001b, Precambrian cratons and Phanerozoic orogens—Gold metallogeny of China: in Piestrzynski et al. (editors), Mineral Deposits at the Beginning of the 21st Century, A.A. Balkema, Lisse, p. 743-746.

Goldhaber, M.B., Bigelow, R.C., Hatch, J.R., and Pashin, J.C., 2000, Distribution of a suite of elements including arsenic and mercury in Alabama coal: U.S. Geological Survey Miscellaneous Field Studies Map MF-2333, http://geology.cr.usgs.gov/pub/mf-maps/mf-2333/

Goldhaber, M.B., Irwin, E., Atkins, B., Lee, L., Black D.D., Zappia, H., Hatch, J. Pashin, J., Barwick, L.H., Cartwright, W.E., Sanzalone, R., Ruppert, L., Kolker, A., and Finkleman, R., 2001, Arsenic in stream sediments of northern Alabama: U.S. Geological Survey Miscellaneous Field Studies Map MF-2357, http://geology.cr.usgs.gov/pub/mf-maps/mf-2357/

Gray, J.E., Theodorakos, P.M., Bailey, E.A., and Turner, R.R., 2000, Distribution, speciation, and transport of mercury in stream sediment, stream water, and fish collected near abandoned mercury mines in southwestern Alaska, USA: *Science of the Total Environment*, v. 260, p. 21-33.

Gray, J.E., Bustos, D.M., Greaves, I.A., and Krabbenhoft, D.P., 2001, Evaluation of mercury contamination at the Palawan Quicksilver Mine, Palawan, Philippines, [abs.]: *in*, 6th International Conference on Mercury as a Global Pollutant, Minamata, Japan, October 15-19, 2001, p.219.

Gray, J.E.; Weaver, J.N., and Labson, V.F., 2002, Mercury contamination from small-scale artisanal gold mines in the Brownsweg area, Suriname, [abs.]: *in*, U.S. Environmental Protection Agency Hardrock Mining Conference 2002, May 7-9, www.epa.gov/ttbnrmrl

Hammarstrom, J.M., Eppinger, R.G., Van Gosen, B.S., Briggs, P.H., and Meier, A.L., 2002, Case study of the environmen-

continued on Page 22

Geological Survey Updates

continued from Page 21

tal signature of a recently abandoned, carbonate-hosted replacement deposit: The Clayton Mine, Idaho: U.S. Geological Survey Open-File Report 02-010, http://pubs.usgs.gov/openfile/of02-010/.

Hart, C.J.R., McCoy, D., Goldfarb, R.J., Smith, M., Roberts, P., Hulstein, R., Bakke, A.A., and Bundtzen, T.K., 2002, Geology, exploration and discovery in the Tintina gold province, Alaska and Yukon: *in* Goldfarb, R.J. and Nielsen, R. (editors), Integrated methods for Discovery: Global exploration in the Twenty-First Century: Society of Economic Geology Special Publication 9, p. 241-274.

Hofstra, A.H. and Cline, J.S., 2000, Characteristics and models for Carlin-type gold deposits, Chapter 5: *in* Hagemann, S. G. and Brown, P.E., eds., Gold in 2000, Reviews in *Economic Geology*, v. 13, p. 163-220.

Kelley, K.D., Leach, D.L. Slack, J.F., Anderson, V.M., Clark, J.L., Ayuso, R.A., and Ridley, W.I., 2001, Evolution of trace element compositions in sphalerite and pyrite through time in the Zn-Pb-Ag shale-hosted Red Dog deposits, western Brooks Range, Alaska [abs]: *Geological Society of America Abstracts with Programs*, v. 33, p. A-272.

Kimball, B.A., Runkel, R.L., and Gerner, L.J., 2001, Quantification of mine-drainage inflows to Little Cottonwood Creek, Utah, using a tracer-injection and synoptic-sampling study: Environmental Geology, v. 40, p. 1390-1404.

Kimball, B.A., Runkel, R.L., Walton-Day, K., and Bencala, .E., in press, Assessment of metal loads in watershed affected by acid mine drainage by using tracer injection and synoptic sampling: Cement Creek, Colorado, USA: Applied Geochemistry..

Leach, D.L., Bradley, D., Lewchuk, M.T., Symons, D.T.A., de Marsily, G., and Brannon, J., 2001, Mississippi Valley-type lead-zinc deposits through geologic time: Implications from recent age-dating research: *Mineralium Deposita*, v. 36, p. 711-740.

Mair, J.L., Hart, C.J.R., Goldfarb, R.J., O'Dea, M., and Harris, S., 2000, Geology and metallogenic signature of gold occurrences at Scheelite Dome, Tombstone gold belt, Yukon Territory, in Emond, D.S. and Weston, L.H., eds., Yukon Exploration and Geology, 1999, Exploration and Geological Services Division, Yukon Indian and Northern Affairs Canada, p. 165-176.

Mast, M.A., Verplanck, P.L., Yager, D.B., Wright, W.G., and Bove, D.J., 2000, Natural sources of metals to surface waters in the upper Animas River watershed, Colorado: Proceedings from the Fifth International Conference on Acid Rock Drainage, Denver, Colorado, May 21-24, 2000: Littleton, Colorado, Society for Mining, Metallurgy, and Exploration, p. 513-522.

Mueller, S., Goldfarb, R.J., and Verplanck, P., 2001, Ground-water studies in Fairbanks, Alaska – A better understanding of some of the United States' highest natural arsenic concentrations: U.S. Geological Survey Fact Sheet FS-111-01.

Nash, J.T., 2000, Hydrogeochemical data for historic mining areas, Humboldt watershed and adjacent areas, northern Nevada, U.S. Geological Survey Open-File Report 00-0459.

Nash, J.T., 2001, Hydrogeochemical investigations of some historic mining areas in the western Humboldt River basin, Nevada, U. S. Geological Survey Digital Data Series, Report: DDS-0070.

Nimick, D.A., and Cleasby, T.E., 2001, Quantification of metal loads by tracer injection and synoptic sampling in Daisy Creek and the Stillwater River, Park County, Montana, August 1999: U.S. Geological Survey Water-Resources Investigations Report 00-4261, 51 p.

