

EXPLORE

Newsletter for
the Association
of Exploration
Geochemists



NUMBER 104

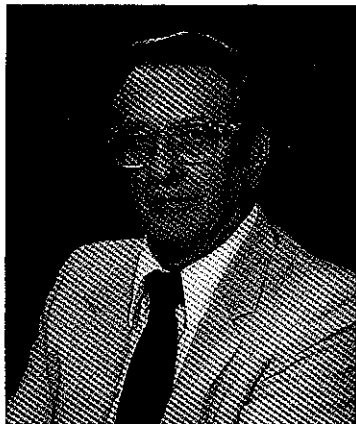
JULY 1999

THE AEG GOLD MEDAL AWARD: A Tribute to R.W. Boyle

by Alan Coope

Mr. President,
Welcome Guests
Ladies and Gentlemen of
the Association

This evening, the Association is honoring one of Canada's most productive pioneers of exploration geochemistry. It is my privilege to present to you some important highlights of the remarkable career of



ROBERT WILLIAM BOYLE.

Bob Boyle grew up on the family farm in southwestern Ontario. As a schoolboy, he was intrigued with chemistry and built his own laboratory in the attic of the farmhouse. His love of the outdoors fueled a friendship with James McCrae, a 70-year old, retired prospector living two farms away. Teenager Bob Boyle was fascinated with tales of exploration and discovery in the wide expanse of northern Canada. Upon graduation from high school, he joined a prospecting syndicate in northern Ontario to earn money to pay for a university education in geology.

However, the World War II years intervened. After 6 years in the Royal Canadian Artillery, during which he found time to take courses in geology at Imperial College in England and at Queen's University in Canada, he enrolled at the University of Toronto in 1946. Summer work, as a diamond driller and as a surveyor, provided the needed funding for his degree in Mining Geology in 1949.

His subsequent work in the Yellowknife camp in the Northwest Territories influenced his ideas on geochemistry throughout his long career. He gained his Masters and Doctorate degrees from the University of Toronto in 1950 and 1953. This research revealed him not only as a person of many talents with an inquiring mind, but also as a competent scientist with a deep interest in the genesis and geochemistry of gold deposits.

In 1952, he became a full-time employee of the Geological Survey of Canada. His GSC memoir on his Yellowknife work was published a few years later. This describes his lateral secretionist ideas which have proven to be integral in the understanding of the formation of endogenic halos around some types of mineral deposits.

Stimulated by his own observations of gold occurring in

Continued on Page 3

PAST PRESIDENTS' MEDAL AWARD: JOHN HANSULD

by David Garnett

The Past Presidents' Medal of the Association of Exploration Geochemists is awarded to John Alexander Hansuld for his service as a founder of the Association, including being its second president; for his vital contributions to the Journal of Geochemical Exploration as its business editor; and for his



David Garnett presents the Past Presidents' award to John Hansuld

indirect contributions to the goals of the Association as a leader of the mining industry, most prominently as the president of Canamax Resources Inc. and as president of the Prospectors and Developers Association.

John was born on 16 October, 1931 at Port Arthur, Ontario. While his formal education as a geologist started at McMaster University his initial stimulus to move into geochemistry came from Harry Warren. After graduating with honours from McMaster in 1954 he went to the University of British Columbia to work with Harry Warren, graduating with an MSc in 1956. He then joined British Newfoundland Exploration as a geochemist, but in 1957 was persuaded by John Riddel to continue his studies for a PhD at McGill, and it was there that he started his work on phase equilibria in relation to Eh and pH.

After leaving McGill, John joined Amax in Toronto, moving almost immediately to Amax's exploration activities in Puerto Rico. The following year, 1962, he was promoted to Chief Geochemist at the Amax headquarters in Denver, followed by a further promotion to Manager of Exploration Research.

John's contributions to geochemical science during his

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Information for Contributors to EXPLORE

Scope. This newsletter is the prime means of informal communication among members of the Association of Exploration Geochemists, but has limited distribution to non-members. EXPLORE is the chief source of information on current and future activities sponsored by the Association, and also disseminates technical information of interest to exploration and environmental geochemists and analytical chemists. News notes of members are appropriate. We welcome short- to moderate-length technical articles on geochemical tools for exploration, concepts for finding ore, mineral-related environmental geochemistry, new analytical methods, recent deposit discoveries, or case histories. The goal of this newsletter is communication among exploration geochemists, and to that end we encourage papers on new methods and unconventional ideas that are reasonably documented.

Format. Manuscripts and short communications should be submitted in electronic form to minimize errors and speed production. Files can be transmitted on IBM-compatible 3.5 inch diskettes or attached to email. Most popular text and graphics files can be accommodated. Figures and photos can be transmitted in hard copy (which we will scan) or as high quality digital files. Some issues are published with color pages for special maps and figures which should be planned by early communication with the editors.

Length: Technical communications can be up to approximately 1000 words, but special arrangements may be made for longer papers of special interest. High quality figures, photos, and maps are welcome if they present information effectively.

Quality: Submittals are reviewed and edited for content and style through peer reviews. The intent is to improve clarity, not suppress unconventional ideas. If time permits, the author will be shown changes to material, by FAX or email. Time constraints do not allow author review of galley proof from the printer.

All contributions should be submitted to J. T. Nash by email (tnash@usgs.gov) or by mail (EXPLORE, c/o J.T. Nash, U.S. Geological Survey, Box 25046 MS 973, Denver, CO 80225 USA). Only in rare situations should FAX be sent (303-236-3200).

Information for Advertisers

EXPLORE is the newsletter of the Association of Exploration Geochemists (AEG). Distribution is quarterly to the membership consisting of 1200 geologists, geophysicists, and geochemists. Additionally, 100 copies are sent to geoscience libraries. Complimentary copies are often mailed to selected addresses from the rosters of other geoscience organizations, and additional copies are distributed at key geoscience symposia. Approximately 20% of each issue is sent overseas.

EXPLORE is the most widely read newsletter in the world pertaining to exploration geochemistry. Geochemical laboratories, drilling, survey and sample collection, specialty geochemical services, consultants, environmental, field supply, and computer and geoscience data services are just a few of the areas available for advertisers. International as well as North American vendors will find markets through EXPLORE.

The EXPLORE newsletter is produced on a volunteer basis by the AEG membership and is a non-profit newsletter. The advertising rates are the lowest feasible with a break-even objective. Color is charged on a cost plus 10% basis. A discount of 15% is given to advertisers for an annual commitment (four issues). All advertising must be camera-ready PMT, negative or file on disk. Business card advertising is available for consultants only*. Color separation and typesetting services are available through our publisher, Vivian Heggie, Heggie Enterprises.

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FROM THE EDITORS

It is a pleasure to send this issue to you with many descriptions of the IGES meeting in Vancouver and also technical notes that convey experience with chemical methods. People and technology like this lead our Association. Obviously a handful are doing most of the writing, which we appreciate, and we encourage all members to share their personal and technical insights through this Newsletter.

The IGES Symposium sessions, both formal and informal, were a great way to catch up with advances in exploration geochemistry. In his remarks at the Awards Ceremony, John Hansuld emphasized the need for better field observations for reliable interpretations of chemical results. There was much discussion of new methods, particularly those using partial extractions designed to find subtle anomalies in soils and surface materials that cover ore (see Radford's description of the Nevada Field trip, p. 8). Many expressed the need to know more details of the methods and quality control for chemistry. EXPLORE is an ideal venue for sharing experience and case histories with the profession; we will be glad to help anyone get their story onto these pages.

Color graphics have been printed in EXPLORE several times in recent years and we look forward to a new arrangement that should allow us to have color pages twice per year. We encourage geochemists to generate color maps to show the spatial aspects of their work that deserve to be shared with colleagues and the public. Contact us if you have an interest and we can help you with the preparation of the color figures, including expert advice from Vivian Heggie our Graphics Editor.

We continue to seek associates who can pull in hot information from other parts of the world: persons with an ear to the ground in Australia, Western Canada, Europe, or other parts of the world are needed to facilitate the flow of technical and member information to the Newsletter. We also seek one or two persons to rotate into editorial positions, to add new perspectives on our activities, and to diversify beyond the current government gray prose. Send your suggestions to Regional Councilors or to us.

Sherm Marsh

Tom Nash



Bob Boyle

Continued from page 1

permafrost ice, and the observations of others on metal dispersion in sub-arctic regions, he initiated geochemical exploration studies in the Keno Hill area of the Yukon in 1953. This program clearly demonstrated the applicability of geochemical methods in permafrost regions of Canada - refuting the views of the naysayers who claimed geochemistry would not be effective in frozen ground. His work, over time, led to important new discoveries, extending the life of the Keno Hill mining camp.