Nordstrom, D.K., Alpers, C.N., Ptacek, C.J., and Blowes, D.W., 2000, Negative pH and extremely acidic mine waters from Iron Mountain, California: Environmental Science and Technology, v. 34, p. 254-258.

Ortiz, R.F., and Bencala, K.E., 2001, Determination of instream metal loads using tracer-injection and synoptic-sampling techniques in Wightman Fork, southwestern Colorado, September 1997: U.S. Geological Survey Water-Resources Investigations Report 00-4154, 26 p.

Runkel, R.L., 1998, One dimensional transport with inflow and storage (OTIS)—A solute transport model for streams and rivers: U.S. Geological Survey Water-Resources Investigations Report 98-4018, 73 p.

Runkel, R.L., and Kimball, B.A., 2002, Evaluating remedial alternatives for an acid mine drainage stream—Application of a reactive transport model: Environmental Science and Technology, v. 36, no. 5, p. 1093-1101.

Seal, RR, II, Hammarstrom, JM, and Meier, A.L, 2001, Geochemical controls on drainage from massive sulfide mines in the eastern USA: Proceedings of the 10th International Symposium on Water-Rock Interaction (WRI10), R. Cidu (ed.), AA Balkema Publishers (Lisse, The Netherlands), v. 2, p. 1273-1276.

Slack, J.F., Kelley, K.D., Anderson, V.M., Clark, J.L., and Ayuso, R.A., 2001, Geochemistry of silicified rocks in the Red Dog Zn-Pb-Ag district, western Brooks Range, Alaska: Evidence for multistage diagenetic and hydrothermal fluid flow and fluid-rock interactions [abs]: *Geological Society of America Abstracts with Programs*, v. 33, p. A-272.

U.S. Geological Survey, 2000, Interim report on the scientific investigations in the Animas River watershed, Colorado to facilitate remediation decisions by the U.S. Bureau of Land Management and the U.S. Forest Service, March 29, 2000 Meeting, Denver, Colo.: U.S. Geological Survey Open-File Report 00-0245, 36 p.

continued on Page 23

Geological Survey Updates

continued from Page 22

Van Gosen, B.S., Eppinger, R.G., Hammarstrom, J.M., Briggs, P.H., Crock, J.G., Gent, C., Meier, A.L., Sutley, S.J., and Theodorakos, P.M., 2000, Analytical Data for Reconnaissance Geochemical Samples from Mine Dumps, Stream Sediments, and Waters at the Thompson Creek Tungsten Mine, Custer County, Idaho: U.S. Geological Survey Open-File Report 00-0239. available at the following URL: http://geology.cr.usgs.gov/pub/open-file-reports/ofr-00-0239/.

Walton-Day, K., Runkel, R.L., Kimball, B.A., and Bencala, K.E., 2000, Application of the solute-transport models OTIS and OTEQ and implications for remediation in a watershed affected by acid mine drainage, Cement Creek, Animas River basin, Colorado, in Proceedings from the Fifth International Conference on Acid Rock Drainage, Denver, Colorado, May 21-24, 2000: Littleton, Colorado, Society for Mining, Metallurgy, and Exploration, p. 389-399.

Yager, D.B., Mast, M.A., Verplanck, P.L., Bove, D.J., Wright, W.G., and Hagemen, P.L., 2000, Natural versus Mining-related water quality degradation to tributaries draining Mount Moly, Silverton, Colorado: Proceedings from the Fifth International Conference on Acid Rock Drainage, Denver, Colorado, May 21-24, 2000: Littleton, Colorado, Society for Mining, Metallurgy, and Exploration, p. 535-547.

Zhou, T., Goldfarb, R.J., and Phillips, G.N., 2002, Tectonics and distribution of gold deposits in China—An overview: *Mineralium Deposita*, v. 37, p. 249-282.

Karen Duttweiler Kelley
Robert G. Eppinger
Katherine Walton-Day
U.S. Geological Survey
Box 25046 MS964
Denver, CO 80225
(303) 236-2467 (ph)
(303) 236-1425 (fax)
kdkelley@usgs.gov (email)
eppinger@usgs.gov
kwaltond@usgs.gov

Geochemical activities at the Geological Survey of Sweden (SGU)

The geochemical mapping activities at SGU have concentrated since 1982 on two different types of media, aquatic vegetation (biogeochemistry) and till (also bedrock geochemistry has been carried out). The aquatic vegetation reflects a combination of natural concentrations in soils and anthropogenic pollution. Till that was formed as a result of the inland ice is, on the other hand, generally uninfluenced by anthropogenic emissions. Analyses of this till are therefore important in order to be able to distinguish between the natural and the anthropogenic load on waterways.

Biogeochemical mapping.

SGU started an innovative monitoring of metals in a monitoring/mapping programme in 1980 (before 1980 traditional inorganic stream sediments were used, a method still used all over the world; however not really perfect for environmental geochemistry). A new method is used, whereby metal concentrations are determined in organic material consisting of aquatic mosses and roots of aquatic higher plants (biogeochemistry). These are barrier-free with respect to trace metal uptake and reflect the metal concentrations in stream water. The roots and mosses respond closely to chemical variations in background levels related to different bedrock types in addition to effects of pollution. These biogeochemical samples provide information on the time-related bioavailable metal contents in aquatic plants and in the environment. One great advantage of using biogeochemical samples instead of water samples is also that the biogeochemical samples provide integrated information of the metal contents in the water for a period of some years. The mapping programme now covers about 65% of the land area of Sweden (40,000 sample sites, one sample every 6-7 km2), where about 80% of the population of Sweden is living. This means that there is now available an extensive analytical data base for use in environmental and medical research.

Soil geochemical mapping.

Since 1982, SGU has also been conducting a country-wide sampling and analysis of the fine fraction in till. This fraction consists of particles that are less than 0.06 mm in diameter, i.e., fine sand-silt-clay. The ongoing soil geochemical sampling programme at SGU today includes more than 26,000 samples of till (one sample every 6-7 km2), thus offering good opportunities to investigate the regional, natural variations in concentrations for several metals and other elements in the fine fraction of the till. Samples are also analysed with regard to pH and buffering capacity. A representative selection of the till samples is also analysed on the <2.0 mm fraction. Other sediments than till (i.e. clay) were included in the soil geochemical mapping programme 1999. These are also analysed on the <2.0 mm fraction.

There is also a till geochemical database compiled by NSG in the early 1990's. This contains over 12 000 samples collected and analysed for mineral exploration purposes.

Mineral exploration.

The above described methods are not only used for environmental geochemistry. The data are also widely used by and sold to international mining exploration companies working in Sweden for exploration purposes.

Urban geochemistry is an increasingly growing topic. A large urban environmental geochemical project has been carried out in the city of Gothenburg, including sampling of surface soils, deeper soils, different biogeochemical sample types and water samples. The project has been carried out in very close cooperation with the city council and the decision makers. Information on heavy metals, organic compounds, and natural background values in different compartments have been shown. Similar investigations will be undertaken also in other urban areas.

Background values.

The geochemical data are also increasingly used in establishing natural background values for planning purposes and environmental activities. This is a growing field for geochemistry. We have close contacts with the Environmental Protection Agency of Sweden, the National Chemical Inspectorate, city planners, municipalities, decision makers etc.

continued on Page 24

Geological Survey Updates

continued from Page 23

Contaminated soils.

This is a rapidly growing field for geochemistry. The government has prioritised the surveying and cleaning up of contaminated grounds all over Sweden (e.g. mining areas, industrial sites etc.). Geochemical expertise is needed for this work. The Geological Survey of Sweden is very much involved in this work.

Medical geology (previously geomedicine) is an emerging international issue and is defined as the science dealing with the relationship between natural geological factors and health problems in man and animals. Several initiatives have been taken by SGU in this field. Three international projects are headed by Olle Selinus:

1. The International Working Group on Medical Geology. http://home.swipnet.se/medicalgeology This is an IUGS working group under the IUGS commission COGEOENVIRONMENT. The working group has more than 200 participants from more than 50 countries. Biannual newsletters are published. A new book: Medical geology is on its way (Academic Press) with more than 50 well known international authors (medics and geoscientists).
2. IGCP project #454 sponsored by UNESCO and IUGS.
3. A medical geology project sponsored by International Council of Scientific Unions (ICSU)

In addition to this, short courses are held regularly all over the world on metals and health. These courses are a cooperation between the international working group on medical geology (led by SGU), USGS in Reston and US Armed Forces of Pathology (AFIP), Washington DC. A new Medical Geology Registry is also under establishment at the AFIP.

Olle Selinus, *head of geochemical division*
Olle.Selinus@sgu.se

Till geochemistry and indicator mineral research activities

Compiled by M.B. McClenaghan
Geological Survey of Canada

Base metal exploration

GSC recently conducted regional-scale till sampling in southeastern Yukon over the upper Paleozoic Yukon Tanana Terrane which hosts the Finlayson Lake massive sulphide district (e.g. Wolverine, Kudz Ze Kayah) to define exploration targets in areas with minimal bedrock outcrop. Highlights of the survey include: 1) identification of a Pb-Zn-Ag-Au glacial dispersal train extending 500 m to 1.5 km north (down-ice) from the Kudz Ze Kayah Zn-Pb-Cu deposit; 2) elevated Au, Hg, Ag, Sb, and As concentrations in the <0.063 mm fraction of till suggesting the presence of epithermal mineralization in the Weasel Lake area; and, 3) elevated Au concentrations in till near Mississipian granite indicating the potential presence of intrusion-related gold mineralization in the region. Till geochemistry data and bedrock geology maps are now available on CD-ROM (Bond et al., 2002). Analyses on different size fractions of till and testing of selective leach methods on soils developed on till are being conducted on samples collected near known mineralization to characterize the surficial geochemical signature of volcanogenic massive sulphides. For more information about this project, contact Jeff Bond or Alain Plouffe at: jeff.bond@yk.gc.ca or aplouffe@nrcan.gc.ca.

Recent publications from this project include:

Bond, J. D., Murphy, D. C., Colpron, M., Gordey, S. P., Plouffe, A., Roots, C. F., Lipovsky, P. S., Stronghill, G. and Abbott, J. G. 2002. Finlayson Lake Targeted Geoscience Initiative - Digital Compilation of Bedrock Geology and Till Geochemistry, northern Finlayson Lake Map Area, Southeastern Yukon (105G), Geological Survey of Canada Open File 4243 & Exploration and Geological Services Division Dept. Indian Affairs and Northern Development, Open File 2002-7D.

Gold exploration

Surficial geological studies are being conducted in the Archean Yellowknife Greenstone Belt, Northwest Territories as part of the GSC's Yellowknife EXTECH III program. These activities will provide baseline data on ice flow history, and evaluations of till geochemistry, visible gold grain counting, and biogeochemistry as exploration techniques in this region. Till geochemistry, a common exploration method in glaciated terrain, may not be as effective in the Yellowknife belt as counting gold grains in till. Gold grains in the heavy mineral fraction of till indicate that background values over granitic rocks are approximately 0-1 grains per 10 kg till sample, and up to 5 grains over volcanic and some metasedimentary rocks. In the vicinity of some past-producing gold mines, till contains significant concentrations of gold grains (20-30). Biogeochemistry has the potential to differentiate between anthropogenic and natural sources of Au in vegetation. Near the Con gold mine for example, Labrador tea contains approximately 12000 ppb Au, and humus, 3000 ppm As, likely due to airborne particulates from the nearby roaster. For more information about this project, contact: Dan Kerr dkerr@nrcan.gc.ca.

Recent publications from this project include:

Kerr, D. 2001. Till geochemistry, Yellowknife area, Northwest Territories, GSC Open File D4019.

Dunn, C.E., Kerr, D., and Nickerson, D. 2002. Comparisons of biogeochemical data from different sample preparation methods, Giant mine area, Yellowknife, Northwest Territories; GSC, Open File 4125.