Bob Boyle's success in demonstrating the value and applicability of geochemical exploration techniques led to the establishment of laboratory facilities at the GSC in the mid-1950's. He attracted experienced geochemists and analysts to the Geological Survey from England, and work on geochemical methods specifically suited to the Canadian environment took on a new emphasis. Research investigations were initiated in the Maritimes and in other parts of Canada.

An important feature of Bob Boyle's publication record, which was established in these earlier years, was that he published both in the scientific literature and in the practical mining journals. This not only quickly established the GSC as a center of expertise in geochemistry, but also gained the interest and the attention of explorationists in the private sector who were encouraged to apply the new geochemical techniques.

Beginning in 1955, and extending through 1975, Bob Boyle was a Special Lecturer at Carleton University in Ottawa. His courses were stimulating, instructive, and popular. His students, now scattered through academia, government, and industry across Canada and across the world, have advanced exploration geochemistry to higher levels and increased our understanding.

In these early years, Dr. Boyle was honored and recognized by academia and industry but most notably was elected a Fellow of the Royal Society of Canada in 1957 in recognition of his pioneering scientific work in geochemical prospecting. He prepared submissions on the role and importance of geochemistry which were used by the federal government in the development of science policy. Additionally, his reputation extended abroad and he was one of the first Canadians to travel to the Soviet Union (in 1962) as an Invited Lecturer at the Vernadsky Institute.

Of historical importance to the Association of Exploration Geochemists, Bob Boyle was a member of the Organizing Committee and Program Chairman of the first meeting of exploration geochemists in Ottawa in 1966. This meeting is now recognized as the 1st International Geochemical Exploration Symposium. In 1970, he was Chairman of the 3rd IGES in Toronto, during which the Association of Exploration Geochemists was founded.

Beginning with studies at Cobalt in Ontario in 1962, and extending over more than 20 years until his retirement from the GSC in 1985, he traveled, lectured, observed, and read extensively. He produced a series of widely acclaimed books and papers on the geochemistry of, and exploration for, mineral deposits. The most notable of these are *"The Geochemistry of Silver and Its Deposits"* (1967) and *"The Geochemistry of Gold and Its Deposits"* (1979), both of which are highly regarded and important standard reference texts to this day.

Other texts, well known to exploration geologists and geochemists, include *"Elemental Associations and Indicators of Interest in Geochemical Prospecting"* (1969, revised in 1974); *"Mineralization Processes in Archean Greenstone and Sedimentary Belts"* (1976); and *"Geochemical Prospecting for Thorium and*

Uranium Deposits" (1982).

In addition to these scholarly productions, Bob traveled widely over six continents to present lectures and give instruction in geochemical prospecting. Several lecture tours were sponsored by international organizations including the IAEA, UNESCO, and UNDP. Many scientists from foreign countries visited the GSC in Ottawa to learn the geochemical exploration methods and gain further experience. In addition, he served in responsible positions with many learned societies

including the Society of Economic Geologists, the International Association for the Genesis of Ore Deposits, and the Association of Exploration Geochemists. He was our President in 1975-76.

In retirement, his productivity is still remarkable. His interest in precious metal deposits has never wavered. His contributions include the widely acclaimed book: *"Gold: History and Genesis of Deposits"* which was sponsored by the Society of Economic Geologists (SEG) and the SEG Foundation, and published in 1987. In 1991, he was the co-recipient, with his co-editors, of the Award of Excellence of the Society of Technical Communicators for the editing of the Geological Association of Canada publication *"Sediment-Hosted Stratiform Copper Deposits"*. His latest book, *"The History of Geochemistry"*, will be published by the year 2000 - the year of his 80th birthday.

Over the course of his prolific career, Bob Boyle has authored or co-authored over 160 publications.

Recognition of his work in exploration geochemistry and the genesis of ore deposits has come from many high-level sources. He was awarded the Willet G. Miller Medal of the Royal Society of Canada in 1971. The Canadian Institute of Mining and Metallurgy elected him a Fellow in 1993, and recognized his scientific papers by awards of the Barlow Medal in 1966 and 1983. The Association of Exploration Geochemists conferred Honorary Membership in 1989, and in 1990 he was made an Honorary Professor of the University of Earth Sciences, Changchun, China. In 1991, he was honored with a Service Award by peers recognizing his contributions to the economic development of the Bathurst, New Brunswick, mining camp. He was the recipient of the Past President's Medal of the Mineralogical Association of Canada in 1993, and the Prospectors and Developers Association of Canada awarded him its Distinguished Service Award in the same year. A most fitting culmination has been the very distinguished honor of election to the Canadian Mining Hall of Fame in 1997.

Mr. President, Bob Boyle's record clearly distinguishes him as a scientist, a pioneer, a leader, a builder, a teacher, a mentor, and a historian.

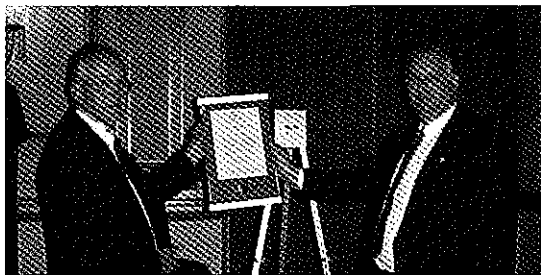
Throughout his career, common characteristics have been his quiet self-effacing nature, his ability to seek out the positive in any situation and produce good science, and his constant encouragement of others to undertake interesting and practical studies.

He has always kept an open mind on science and has never

Continued on Page 4



Bob Boyle *continued from Page 3*



Bob Garrett, on behalf of Bob Boyle, accepts the Gold Medal Award from Alan Coope

been one to jump on the bandwagon of the time. He gives as much attention to the unusual and unexpected as he does to the data that conforms with conventional thought. This inquisitiveness, this constant search for discovery, conforms with the prospecting instincts that he discovered at an early age.

When it comes to taking credit for various achievements, his tendency has always been to stand back and let others share the recognition and the benefits.

We, as members of the Association, have benefited significantly from his outstanding scientific and practical contributions to geoscience, and particularly to exploration geochemistry.

Unfortunately, on his doctor's advice, Bob Boyle is not with us this evening. Bob Garrett will be accepting on Bob Boyle's behalf, and I invite him to come forward so that we may, humbly and proudly, salute our gifted and productive colleague with the award of the Gold Medal of the Association.

J. Alan Coope

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Past-President's Medal

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graduate studies and early years with Amax were in describing the controls on the mobilization and fixing of metals in the surface environment, most notably molybdenum. John, in fact, contributed a paper on this topic to the 1966 Ottawa Symposium on Geochemical Prospecting, now regarded as the seminal meeting leading to the founding of our society.

But John Hansuld's main contributions to mineral exploration were not as a researcher. His most notable talent was as a manager and leader. In 1967 he returned to Toronto as Regional Exploration manager for Eastern Canada. Recognizing his talent, Amax supported further graduate studies at Harvard Business School, where he received a PMD in 1968. Moving further up the corporate chain, John became Canadian Exploration manager of Amax in 1973 and in 1978 Senior Vice-President of Amax with responsibility for the world-wide exploration budget.

John's greatest achievement as a mining manager was in spearheading the formation of Canamax Resources Inc. in 1982. He completed a \$29 million public issue and established his reputation as "father of flow-through shares" and from 1983 to 1989 was president and CEO of Canamax. Leaving the Amax organization in 1989, he has held a variety of management positions in the mining community, which continues to this date.

John Hansuld's contributions to the Association of Explora-

tion Geochemists commenced before its founding. He was one of the small group who met and developed the concept of a society that would promote the development of geochemical exploration and bring together professionals serving this field. He spearheaded the organizing committee of the 2nd International Geochemical Exploration Symposium, held in Denver (Golden) in 1968, and it was in his suite at the Holiday Inn that some 25 dedicated geochemists met as a steering committee to plan the way ahead. The result was the Association as we know it today, which was founded in 1970 with John as Vice-President and Chair of the Admissions Committee.