Studies in Nunavut

Till geochemistry and surficial geology mapping in Nunavut by the GSC has been focused in four areas of proven or potential mineralization. The main objective of these studies is to provide a Quaternary geology framework for drift prospecting. The areas include:

1) The Meliadine Trend, near Rankin Inlet, where major gold occurrences hosted by rocks of the Archean Rankin Inlet greenstone belt have recently been discovered. The mineralization is hosted in the oxide facies of iron formation occurring within the Rankin Inlet Group along the Meliadine Trend, a regionally pervasive structural zone. Because a large part of this highly prospective area is covered by a thick blanket of glacial sediments, the study was directed at determining the geochemical and mineralogi-

continued on Page 25

Geological Survey Updates

continued from Page 24

cal signature (including partitioning studies) of the known gold occurrences in the glacial sediments and developing a glacial dispersal model for the area.

2) The MacQuoid-Gibson greenstone belt, which is prospective for gold and base metal deposits. Prospecting in the western extension of this belt is hampered by a thick cover of glacial drift formed by the dispersal of debris derived from easily weathered Proterozoic rocks of the Dubawnt Supergroup, which outcrop to the west and northwest. These exotic Dubawnt-derived sediments tend to mask the geochemical signature of the underlying granite/greenstone terrane. Consequently, the study is designed to determine methods for interpreting subtle changes in till geochemistry that are related to the Archean greenstone terrane and potential mineralization.
3) Central Baffin Island, where surficial geology studies involve drift prospecting for gold, PGE, diamonds, and base metals. The study is focused on the Proterozoic metasedimentary sequence within the Foxe Fold Belt and the older Archean terrane. Till geochemical data are being correlated with bedrock geology and lake sediment geochemical data for the region. Radiometric analyses of till samples have also been completed.
4) The Committee Bay area, where a till geochemical survey by the GSC is a joint project with Canada-Nunavut Geoscience Office. The area is underlain primarily by Archean rocks of the Committee Bay greenstone belt, which is composed of Prince Albert Group supracrustal rocks, and is prospective for Au, Ni-PGE and base metal deposits. The mineralogical and geochemical composition of till will be examined using both orientation studies and a regional perspective.

For more information about these projects, contact: Isabelle McMartin imcmarti@nrcan.gc.ca, Penny Henderson pehender@nrcan.gc.ca, Ted Little elittle@nrcan.gc.ca, or Lynda Dredge ldredge@nrcan.gc.ca.

Recent publications include:

Dredge, L.A. 2002. Surficial material, central Baffin Island. In GSC Current Research 2002 - C20.

Henderson, P.J. 2000. Drift composition and surficial geology, MacQuoid Lake area (NTS 55M/7 and 55M/10), Kivalliq region, Nunavut: a guide to drift prospecting. GSC Open File 3944.

Little, E.C., Ferbey, T., McMartin, I., Ozyer, C.A., and Utting, D.J. 2002. An Overview of Quaternary Research for the Committee Bay Project, Central Nunavut. In GSC Current Research 2002-C13.

McMartin, I. 2000. Till composition across the Meliadine Trend, Rankin Inlet area, Kivalliq Region, Nunavut, GSC Open File 3747.

McMartin, I. and Henderson, P.J. 1999. A relative ice flow chronology for the Keewatin Sector of the Laurentide Ice Sheet, Northwest Territories (Kivalliq region, Nunavut. In GSC Current Research 1999-C, 129-138.

McMartin, I. Little. E., Ferbey, T., Ozyer, C. and Utting, U. in press. Drift prospecting across the Committee Bay greenstone belt, central mainland Nunavut (NTS 56K, 56J-north and 56O-south); Geological Survey of Canada Open File 4277.

Diamond exploration

GSC is continuing its glacial dispersal studies in the Kirkland Lake-Lake Timiskaming kimberlite fields of northeastern Ontario. Most recently, trenches were excavated into two kimberlites to reveal a striated kimberlite surface and to collect till samples to document both indicator mineral and till geochemical glacial dispersal patterns. Kimberlite boulders from local ('down-ice') gravel pits were also collected to determine the source of the boulders in the eskers. A significant highlight of the project has been the GSC's discovery of a new kimberlite within the Lake Timiskaming kimberlite cluster. GSC studies of this new kimberlite, as well as several other known kimberlites, include indicator mineralogy, geochemistry, petrography, and age dating. Groundwater and selective leach soil geochemical studies will be conducted over some of the kimberlites in the summer of 2002.

A reconaissance-scale till geochemical and kimberlite indicator mineral survey conducted by GSC south of the Lake Timiskaming kimberlite cluster has provided information on the distribution and extent of glacial dispersal of kimberlite indicator minerals from the known kimberlites, and identified new indicator mineral anomalies in till not related to the known kimberlites. These GSC till data complement kimberlite indicator mineral data for stream sediments collected in the same region by the Ontario Geological Survey. For more information about this project, contact: Beth McClenaghan bmcclena@nrcan.gc.ca.

GSC is also continuing kimberlite glacial dispersal studies in the Lac de Gras area where detection of new kimberlites is proving more and more difficult in areas covered by thick glacial sediments that contain few kimberlite indicator minerals. Ongoing research is focussing on surficial geology and the spectral reflectance characteristics of kimberlite, till and bedrock for kimberlite exploration in the Diavik Mine area. For more information about this project, contact: Dan Kerr dkerr@nrcan.gc.ca.

Recent publications from these projects include:

McClenaghan, M.B., Kjarsgaard, I.M. and Kjarsgaard B.A. 2001. Reconnaissance-scale till survey in the New Liskeard-Temagami-region, Ontario: kimberlite indicator mineral and geochemistry; Geological Survey of Canada, Open File 4086.

McClenaghan, M.B., Ward, B.C., Kjarsgaard, B.A., Kjarsgaard, I.M., Stirling, J.A.R., Dredge, L. and Kerr, D. 2000. Mineralogy and geochemistry of the Ranch Lake kimberlite and associated glacial sediments, Lac de Gras region, NWT. Geological Survey of Canada, Open File D3924.

McClenaghan, M.B., Kjarsgaard B.A., and Kjarsgaard, I.M. 2002. Kimberlite indicator mineral content and geochemistry of till around the Peddie kimberlite, Lake Timiskaming, Ontario; Geological Survey of Canada, Open File 4262.

Kerr, D., Budkewitsch, P., Bryan, D., Knight, R., and Kjarsgaard, B. 2002. Surficial geology, spectral-reflectance characteristics, and their influence on hyperspectral imaging as a drift-prospecting technique for kimberlite in the Diavik diamond mine area, Northwest Territories; GSC, Current Research 2002-C4.

continued on Page 26

Geological Survey Updates

continued from Page 25

Weathering and soil formation

Ongoing research, carried out as part of the GSC's Metals In The Environment Program (MITE) and earlier Federal-Provincial mineral development agreements, has focussed on drift prospecting in glaciated terrain and on the effects of weathering and soil-forming processes on soil geochemistry. Exploration-related work includes interpretations of till geochemical data in terms of the physical processes associated with glacial erosion, transport, and deposition. It has resulted in geochemical models for glacial dispersal trains in Labrador, Nunavut, and Newfoundland, and it has identified the main geological factors affecting their formation. Through more detailed studies of environmental geochemistry, it has provided a mineralogical basis for the interpretation of geochemical data, and has identified the effects of secondary processes on the form, concentration, and distribution of trace elements in soil profiles. In till collected as part of regional geochemical surveys and in soils developed on till, Mg-bearing phyllosilicates have been shown as the principal host minerals for some trace metals (e.g. Cu, Ni, Cr). For more information, contact: Rod Klassen klassen@nrcan.gc.ca.

Recent publications from this work include:

Klassen, R.A. 1999. The application of glacial dispersal models to till geochemistry in Labrador, Canada. Journal of Geochemical Exploration, v. 67, p. 245-269.

Klassen, R.A. 2001. The interpretation of background variation in regional geochemical surveys - an example from Nunavut, Canada. Geochemistry: Exploration, Environment, Analysis, v. 1, p. 163-173.

Klassen, R.A. 2001. A Quaternary geological perspective for geochemical exploration in glaciated terrain. In: M. B. McClenaghan, P.T. Bobrowsky, G.E.M. Hall and S.J. Cook (Editors), Drift Exploration in Glaciated Terrain. Special Publication 185. Geological Society of London, p. 1-17.

Accessing digital geochemical information

The search for government geochemical information can be difficult at the best of times. Thanks to Internet technology, users are able to discover a variety of data over the web that can accelerate their access to important information. The challenge now faced by users is the amount and quality of information that is available through the Internet and the number of different web sites supposedly providing relevant information.

Geochemistry On Line is a 'one stop' Internet access initiative of the National Geological Surveys Committee (NGSC) in Canada. Through the support of the Canadian Geoscience Knowledge Network (CGKN) this project has developed a supporting infrastructure to ensure information quality and accessibility. Currently, the web site features 'real time' data from provincial agencies (Saskatchewan, Manitoba and Nova Scotia) and the Geological Survey of Canada. A stepwise interface allows the user to build an up-to-date snap shot map of the collected and analysed geochemical data for a specific area of interest. Development of this initiative continues. With more provincial and territorial agencies intending to collaborate on this initiative, the information available through this single access window will grow. Users will be able to query a single data source for their geochemistry needs, confident in the quality and consistency of information, rather than using a 'shot gun' approach to data discovery. Additionally, industry and other groups are showing a strong interest in the development of such a research tool.

Check out the Potential: http://Geochemia.cgkn.net
For more information about these data and services contact:
Guy Buller gbuller@nrcan.gc.ca
or Andy Moore amoore@nrcan.gc.ca

M. Beth McClenaghan
Terrain Sciences Division
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario
CANADA K1A 0E8
Phone: (613) 992-7805 Fax: (613) 992-0190
Email: bmcclena@nrcan.gc.ca
Web site: http://sts.gsc.nrcan.gc.ca/

Call for Abstracts

GSA Denver October 27-30, 2002, Technical Session 14

Integrated Studies of the Effects of Abandoned Mines on the Environment

Integrated studies of the historical effects of abandoned mines on the environment are necessary to develop a comprehensive scope of the problem, and are useful to help plan successful remediation of mine and mineral processing sites. Integrated multidisciplinary studies examining effects of mining and mineral deposits on the chemistry of surface water, ground water, and biosystems are most well suited to form a holistic view of their cumulative environmental impact. We invite presentations of integrated studies (including any combination of the following disciplines: geology, geophysics, aqueous geochemistry, biology, remote sensing) documenting the effect of historical mining at a watershed scale so that new approaches can be shared with the larger scientific audience.

To be included in this technical session, you must indicate T14. Integrated Studies of the Effects of Abandoned Mines on the Environment when you submit your volunteered abstract to GSA. Please see the abstract submission information at http://www.geosociety.org . **THE DEADLINE FOR ABSTRACT SUBMISSION IS JULY 16, 2002.** Please note that everyone is allowed only one volunteered abstract as speaker. You can co-author but not be speaker for additional volunteered abstracts.

Convenors:

Stan Church, U.S. Geological Survey,
schurch@usgs.gov
Joe Donovan, West Virginia University,
donovan@geo.wvu.edu
David Nimick, U.S. Geological Survey,
dnimick@usgs.gov
Mary Stoertz, Ohio University, stoertz@ohio.edu
Katie Walton-Day, U.S. Geological Survey,
kwaltond@usgs.gov

CALENDAR OF EVENTS

International, national, and regional meetings of interest to colleagues working in exploration, environmental and other areas of applied geochemistry.

■July 14-August 2, 2002, 9th International Platinum Symposium and Field Conference, Bozeman, Montana. Organizers: IGCP (International Geological Correlation Programme) 427, Society for Geology Applied to Mineral Deposits. Information: Roger Cooper, (409) 880-8239, fax 409-880-8246.