In the second year of the Association's history he was President. In this position he felt the need to enhance communication between the far-flung community of its members. He took the leadership position in establishing the Newsletter and the Journal of Geochemical Exploration. In retrospect, it seems very bold that a young society, yet to celebrate its second birthday, one with a small membership and even smaller treasury, should found a scientific journal. This initiative could easily have fallen flat and taken with it the credibility of the Association. Indeed, it almost did. Papers were hard to come by at the outset and the financial condition delicate. John dedicated himself to the financial task and in 1973 joined the editorial board as Business Editor. Over a number of years he negotiated a series of contracts with the publisher that were highly advantageous to the Association. He was able to persuade the publisher to accept a profit sharing agreement at a time when it appeared improbable that the specified sales targets could be met. However, with the growth of our association and our journal, this savvy negotiation led to hundreds of thousands of dollars flowing back to the society's coffers. Indeed, every member, past and present, has benefited from a lesser cost of membership thanks to John's efforts. Recognition of these efforts was expressed by the Distinguished Service Award of the Association presented in 1982 in Saskatoon to celebrate the tenth anniversary of the founding of the journal. John has continued as a member of the editorial board to this date, always providing wise counsel to the editor.

John's activities outside the Association have brought credit to our organization and greater attention to the science of exploration geochemistry. Most notable among these activities were his presidency of the Prospectors and Developers Association of Canada for the years 1993 to 1996. He was instrumental in taking the PDAC from an essentially Canadian organization to one of global influence. John's contributions have been recognised both by the PDAC and the broader mining industry. He was the Northern Miner's "Mining Man of the Year" in 1988; the PDAC made him "Developer of the Year" in 1989, and also gave him the Distinguished Service award in 1998. In addition, he was inducted into the McMaster Alumni Gallery in 1990 for his many achievements.

It is a measure of the esteem in which he is held that John Hansuld has been nominated for this award by four of our most distinguished members - Peter M.D. Bradshaw, Eion M. Cameron, J. Alan Coope and Arthur W. Rose — and it gives me great pleasure to present the Past Presidents' Medal of the Association of Exploration Geochemists to him.

David Garnett

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JOHN HANSULD'S ACCEPTANCE

Thank you very much for those kind introductory remarks. I would like to thank the Association and Council for making this award. I was indeed delighted and honoured. I want to give a special thanks to the Awards Committee and to those who put forward my nomination. I must admit that I was surprised that there were enough people still around who are old enough to know what went on in the early days of the Association, but more importantly, enough who could remember what went on!

I am pleased to receive the award for a number of reasons. First, even though some of you out there probably don't know who I am or haven't heard my name, I did spend the first 15 years of my professional career doing geochemistry. It was a fun time, it was a pioneering time, and it was, indeed, a challenging time. We had to convince geologists that geochemistry could help them find ore deposits; we had to convince companies that geochemical surveys should be added to their exploration programs; and, interestingly enough and probably the most difficult people we



AEG President enjoy awards banquet: Erick Weiland, John Hansuld, and David Garnett (L to R).

had to convince were the universities - in that geochemistry was a valid scientific endeavour and should be taught at the university level. I can tell you from personal experience that you had to be very thick skinned to call yourself a geochemist in those early days. We did everything - from collecting the samples, preparing the samples, doing the analysis, plotting the data, interpreting the results, and writing the report. Those were the days of dithizone and one quickly learned to distinguish between the orange colour of iron and the red of zinc. It was a never-ending learning experience and there were lots of "firsts" as I literally made up data forms and procedures as I went along.

The second reason why I am delighted to receive this medal, particularly at this symposium, is because it was here in Vancouver that I started my geochemical career. Actually, what took place was that in my fourth year seminar course at McMaster, I gave a paper on the newly discovered Bathurst Camp. This was in 1953-54 and geochemistry had played a role in its discovery. The geochemical methods used seemed such a logical application which appealed to my German logic. I asked the head of the geology department what I could do to learn more about geochemistry, and he suggested that I write to Harry Warren.

As a result, I spent most of the summer of 1954 on the Missinabic River in northern Ontario water testing for heavy metals using the Warren field kit and that fall, with two scholarships in hand, thanks to Harry, I started my Masters program at UBC, where I did my thesis on the natural leaching of the Britannia copper ores. I am thrilled to see that this symposium is dedicated to Harry and I am very impressed by the splendid

tribute given to him inside the program cover. Dr. Warren was, in my view, light years ahead of his time and really did a great deal to promote the broader use of trace metal geochemistry. I am glad he is finally getting the recognition he so richly deserves and was pleased that he was inducted into the Canadian Mining Hall of Fame earlier this year.

The awarding of the medal is in recognition of my contributions in the early days of the Association. I was and continue to be very proud of those early days and what we accomplished in a relatively short period. In the first two years we started a newsletter and founded a journal. The newsletter, thanks to the efforts of others that followed, has evolved into what I consider to be one of the best in the scientific world. Probably the best thing we did was to team up with Elsevier in launching our new Journal. Elsevier was and is a world class scientific publishing house and virtually over night they gave the Association international recognition and, more importantly, the Journal global distribution. It was like instant tea! I know the Association has recently decided to leave Elsevier and go elsewhere. Times change; however, I can vouch for the fact that we had a great relationship in those early startup days with Elsevier, thanks to people like Frans van Eysinga and Herman Frank. I wish you well with your new journal.

Plato, in his work *The Republic*, dated 427 BC, states: "The beginning is the most important part of the work." I can tell you that the beginning of this Association required a lot of hard work and dedication as we laid the foundation for what has become a very successful and respected organization. Although it is always risky to name names, I would like to recognize some of those early players. First, Alan Coope. Alan is the one who drew up the charter and formalized the founding of our Association and can be called the father of the Association. Ian Nichol, the first secretary, did yeoman work, and, although at times we had our differences, as a team Ian and I got things out and in a timely fashion. Ian deserves a lot of recognition for his efforts. And then there was Eion Cameron, our first and, until a few months ago, the only editor of the Journal. How Ian was able to balance the egos and pride of authorship of the members with the ever changing schedule of Elsevier without losing his sanity was beyond me. He did a wonderful juggling job of keeping everyone happy and on time. Chris Gleeson, our first treasurer, guarded our finances and made sure that Amax, Newmont, the GSC, the USGS, and others paid for all the stamps, postage, long distance phone calls, and secretarial services, etc., so that we could preserve our precious, limited financial resources. Finally, I would be remiss if I didn't mention Herb Hawkes. Herb was a real class act who unselfishly made available his personal bibliography, which he updated and provided to the Association; it was our first official AEG publication.

I would now like to make a couple of observations. First, the importance of field data in the interpretation of geochemical results. I sat in on a few papers today and clearly the message is still there that we need better field observations in order to avoid erroneous interpretations. I can't say enough about that and, in fact, in 1968 at the Denver symposium, I moderated a panel discussion on "what's a geochemical analysis?" We had a whole array of speakers representing the entire cross section of those involved in exploration - from the field sampler, geologist, chemist; analyst; exploration manager; educator, etc. The common theme from all was the need for better communication between those collecting the field data and those analyzing and interpreting the results. I just can't stress the importance of field data enough.

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John Hansuld's Acceptance

Continued from Page 5

My second point is with respect to the environment. I see the word 'environment' has been added to the scope of the Journal and is an integral part of the Association's activities. I don't have a problem with this; in fact, I think it's probably overdue. Who better qualified to analyze and interpret trace element data than an exploration geochemist? However, having said that, I have been personally involved in situations which have included environmental groups, and I would seriously caution you not to let the Association get hijacked by the environmentalists as they can be a very vocal, very strong group with seemingly unlimited financial resources.

In closing, I would like to thank everyone again for this honour. It means a lot to me.

By the content and scope of this symposium, exploration geochemistry is clearly alive and well. Admittedly, the numbers here are down, but that's mainly because of the financial slump of our industry. Certainly, it's not a reflection on the interest in and importance of exploration geochemistry. The theme of your meeting is geochemistry into the 21st century. There are certainly still lots of challenges to be met and I wish the Association and you all well in the next millennium. Bonne chance and hasta luego!

John Hansuld

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STUDENT PRIZE

MATTHEW LEYBOURNE



The Association of Exploration Geochemists and XRAL Laboratories, a Division of SGS Canada, take pleasure in announcing the 1998 Student Paper Competition Award. This is awarded for the best paper in a refereed scientific journal by a student, on work performed as a student. It must be published within five years of graduation and must address an aspect of exploration geochemistry. The student must be the principal author and nominations may be made by anyone familiar with the student's work.

Entries closed at the end of 1998 for the Association's twelfth biennial Student Paper Competition. There was a total of five entries from four entrants from Egypt, China and Canada. They were of a high standard but the choice was very clear. The winner is Matthew Leybourne, now Research Scientist (Post-Doctoral Research Fellow) with the Mineral Resources Division of the Geological Survey of Canada. His winning paper is based on research for his Ph.D. Thesis, at the University of Ottawa, supervised by Dr Wayne Goodfellow, which Matthew completed in 1998.

Matthew obtained his B.Sc. in Earth Sciences at the University of Waikato, Hamilton, New Zealand in 1985. He then worked briefly as a research assistant for the Water Quality Division of the New Zealand Ministry of Works and for the Department of Geology at Acadia University, Wolfville, Nova Scotia, where he stayed on to do his M.Sc., completing in 1988. After that he worked as a research associate with the Geological Survey of Canada, as a laboratory analyst with the University of Ottawa, as a hydrogeochemist with the Geological Survey of Canada and as a contract geologist. He gained a wide experience in soil hydraulic conductivity, mapping volcanics, mineralogy, geochemistry, analysis, isotopes, fluid inclusions, hydrothermal alteration, petrography and microbeam techniques. He is a member of the International Association of Hydrogeologists, the Geochemical Society, the Geological Society of America, the American Geophysical Union and the International Association of Geochemistry and Cosmochemistry.

He received a \$500 cash prize from XRAL, a two year membership of the Association of Exploration Geochemists, together with the Journal and Explore, a certificate of recognition and \$500 towards expenses to attend the 19th IGES in Vancouver, where the award was presented.

His award-winning paper is entitled "Hydrogeochemical, isotopic, and rare earth element evidence for contrasting water-rock interactions at two undisturbed Zn-Pb massive sulphide deposits, Bathurst Mining Camp, N.B., Canada" which was published at the end of 1998 in the Journal of Geochemical Exploration Volume 64 and was co-authored with W.D. Goodfellow and D.R. Boyle. A copy of the abstract follows:

"A detailed hydrochemical study at two undisturbed Ordovician massive sulphide (Zn-Pb) deposits (Restigouche and Halfmile Lake deposits, Bathurst Mining Camp, New Brunswick) was initiated to elucidate the processes controlling the oxidation and dissolution of sulphide minerals, the subsequent dispersion of metals in ground and surface waters and the

Continued on Page 7

Student Prize *Continued from Page 6*

precipitation of secondary minerals. Groundwater hydrogeochemical signatures are different for the two deposits. Elements that form sulphide minerals in the deposits correlate positively in surface waters and increase with proximity to the Restigouche deposit, whereas metal contents for Halfmile Lake surface waters are lower, though still typically higher than background levels. Variations in the composition of ground and surface waters draining the two deposits reflect in part differences in the depth and geometry of the massive sulphides and host lithologies. The Halfmile Lake deposit is deeper, more steeply dipping, and overturned compared to the shallower Restigouche deposit. Groundwaters at the Halfmile Lake deposit up to 760 m below surface are low-TDS ($<250 \text{ mg l}^{-1}$), Ca-HCO_3 to Na-HCO_3 waters with oxygen and hydrogen isotopic compositions identical to surface waters. Groundwater REE patterns are flat to LREE-enriched and are similar to host lithologies, unlike the surface waters which are LREE-depleted compared to shale. The Restigouche groundwaters range up to $21,000 \text{ mg l}^{-1}$ TDS (Na-Cl waters) and display heavier oxygen and hydrogen isotopic compositions than local surface waters. Variations in groundwater composition require that the two deposits have different hydrologies which influence the natural oxidation of the massive sulphides and thus the environmental hydrochemical signature."

The Association of Exploration Geochemists would like to thank XRAL Laboratories for, once again, supporting this worthy cause, which encourages young geochemists to publish their research in a timely manner.

I.D.M. Robertson

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PRESIDENT'S MESSAGE

For those who missed the 19th IGES, you missed Vancouver at it's best. The sun was out most of the week. Wednesday was a great day to see the city, Sue and I toured the Gardens, or just enjoy the day. The 19th IGES was well attended with just under 300 attendee's from around the world. Of course what is a symposium without some controversy? For the 19th IGES it seemed to be selective ion leaches that generated the most heated discussions. The organizing committee must be congratulated and thanked for a job well done!



Erick Weiland

During the week we were able to honor three of our own: Harry Warren, Robert Boyle, and John Hansuld. It was noted that Association members are providing the scientific and technical leadership and training to deal with today's challenges. Members not only provide expertise with respect to mineral discovery but also leadership in identifying, mitigating, and reducing the environmental impact of both old and new mining developments.

I presented two challenges to the IGES attendee's and would like to extend them here to all AEG members. The first was: "to challenge each of you to continue in the fine tradition of the AEG and to advance the application of geochemistry and, in this process, help AEG provide a solid forum from which to exchange ideas and communicate advancements". The second challenge was issued during my closing address: "Geochemistry can provide a powerful exploration tool. However, it can not be used in a vacuum. Common sense and continual questioning must accompany each step. As scientists we must remember that it is our job to formulate the questions that will allow us to move forward and take care not to present as "the final truth", those ideas which are only a snap shot of our current knowledge and understanding."

Fortunately, Vancouver provided AEG Executive and Council with a great opportunity to discuss many items in greater detail than usually permitted over phone or email. Lots of discussion centered around how best to communicate with the membership and how best to use the Web page to aid in this communication. One of the ideas that is being evaluated at the present time is that of having a member-only area on the Web page which would contain the membership directory, bibliography, council meeting summaries, and other useful information. The Web page has come a long way since it's inception thanks to Eric Grunsky and Beth McClenaghan. AEG owes a real debit of thanks to Eric Grunsky for securing the www.aeg.org name and getting the web page started. As the future unfolds, the web page will increasingly be an effective vehicle for discussion and distribution of information. A drive is being spearheaded by Paul Taufen to find out how many members have access to email and to update the AEG database with email addresses. If you have any suggestions, please do not hesitate to let us know.

After many years as one of Australia's Regional Councilors, Nigel Radford has accepted the nomination for and been elected to the office of 2nd Vice-President. This means that Nigel will have increased responsibilities on the Executive, will move upward to be 1st Vice President in 2000, and will be the President of AEG in 2001. Since Paul Taufen has returned to the US, this again provides AEG with an Executive composed of representatives from the three major member countries. Nigel graduated in Earth Sciences from Leeds University (UK) in 1971. He completed a MSc in Mineral Exploration under Cliff James at Leicester University in 1972. After working in the New Hebrides in the South Pacific (rough duty - a paid vacation?) for 3 years, he went back to Leicester to complete a PhD in Geochemistry under Cliff James. He worked in uranium exploration in the UK from 1978 to 1981. Finally he tired of commuting in and out of London so he, his wife and son, headed down under emigrating to Australia in 1981. He started out based in Darwin, Senior Geochemist for Geopeko, until 1984 when he transferred to Perth and worked for BP Minerals. In 1987 he went from the BP to experience life on the edge with a active junior gold producer, Metana Minerals. In 1991 he took on his present role as Chief Geochemist with Normandy Mining. Normandy is Australia's largest and the world's 7th largest gold producer. Throughout his time on Council he has added much to AEG. Welcome aboard Nigel.

Erick Weiland

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IGES NEVADA FIELD TRIP - APRIL 1999

by Nigel Radford

Following on from the 19th IGES in Vancouver, nearly 40 of the participants, from all over the world, including North America, South America, Europe, Australasia and the former Soviet Union, took part in a novel field excursion to Nevada. The participants came from all sides of the profession, from industry, academia, laboratories, and government institutions. We visited four mines and one active prospect in three days.

The novelty stemmed from being able to examine, first hand, two active field tests of partial extraction geochemical methods. Prior to the trip, a suite of soil samples from the Ivanhoe prospect was collected and several laboratories agreed to analyse the samples by numerous different "partial" and "total" techniques. The analytical data were available to the participants at the start of the trip, and the site was visited to allow each participant to make their own interpretation.

In the second case history, we were able to visit the Marigold Mine where Barry Smee has conducted a partial extraction experiment over known mineralisation under varying thicknesses of Tertiary gravels. For further details see Barry's article in *Explore*, Number 102, January 1999.

Additionally, we were fortunate to travel in the company of Alan Coope who, in 1960, led the Newmont team that discovered the Carlin deposit, the first of the giant sediment-hosted disseminated gold deposits of the so-called Carlin type. It was

fascinating to have the insight from Alan as to what it was like in the early exploration stages when these massive deposits were first discovered. The photo below shows Alan trying to wipe the grin off his face as he examines the effects of his handiwork from the bottom of Gold Quarry. And why wouldn't he smile?