■July 21-25, 2002, 9th International Platinum Symposium, Holiday Inn - Grand Montana, Billings, MT, USA , by the IGCP427/ SEG/SGA. (Roger Cooper, Dept. of Geology, Lamar University,P.O. Box 10031, Beaumont, TX 77710, Phone: 409-880-8239 EMail: cooperrw@hal.lamar.edu Web: http://www.platinumsymposium.org)

■July 22-27, 2002, The Earth System and Metallogenesis: A Focus on Africa, Windhoek, Namibia , by The Geological Society of Namibia, The Geological Society of South Africa, and The Geological Society of Zambia. (The Secretary, IAGOD/ GEOCONGRESS 2002, P.O. Box 44283, Linden 2104, South Africa, EMail: gssa@pop.onwe.co.za Web: http://www.gssa.org.za)

■Aug 31-Sep 04, 2002, Emerging Concepts in Organic Petrology and Geochemistry, The Banff Centre, Banff, Alberta, Canada , by the Canadian Society for Coal Science and Organic Petrology (CSCOP) & The Society for Organic Petrology (TSOP). (Dr. Martin Fowler, Geological Survey of Canada, 3303-33rd St. NW, Calgary, Alberta T2L 2A7 Canada, Phone: 403-292-7038 FAX: 403-292-7159 EMail: Mfowler@nrcan.gc.ca Web: http://www.cscop-tsop2002.com)

■September 1-4, 2002, AusIMM 2002 - 150 Years of Mining, Auckland, New Zealand. Technical and poster sessions on Geoscience, Mining, Metallurgy, Environment and General topics. Field trips to geothermal systems, and epithermal and orogenic lode gold deposits. Details and registration form available on website http://www.ausimm.co.nz EMail: conference2002@ausimm.co.nz

■October 27-30, 2002, Annual Meeting of the Geological Society of America, Denver, Colorado. INFORMATION: TEL 1-800-472-1988, meetings@geosociety.org.

■November 20-23, Role of Natural Resources and Environment for Sustainable Development in South and Southeast Asia (NESDA), Dhaka, Bangladesh. Information: Afia Akhtar, Geological Survey of Bangladesh, 153 Pioneer Road, Segunbagicha, Dhaka 1000, Bangladesh, 880-2-418545.

■December 14-19, Geochemistry of Crustal Fluids: The Role and Fate of Trace Elements in Crustal Fluids, Seefeld in Tirol, Austria. Information: European Science Foundation, EURESCO Office, 1 quai Lezay-Marnésia, 67080 Strasbourg Cedex, France.

■February 24-26, 2003, Society for Mining, Metallurgy, and Exploration (SME) annual meeting, Cincinnati, OH. INFORMATION: SME (sme@smenet.org). SME, Meetings Dept., P.O. Box 277002, Littleton, CO 80127, 800-763-3132. SME (sme@smenet.org)

continued on Page 28

THE ASSOCIATION OF EXPLORATION GEOCHEMISTS

P.O. Box 26099, 72 Robertson Road, Nepean, Ontario K2H 9R0 CANADA • Telephone (613) 828-0199

OFFICERS

January - December 2002

Philippe Freyssinet, *President*
BRGM
BP6009
Orleans, France 45060
TEL: +33 238 64 3005
FAX: +33 238 64 3652
email: p.freyssinet@brgm.fr

Stephen D. Amor, *Vice President*
1235 Fairview Street, Suite 353
Burlington, Ontario
Canada L7S 2K9
TEL: +1 905 308 9514
FAX: +1 905 308 9414
email: SteveAmor@compuserve.com

David B. Smith, *Secretary*
U.S. Geological Survey
Box 25046, MS 973
Denver, CO 80225
USA
TEL: (303) 236-1849
FAX: (303) 236-3200
email: dsmith@helios.cr.usgs.gov

Gwendy E.M. Hall, *Treasurer*
Geological Survey of Canada
601 Booth Street, Room 702
Ottawa, ON K1A 0E8
CANADA
TEL: (613) 992-6425
FAX: (613) 996-3726
email: ghall@gsc.nrcan.gc.ca

COUNCILLORS

Councilor Emeritus
Sherman Marsh

2001-2002
Paul Taufen *(ex-officio)*
Robert J. Bowell
Mary E. Doherty
Dave Kelley
Christopher Oates
Cliff Stanley

2002-2004
Nigel Radford *(ex officio)*
Chris Benn
Richard Carver
David Garnett
Robert Jackson
Paul Morris

Australia
Leigh Bettenay
Nigel Brand
Mark Elliott

Brazil
Germano Melo Jr.

Chile
Alvaro Puig

China
Xueqiu Wang

Europe
J. B. De Smeth

Northern Countries
Vacant

Southeast Asia
Tawsaporn Nuchangong

Southern Africa
Charles Okujeni

UK and Republic of Ireland
Deirdre M. A. Flight

COMMITTEES

Australian Geoscience Council Representative
Graham Taylor

Canadian Geoscience Council Representative
W. K. Fletcher

Awards and Medals Committee
Eric Weiland, *Chair*
John S. Cone
Robert G. Garrett
Günter Matheis
Barry W. Smee

Bibliography Committee
L. Graham Closs, *Chair*
Robert G. Garrett
Richard K. Glanzman
Eric C. Grunsky
Peter J. Rogers

Distinguished Lecturer Committee
David Garnett, *Chair*

Election Official
Sherman Marsh

EXPLORE
Mary Doherty, Editor
Lloyd James, Assoc. Editor
David Kelley, *Business Manager*

Geochemistry: Exploration, Environment, Analysis
Gwendy E.M. Hall, *Editor-in-Chief*

Admissions Committee
Nigel Radford, *Chair*

New Membership Committee
Shea Clark Smith, Chair
Mark S. Elliot
Germano Melo, Jr.

Publicity Committee
M. Beth McClenaghan, *Chair*
Sherman P. Marsh
J. Stevens Zuker
R. Steve Friberg

Regional Councillor Coordinator
Philippe Freyssinet

Short Course Committee
Colin E. Dunn, *Co-Chair*
Vlad Sopuck, *Co-Chair*

Student Paper Competition
Ian Robertson, *Chair*
J.B. de Smeth
Richard Davy
Owen Lavin

Symposium Committee
Steve Amor, *Chair*
Eion Cameron
Mario Desilets
Philippe Freyssinet
Gwendy Hall
Virginia McLemore
Barry W. Smee
Graham F. Taylor

Web Site Committee
Steve Amor, *Chair*
Richard Carver

Betty Arseneault, *Business Manager*
P.O. Box 26099, 72 Robertson Road, Nepean, ON K2H 9R0 CANADA,
TEL: (613) 828-0199 FAX: (613) 828-9288, e-mail: aeg@synapse.net
Steve Amor, *Webmaster* e-mail: SteveAmor@compuserve.com
Gwendy Hall, Journal Editor-in-Chief,
Geochemistry: Exploration-Environment-Analysis
e-mail: Ghall@nrcan.gc.ca

Calendar of Events

continued from Page 27

■May 12-16, 2003, GeofluidsIV: Fourth international conference on fluid evolution, migration and interaction in sedimentary basins and orogenic belts, Utrecht University, Utrecht, The Netherlands , by the Netherlands Institute of Applied Geoscience TNO-National Geological Survey. (Ms. J.M. Verweij, PO Box 80015, 3508 TA Utrecht, The Netherlands, Phone: +31 30 256 4600 FAX: +31 30 256 46 05
EMail: j.verweij@nitg.tno.nl Web: http://www.nitg.tno.nl)
■June 1-7, 2003, AMERICAN SOCIETY for SURFACE MINING and RECLAMATION (ASSMR) 19th National Meeting and Billings Land Reclamation, Billings, Montana. INFORMATION: Dennis Newman, dneuman@montana.edu, http://www.ca.uky.edu/assmr/Upcoming_Events.htm
■July 12-18, 2003, 6th International Conference on Acid Rock Drainage (ICARD), Cairns, Australia; INFORMATION: Clive Bell, c.bell@mailbox.uq.edu.au or website http://www.ausimm.com.au/events/event_writeups/icard.asp
■August 29 - September 3, 2003, 21st International Geochemical Symposium (IGES), Dublin, Ireland. Information: The Secretary LOC - Eibhlin Doyle (e-mail eibhlindoyle@gsi.ie).
■September 13, 2003, 6th Intenational Symposium on environmental geochemistry, Edinburgh, Scotland. Information: Dr. John G. Farmer, Department of Chemistry, University of Edinburgh, phone +44(0)131 65- 4757.
E-mail: J.G.Farmer@ed.ac.uk
■October 5-10, 2003, The XII International Mineral Processing Congress, Cape Town, South Africa. Information: www.impc2003.org.za.
■November 2-5, 2003, Annual Meeting of the Geological Society of America, Seattle, Washington. INFORMATION: TEL 1-800-472-1988, meetings@geosociety.org.
■Oct 10-15, 2004, SEG International Exposition & 74th Annual Meeting, Denver, Colorado, US , by the SEG. (Debbi Hyer, 8801 S. Yale, Tulsa OK 74137, Phone: (918) 497-5500 EMail: dhyer@seg.org Web: http://meeting.seg.org)

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

Virginia T. McLemore
New Mexico Bureau of Mines and Mineral Resources
New Mexico Institute of Mining and Technology
801 Leroy Place
Socorro, NM 87801 USA
TEL: 505-835-5521
FAX: 505-835-6333
e-mail: ginger@gis.nmt.edu

IMPORTANT NOTICE

to all AEG Fellows and Members

Proposed expansion of The Association of Exploration Geochemists

The Association of Exploration Geochemists (AEG) has, for more than thirty years, sought to represent the interests of geochemists in and associated with the mineral exploration industry. In recent years it has become increasingly apparent that there are no rigid boundaries between exploration and environmental geochemistry when these sciences are applied to mineral resource problems - the underlying principles are the same whether we are looking at a dispersion train or a pollution train. Indeed, the community at large expects a "cradle-to-grave" approach to resource management. The title of the AEG's new flagship journal, "Geochemistry: Exploration Environment Analysis" (GEEA) explicitly recognises that exploration and environmental geochemistry are inter-twined.

Over the last fifteen years this issue has been a regular topic for debate by Council, in the pages of Explore and at Annual General Meetings, and as time has passed it has become clear that more and more AEG members are in favour of embracing environmental geochemistry in so far as it relates to mineral resources. Indeed, it is probably true to say that a significant number of current AEG members, who began their careers as explorers, would now be justified in calling themselves environmental geochemists. The AEG Council feels that it is now appropriate to replace this de facto situation with a more formal recognition of the science of environmental geochemistry as it relates to mineral resources. This would involve a revision of the By-Laws which govern our activities and could also involve a change of name of the Association.

The Preamble to the By-Laws defines the purposes for which the Association is constituted. If we are to expand the scope of the AEG it is proposed that this Preamble should read as follows:

> "PURPOSE. The Association of Exploration Geochemists is constituted for the following purposes; to form a united and representative group of persons specializing in the geochemistry of mineral resources; to advance the science of geochemistry especially as it relates to the geochemistry of mineral resources - their exploration, exploitation, and environmental impact; to foster the common scientific interests of geochemists working in these areas; to facilitate the acquisition of professional knowledge and information relevant to the geochemistry of mineral resources, and to promote the interchange thereof amongst its members; to encourage research into dispersion of geochemical species, both natural and anthropogenic, and to use this knowledge for the development of methods for the improved detection and understanding of these dispersion patterns; to advance the status of the profession and to promote and maintain high standards of training and ethics amongst its members."

The above Preamble is based on, and is very similar to, the existing AEG Preamble. It differs in that it now focuses on the 'geochemistry of mineral resources' rather than on the narrower field of 'exploration geochemistry'. It is important to note that the proposal is not aimed at embracing the whole field of environmental geochemistry.

While it would not be impossible to continue as the Association of Exploration Geochemists, logic dictates that a change of name would be appropriate. This would more accurately reflect the expanded scope of the Association. Council asks that members of the AEG consider the following resolution:

> It is proposed that the name of the Association be changed from the "Association of Exploration Geochemists" either to the "Association of Exploration and Environmental Geochemists" or to "The Association of Applied Geochemists".
>
> The title "Association of Exploration and Environmental Geochemists" is attractive in that its acronym becomes "A double E G", which is the reverse of the Journal's acronym, "G double E A". The alternative, the "Association of Applied Geochemists" is somewhat less cumbersome as a title but might cause confusion by implying a link with the Elsevier journal 'Applied Geochemistry'.

The AEG Council calls for comment on the above proposals from all members, whether or not they have voting rights. In the light of these comments it is intended that final versions of the revised Preamble and of the proposal to change the name will be circulated to all Fellows for voting later this year. The results will be announced at the Annual General Meeting which is scheduled for mid-November.