Firstly, the thanks! Thanks are due to Bruce Ballantyne and Dave Vanderkley who organised the trip on behalf of the 19th IGES. Despite their worst fears, all the plane connections worked, everyone got fed and watered and we didn't lose anyone! Bruce deserves special thanks for collecting the soil samples over Ivanhoe. We're also very grateful to Earl Abbott, Steve Freiberg and Scott Price who drove the minibuses and provided invaluable geological background to Nevada for those of us who were new to the region, as well as being great fun to have around! Thanks go to Barry Smee for sharing with us his orientation work at Marigold.

Very sincere thanks are due to the owners and staff of the sites we visited. To Great Basin Gold, and especially Jim Oliver, for showing us round Ivanhoe, for allowing us to use it as a test case study and for providing logistical support during the sample collection stage. To Glamis Gold, and Doug McGibbon, for access to the Marigold mine and allowing Barry to present his research work. To Franco-Nevada and Euro-Nevada and their staff Joe Standburg and Pat Goldstream for a fascinating visit to the Ken Snyder Gold mine at Midas. Joe and Pat kindly gave up their day-off to show us around! Greater love hath no man.....! To Barrick and to Keith Bettles and his team at Goldstrike, a truly world-class gold mine! And last but by no means least, our thanks to Newmont Gold and Robert Jackson for allowing us access to Gold Quarry, again a truly world-class operation. All the mine geologists went out of their way to present to us data of a geochemical nature as well as the more usual mine geology information.

Our sincere thanks are due to the labs which took part in the Ivanhoe exercise, namely, in alphabetical order, Acme, Actlabs, Sawex and XRAL.

We saw a dramatic variation in mine sizes, ranging from the modest 500 tpd underground operation at Ken Snyder mine to the massive Gold Quarry and Post Betze pits, where 500t is shifted by just two of the monster haulpacks leaving the pits! Grades show just as dramatic variations, going from 1 opt Au at Ken Snyder (plus 13 opt Ag) to grades of 0.05 opt Au at Gold Quarry.

With regard to the "deep penetrating" geochemical experiments, the consensus seemed to be that Ivanhoe is a tough test for any surface geochemical technique trying to detect known

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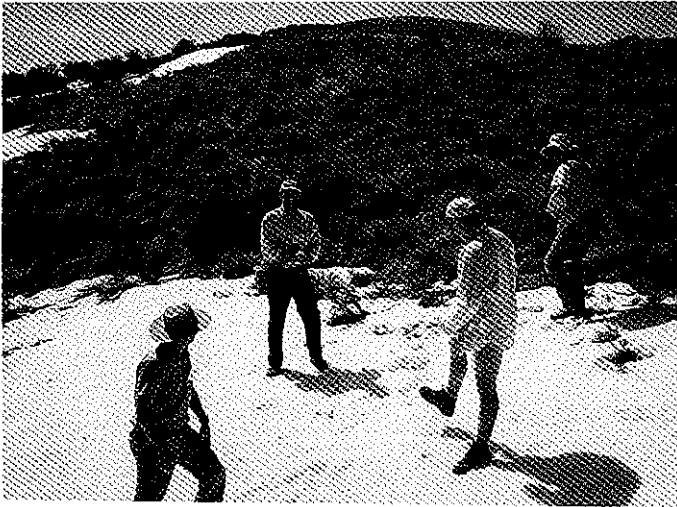
Sample preparation: Flin Flon (Manitoba), Saint John (N.B.), Yellowknife (N.W.T.), Tumeremo (Venezuela), Medellin (Colombia), Ulaanbaatar (Mongolia)

Laboratories: Ecuador, Bolivia, Brazil, Chile, Ghana, Zimbabwe, Kazakistan, Europe and elsewhere.

deeply concealed mineralisation. With time, each of us will doubtless produce several interpretations of the Ivanhoe data set, but at least we did see "rabbit's ears" over the prospect. They disappeared almost as soon as they were spotted, but they were repeatable, as the jackrabbit came back later!

There does seem to be a response over mineralisation at Marigold, but for Ca and pH rather than the elements associated with mineralisation, such as Au, As, Hg. There's a lot we have to learn yet, and these sort of field classes will help no end in adding to our fund of knowledge.

The second photo shows some of the snow-deprived,



Australian geochemists confusing the white stuff, snow, (which they were not supposed to be looking at let alone playing with) with the white quartz vein, which they were supposed to be looking at. Playing in the snow are (left to right) David Gray (CSIRO), Leigh Bettenay (Homestake Australia), unidentified line dancer with frostbitten knees, and Mel Lintern (CSIRO).

For some, the visit to Marigold was a moving experience! Barry Smee (right, kneeling) thinks Mel Lintern (head bowed in contemplation) is giving thanks to the Great Geochemist in the Sky at the anomalous soils sample pit. Mel however is trying to warm his hands after the snowball fight, and thinks the heat coming from the exothermic reaction of Barry's acid bottle might do the trick. Nevertheless, most participants got down on their knees here in front of Saint Barry, this author/



photographer included! pHallelujah!

All in all it was a great trip. And Janice Fingler even managed a win in the casino!

Nigel W. Radford

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GEOCHEMICAL METHODS FIELD TRIP

South-central British Columbia, April 16 to 19, 1999

by Beth McClenaghan and Matt Leybourne

Twenty-one participants from eight countries embarked on a three day post-conference field trip to south-central British Columbia, Canada. The trip was led by an enthusiastic team from the British Columbia Geological Survey, Peter Bobrowsky, Mike Cathro, Steve Cook, Antigone Dixon-Warren, Ray Lett and Roger Paulen. We enjoyed warm weather and beautiful mountain scenery for three days. The trip was a valuable introduction to the geology and exploration challenges in the glaciated and thick drift covered Interior Plateau as well as the geochemical exploration methods that can be used there.

The first day, we traveled east from Vancouver up the Fraser Valley and along the Coquihalla Highway where we temporarily lost Steve Cook (selective leach demonstration?) at the toll gate. We used the unplanned stop to stretch our legs and throw snow balls. At the first official stop, we examined a thick section of Fraser glaciation drift, alluvial fan sediments and buried volcanic ash exposed in a road cut just south of the town of Merritt. This was the first of many sections we would visit over the next three days that highlighted the thick and variable cover of glacial and post-glacial sediments that fill the valleys and underlie the Interior Plateau. As we left this stop, our NASCAR-trained bus driver demonstrated his hairpin turning technique as he used gravity (and not the bus engine) to hurl our bus down the mountain and into the town of Merritt, thanks to a blown hose.

Our next stop was the Big Kidd copper-gold porphyry deposit, an old copper prospect re-discovered for its significant gold content by a prospector sampling bedrock in the new highway road-cut. The prospect is an example of an alkalic porphyry deposit with high gold contents, which are uncommon except in British Columbia. The Big Kidd deposit is unusual in that it is not eroded; it has an intact volcanic neck and breccia pipe. Wine tasting at a small vineyard in Kelowna (Photo 1), followed by more wine tasting while listening to an enthusiastic presentation by a local college professor (Dr. J. Greenough) on the relationship between local sediment chemistry and wine chemistry, provided a pleasant ending to our first day. As wine

Continued on Page 10



1. Peter Bobrowsky, Beth McClenaghan and Lori Wilkinson enjoying some wines at the Quail's Gate Winery in Kelowna.

Canadian Field Trip

Continued from Page 9

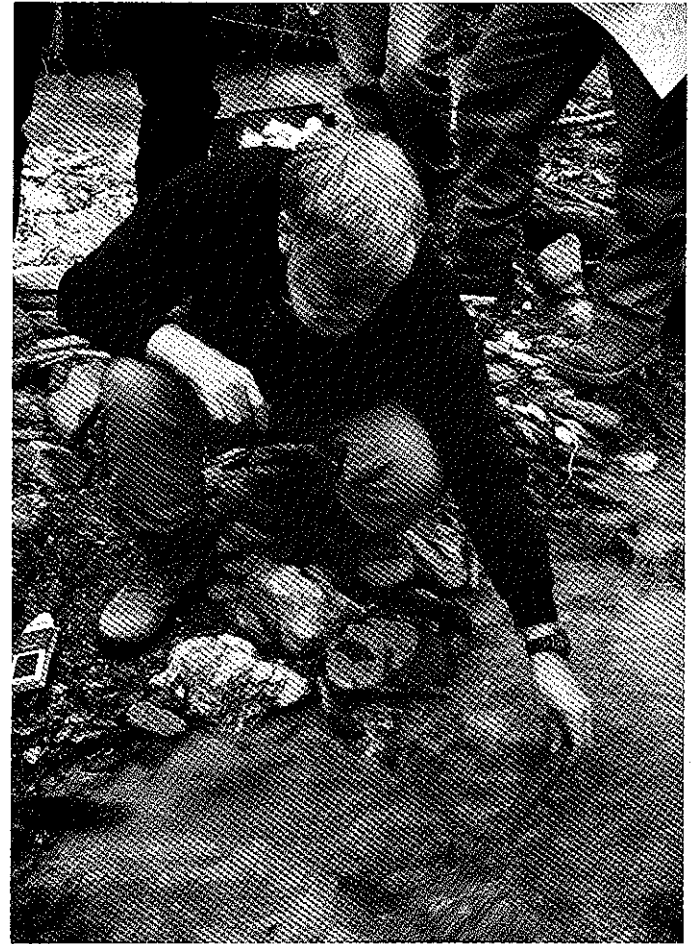
sampling progressed, so did the novelty of ideas for future geochemical research.