While it is now over ten years old the review of the AEG's identity, published in 1991 (Explore No 73), contains much that is still relevant to today's debate. A copy of this report will be placed on the AEG's website, which will also carry an electronic discussion page. Members are encouraged to use this, or to submit letters to 'Explore'. We hope to be able to incorporate these into a review of the issues in the next edition of 'Explore'. Comments can also be sent to either Nigel Radford or David Garnett. Contact details are given below. All comments must be received by the end of August 2002.

AEG Council June 2002.

Contact details for comments:

David Garnett: Becquerel Laboratories, PMB 1, Menai, NSW 2234, Australia (naa@bq.com.au).

Nigel Radford: c/o CSIRO Exploration and Mining, PO Box 1130, Bentley, WA 6102 (Nigel.Radford@csiro.au).

EXPLORE

Newsletter No. 116 JULY 2002

Editor: Mary E. Doherty (303) 278-6876 Fax: 303-215-0641
MaryEDoherty@earthlink.net
Associate Editor:
Lloyd James (303) 741-5199 (l-njames@ecentral.com)
Assistant Editors:
Steve Amor (steveamor@compuserve.com)
Chris Benn (Chris.J.Benn@BHPBilliton.com)
Richard Carver (RichardCarver@gcxplore.com)
Patrick Highsmith (phighsmith@alschemex.com)
Robert Jackson (rjac2@newmont.com)
Allan Kelly (aj-kelly@bigpond.com)
Barry Smee (bwsmee@attglobal.net)
Business Manager:
David Kelley (303) 268-8318 (dave.kelley@wmc.com)
Back Issues contact:
Betty Arseneault (aeg@synapse.net)

EXPLORE is published quarterly by the Association of Exploration Geochemists, P.O. Box 150991, Lakewood, CO 80215-0991, USA.
EXPLORE is a trademark of the Association of Exploration Geochemists.
Type and layout of EXPLORE: Vivian Heggie, Heggie Enterprises, Thornton, CO (303) 288-6540; <vjmheggie@starband.net>

LIST OF ADVERTISERS

New Members…

To All Voting Members:
Pursuant to Article Two of the Association's By-Law No.1, the 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 David B. Smith, Secretary AEG, USGS, Box 25046, MS 973, Denver, CO 80225, USA.

FELLOWS
Elizabeth A Bailey, *Research Chemist*,
USGS, Anchorage, Alaska.

MEMBERS
Robert L Kromarov, *General Manager, Exploration,*
Perth, Western Australia.
Gib McArthur, *Environmental Geologist,*
Victoria, Canada.

Thank You

Many thanks to the members of AEG who cheerfully manned the AEG booth during the SEG2002 meeting in April: Bob Eppinger, Patrick Highsmith, Jeff Jaacks, Lloyd James, Dave Kelley, Sherm Marsh, Ed Post, Dave Seneshen, and Clark Smith.
Thank you all.

Coming soon in the AEG **EXPLORE** newsletter:
Technical articles and letters to the editor are encouraged as submissions for discussion within the newsletter. In addition, each issue of **EXPLORE** will contain a series of short discussion papers which provide either an update on a particular geochemical topic, or present current debates about issues of interest. The Associate Editors are thanked for their participation and assistance with these focus issues. Suggestions for future "Focus" topics may be forwarded to the editor (MaryEDoherty@earthlink.net).

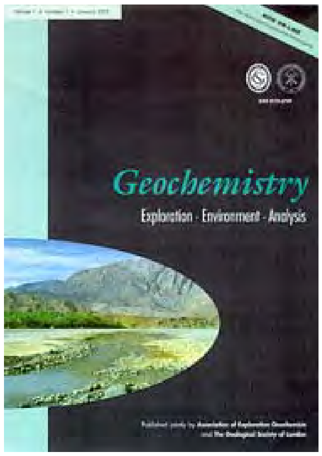
Issue: Focus topic and Contact:
117 Software Update
Richard Carver(richardcarver@gcxplore.com)
Contributor Deadline August 31, 2002
Publication Date: October 2002

118 Geochemical Process Debate
Contributor Deadline November 30, 2002
Publication Date: January 2003

119 Geochemical Standards
Contributor Deadline February 28, 2003
Publication Date: April 2003

120 Environmental Geochemistry Update
Contributor Deadline May 31, 2003
Publication Date: July 2003

The Association of Exploration Geochemists Journal
GEOCHEMISTRY:
Exploration, Environment, Analysis



The GEEA Journal covers all aspects of the application of geochemistry to the exploration and study of mineral resources, and related fields, including the geochemistry of the environment. Topics include: the description and evaluation of new and improved methods of geochemical exploration; sampling and analytical techniques and methods of interpretation; geochemical distributions in and around mineralized environments; and processes of geochemical dispersion in rocks, soils, vegetation, water and the atmosphere. Papers that seek to integrate geological, geochemical and geophysical methods of exploration are particularly welcome. Given the many links between exploration and environmental geochemistry, the journal encourages the exchange of concepts and data; in particular, to develop mineral resources while protecting the environment. Submission of Letters to the Editor is encouraged; this provides a means of commenting on papers that have been published in the journal. GEEA is published by the Geological Society of London.

Notice to Members

The AEG is looking for a volunteer Webmaster from amongst its membership to take over from Steve Amor when he becomes President in 2003. Basic knowledge of web page design and HTML coding would be desirable but not essential; knowledge of more advanced programming techniques (JavaScript, ASP, etc.) and online database creation a definite asset.

Interested persons may contact Steve Amor (steveamor@compuserve.com) or any Council member.

EXPLORE

Newsletter for The Association of Exploration Geochemists

P.O. Box 150991, Lakewood, CO, 80215-0991, USA

Please send changes of address to:
Association of Exploration Geochemists
P.O. Box 26099, 72 Robertson Road, Nepean, Ontario, K2H 9R0, Canada · TEL: (613) 828-0199 FAX: (613) 828-9288
e-mail: aeg@synapse.net • http://www.aeg.org /aeg/aeghome.htm

PR SRT STD.
U.S. POSTAGE
PAID
DENVER, CO
PERMIT NO. 3550