The second day began with an overview of Adams Lake regional till geochemical program, which is part of the British Columbia Geological Survey's 3-year integrated regional exploration program northeast of Kamloops. Field trip stops that followed allowed participants to examine a thick section of till (Photo 2), one of the main exploration sampling mediums in the region. We then proceeded to the Homestake Mine, an



2. A keen group examining a thick glacial till section at Adams Lake. Note the serious gravity problem at this site.

inactive Au-Ag-Cu-Pb-Zn deposit hosted in felsic to intermediate volcanic rocks. The orange colour of the stream water draining the deposit and abundance of Fe-coated rocks on the stream bed reflected the significant transport of metal-rich waters and precipitation of Fe and Mn oxyhydroxides. Surface water pH values in excess of 8 indicated the significant buffering/dilution by unmineralized waters. Stream water at this site contains anomalous concentrations of Au, As, Sb, Ba, Cu, Mo, Pb and Zn. This strong multielement response in water demonstrates the potential of this sample medium in detecting buried mineralization. Ray Lett (Photo 3) used this site to

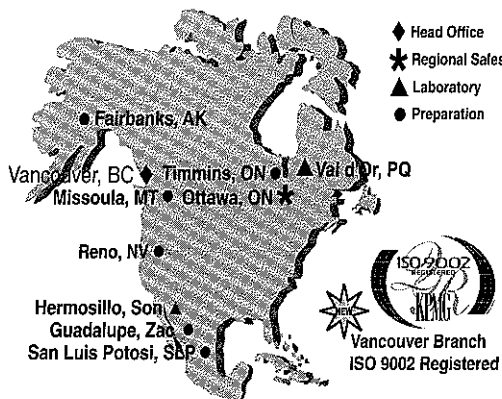


3. Ray Lett demonstrating water sampling and pH measuring techniques in a creek draining the Homestake Mine.

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demonstrate collection methods for stream sediments and waters that are typically used for regional geochemical surveys. This stop was followed by a short visit to the inactive Samatosum Mine pit (Au-Ag-Cu-Pb-Zn-barite deposit), which was discovered using soil geochemistry and diamond drilling. The initial discovery of mineralized rocks in the area was the result of anomalous stream sediment geochemistry. Our second day ended with a quick look at a thick sequence of glaciolacustrine sediments that are commonly encountered in the Thompson Valley and the south-central Okanagan area. These sediments displayed impressive dewatering and synsedimentary deformational structures.

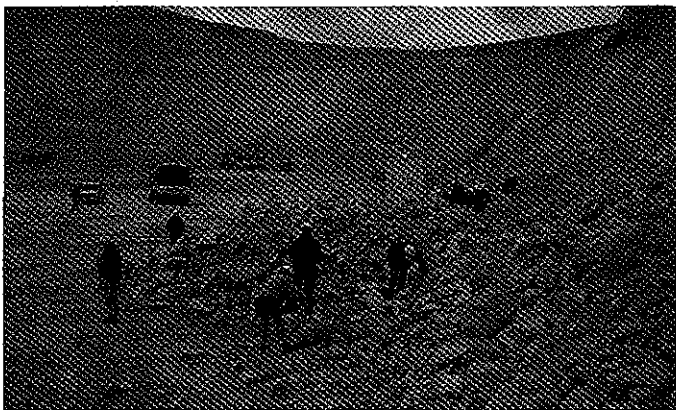
Our final day started with a demonstration of lake sediment sampling by Steve Cook. He described the British Columbia Geological Survey's regional lake sediment survey program, explained the equipment used to collect the samples and then

Continued on Page 11

Canadian Field Trip

Continued from Page 10

demonstrated his finely tuned skills as he and Mike Cathro collected an organic lake sediment sample (a very smelly one!) from the bottom of Inks Lake. We ate lunch overlooking one of the world's largest open pit Cu-Mo mines, the Highland Valley Copper mine. The Highland Valley porphyry deposits are within the Late Triassic Guichon Creek batholith. Mineralization consists of quartz veinlet stockworks with chalcopyrite, bornite, pyrite, molybdenite, digenite and covellite. The low contents of Fe-sulfides at this deposit means that acid-mine drainage problems are minimal. Unfortunately, Cominco announced just recently that the mine will be closing in the next few months



4. Collecting ore samples in the bottom of the Valley pit, at the Highland Valley Cu-Mo mine.

because of low copper prices and high electricity charges. After lunch, we toured the active Valley pit, stopping to look at the spectacular sequence of glacial sediments overlying the deposit and ending up in the bottom of the pit collecting ore samples (Photo 4). After leaving the pit, we were given a tour of the large mill complex that processes approximately 140,000 to 180,000 tonnes of ore (0.4 % Cu, 0.008 % Mo) per day. Our drive back to Vancouver at the end of the day took us through the beautiful Fraser Canyon.

This trip was well organized and covered a wide variety of interesting geological and geochemical features and sites that are significant to the exploration geochemist. The leaders ensured we were well fed and quenched with local British Columbia wines and beer. The running commentary between stops by Mike Cathro, the regional Geologist for the B.C. Mines Branch, allowed us to understand the regional geological context of each field trip stop. Mike pointed out significant geological and cultural features through the bus windows as we drove along the back roads and highways of the region. The trip was accompanied by a well documented and illustrated field trip guide book showing locations and details about stops visited over the three-day period. This field trip summary and many other colour photos from the 3-day trip can be viewed on the AEG web site at <http://www.aeg.org>.

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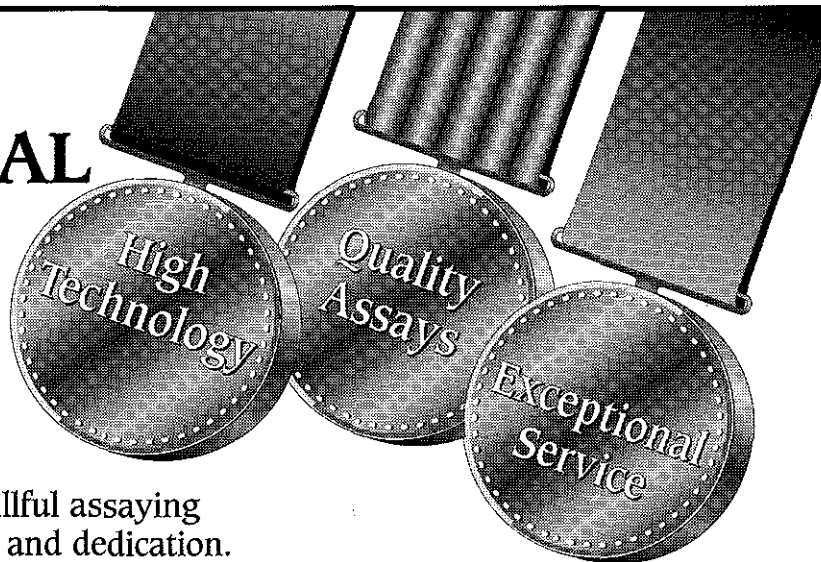
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TECHNICAL NOTE

Platinum Group Element Analyses: Comparison of Standard Analyses at four Laboratories

by Mary Doherty

Despite purported advances in the analytical chemistry of platinum group elements (PGE), our experience in recent years demonstrates that obtaining reliable PGE analyses for exploration is far from routine. This note summarizes mixed results from four commercial laboratories which indicate that diligent planning and quality control on the part of the geochemist are required, to essentially design a customized procedure with the lab in order to optimize results. In an effort to identify reliable laboratories for the determination of platinum group elements in a recent exploration program, we assembled a series of certified international reference control standards and two splits of each were submitted to four commercial laboratories in Canada and Australia. The results of this "round robin" were deemed crucial to the success of the program. Only two of the four laboratories provided reasonable determinations for the samples, and these had numerous errors. The purpose of this note is to raise awareness as to potential problems with PGE determinations rather than to harass the chemists; hence, reference will be simply to Labs 1, 2, 3, and 4.

A wide range of methods, costs, and data can be obtained for PGE determinations. Analytical methods at the laboratories


ranged from a NiS fusion / INAA determination to Pb fusion / ICP or AA determination. Costs ranged from equivalent U.S. \$35 / sample to \$125 / sample. Turn-around times for these batches of 19 samples ranged from one month to four months.

Standards were assembled from the Geological Survey of Canada (GSC), the U.S. Geological Survey (USGS), and from Brammer Standards Company. In addition, volcanic rock was pulverized to serve as a "blank". Two splits from each of these were submitted as samples to each of the four commercial laboratories, representing a "round robin" test of accuracy and precision at the laboratories. Lab #1 used a Pb fusion / ICP determination; Lab #2 a NiS fusion, INAA determination; Lab #3 either a Pb or NiS fusion / INAA determination, and Lab #4 a NiS fusion / ICP determination. Two determinations for each of these procedures are shown on the accompanying graphs.

Platinum & Palladium

High concentrations for Pt (>1 ppm) are contained in standards SARM-7 (S. Africa - Accepted value 3.74 ppm Pt), and STC-1 (USGS, accepted value 2.44 ppm Pt). There is little agreement between labs in the determination of Pt & Pd for standard STC-1. There is either a problem with homogeneity of PGE in this standard, or all of the labs struggled with this sample matrix. Lab #1 was within range for SARM-7 but unacceptably high for STC-2. Lab #2 obtained correct analyses for SARM-7 and acceptable range for the Pd in STC-1. Lab #4 did not correctly identify the concentrations for any of these samples, being off in both accuracy and precision based on two analyses. Lab #3 analyzed these standards via NiS fusion / INAA determination twice and by Pb collection / ICP determination twice.

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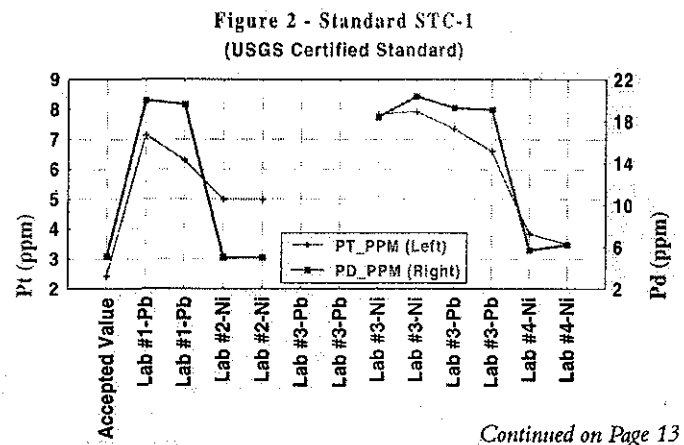
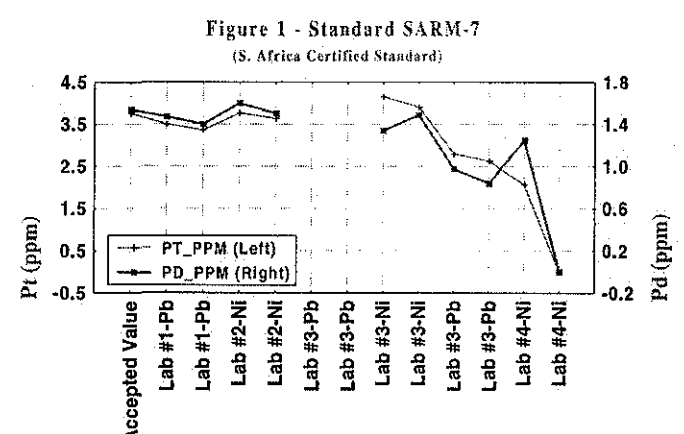
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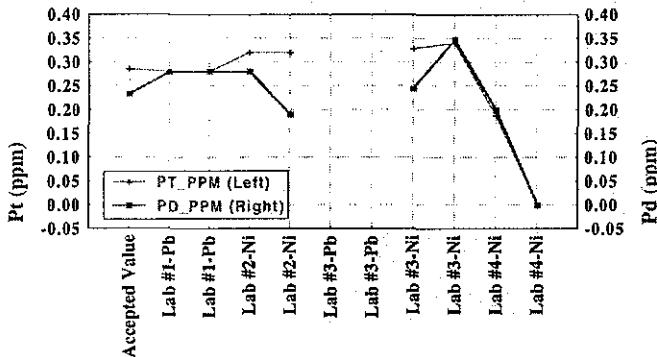
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Technical Note

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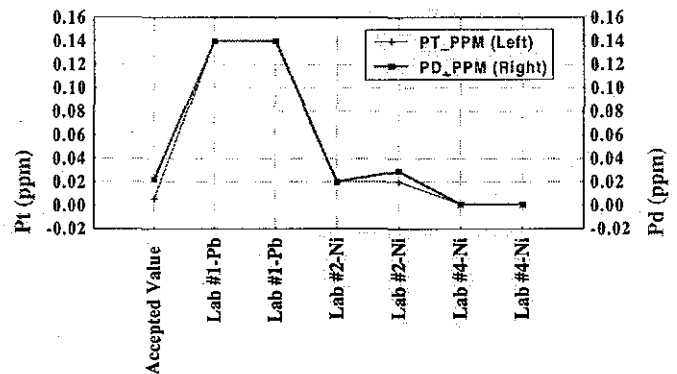
The first two determinations shown in Figures 1 and 2 are those from the NiS collection procedure, the latter two concentrations are from the Pb collection procedure. The lead collection fire assay method provided consistently lower results for these as well as all of the other standards. Note the discrepancy between Pt and Pd in the first NiS determination at Lab #3, SARM-7. It appears that inadequate parting of Pt and Pd provided erroneously high Pt and low Pd results. The second determinations were closer to accepted values. Determinations for STC-1 were off with both methods at Lab #3.

Figure 3 - Standard WPR-1
(GSC Certified Standard)




Moderate concentrations for Pt (>0.1 ppm <1 ppm Pt) are contained in standard WPR-1 (GSC standard, accepted value 0.285 ppm Pt). Lab #1, Lab #2, and Lab #3 were all within acceptable range with good precision for WPR-1, with Lab #1 reporting 0.28 ppm, Lab #2 0.32 ppm, and Lab #3 0.33 ppm Pt. Lab #4 erred for both determinations.

Figure 4 - Standard TDB-1
(GSC Certified Standard)




Low concentrations of Pt (<0.1 ppm) are contained in standards TDB-1 (GSC standard, accepted value 0.0058 ppm Pt), and WGB-1 (GSC standard, accepted value 0.0061 ppm Pt). Both standards are reported as <0.14 by Lab #1, a very high detection limit. Lab #2 reported a detection limit of 0.02 ppm and correctly reported these standards at or below detection

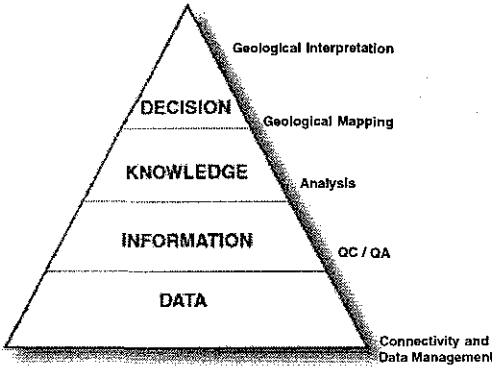
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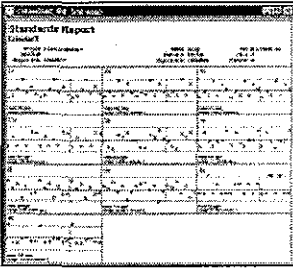


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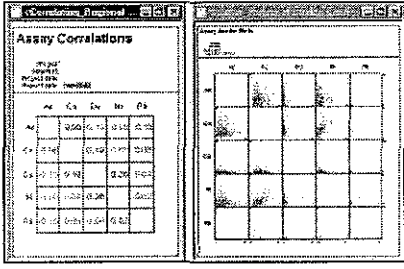


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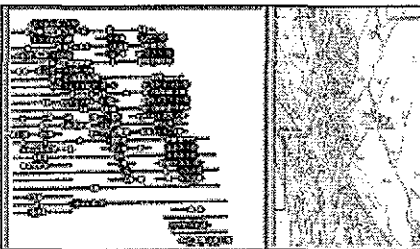
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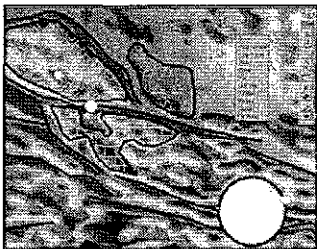
Increase Success through Careful Quality Control



Identify Relationships with Interactive Multi-Element Analysis



Create Geochemistry or Multidisciplinary Maps and Link to Original Data

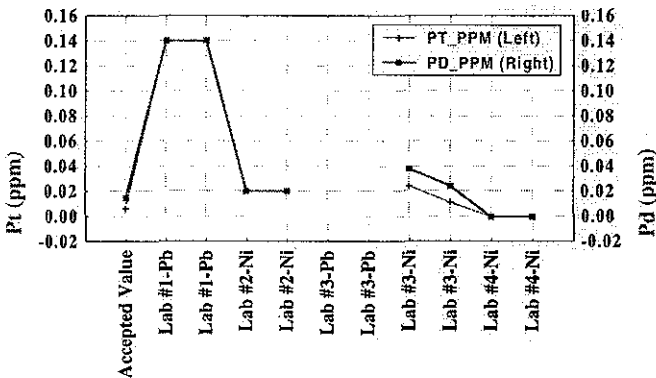


Develop Geologic Interpretations Dynamically on Your Desktop

Technical Note

Continued from Page 13

Figure 5 - Standard WGB-1
(GSC Certified Standard)



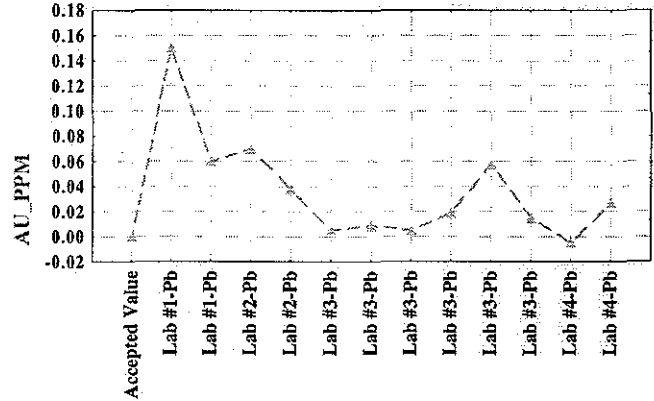
limits. Lab #4 reported a detection limit of 0.0005 ppm and erroneously reported all three standards to be less than detection limits of 0.0005 ppm. Lab #3 provided determinations ranging from 0.024 to 0.01 ppm Pt, reasonable at these ranges.

The volcanic blank should have no detectable platinum, and should have been reported at less than detection levels by all of the labs. Lab #1 reported 0.14 ppm and < 0.07 ppm Pt for the blank. Lab #2 reported less than detection limit of 0.02 ppm. Lab #3 reported 0.0011 and <0.0005. Lab #4 detected Pt and Pd although concentrations reported by this lab for the standards were generally low.

Gold

The volcanic blank has been used repeatedly in our gold program, and contains no gold. All four of the labs reported Au in these samples, ranging from < 0.005 to 0.15 ppm Au. Gold was also erroneously high in determinations by Lab #1 for several of the other low grade standards.

Figure 6 - Gold Concentrations Reported in Blank



Conclusions

The best analytical data for the platinum, palladium and gold were provided by a NiS collection fire assay / INAA determination, essentially handled as a customized assay. This

Continued on Page 15







GEOLOGY AND ORE DEPOSITS 2000:

The Great Basin and Beyond

A Geological Society of Nevada Symposium
May 15-18, 2000,
Reno/Sparks, Nevada, USA

Co-sponsored by:

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Deadlines for the Next Four Issues of EXPLORE

Contributors's deadlines for the next four issues of EXPLORE are as follows:

Issue	Publication date	Contributor's Deadline
105	October 1999	August 31, 1999
106	January 2000	November 30, 1999
107	April 2000	February 28, 2000
108	July 2000	May 31, 2000

Shea Clark Smith

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3rd Announcement and Call for Papers

GEOLOGY AND ORE DEPOSITS 2000: The Great Basin and Beyond

A Geological Society of Nevada Symposium May 15-18, 2000

John Ascuaga's Nugget, Reno/Sparks, Nevada, USA



Dear Colleague:

The Geological Society of Nevada (GSN) is pleased to report on the progress of the upcoming Symposium—*Geology and Ore Deposits 2000: The Great Basin and Beyond*. The Symposium will be held in Reno-Sparks, Nevada, May 15 through 18, 2000 at John Ascuaga's Nugget. The 1995 Symposium was attended by nearly 1,500 registrants and guests from around the world. We look forward to your attendance in the year 2000. Please help GSN achieve its goal of 2000 attendees by distributing this announcement to people who are not on our mailing list. The Symposium events are accomplished solely with the hard work and determination of volunteers interested in expanding educational and informational opportunities. The Symposium provides a forum for verbal presentations and for publishing quality and timely information related to the Earth Sciences and the Exploration and Mining Industry. The Symposium also provides an excellent networking opportunity for those companies that service the industries associated with the Earth Sciences and Mining. Students in particular, are encouraged to submit papers for either Technical or Poster Sessions. Prizes will be awarded for the best papers authored and presented by students enrolled in degree programs. Registration information will be distributed in late October along with the 4th Announcement.

The Symposium will examine the geologic and tectonic setting of ore deposits worldwide, with particular emphasis on the geology of world class mineral districts within and outside the Great Basin of the western United States. Descriptive papers on recently discovered ore deposits are especially encouraged, as are papers on general geology, geochemistry, geophysics, and tectonics of the Great Basin and western Cordillera. Original papers on geology and ore deposits outside the Great Basin are expressly invited. There will be Keynote and Luncheon presentations by eminent geoscientists currently involved in research relating to the session topics.

Call for Papers:

The Program Committee invites abstracts of original papers (for oral or poster presentations or for publication-only) bearing on the following sessions. Abstracts can be mailed or faxed to the address below, or authors may e-mail them to GSN by pasting into a normal e-mail message (do not send as attachments). **The deadline for submission of abstracts, short papers and full manuscripts is October 1, 1999** — the same date for all three. Prior to the submission deadline, authors are encouraged to submit abstracts so the Program Committee can begin organizing the oral/poster sessions. Abstracts will be limited to 400 words. Abstracts, short papers and full manuscripts will be reviewed and returned to authors if revisions are necessary. The deadline for final revised abstracts is February 1, 2000.

Co-sponsors:



Nevada Bureau of Mines and Geology

The deadline for final revised short papers and full manuscripts is April 1, 2000. *Symposium Proceedings* are to be published by October 2000. To meet the printing schedule, abstracts, short papers and full manuscripts received after the above deadlines **will not** be considered for publication.

Detailed instructions for abstract and manuscript preparation can be found in the "Authors Guidelines" section of the GSN Web site (<http://www.seismo.unr.edu/GSN>), or authors may request a copy of the guidelines by writing or calling the GSN office at 775/323-4569.

GSN will publish a *Program with Abstracts*, hard-bound volumes and CDs of the 2000 *Symposium Proceedings* and *Field Trip Guidebooks*.

TECHNICAL PROGRAMS

Geology of Nevada in the Context of the Great Basin and the Cordillera

Leaders: J. Price, C. Henry, L. Garside, J. Faulds (all NBMG)

Ore Deposit Modeling for Frontier Exploration

Leaders: T. Theodore (USGS), P. Vikre (Consultant), G. Arehart (UNR)

Environmental Geology—From Exploration to Remediation

Leaders: D. Struhsacker (Consultant), R. DeLong (EMA)

World Class Ore Systems—Ultimate Origins

Leaders: T. Thompson (CREG, UNR), D. Groves (Newmont)

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Leaders: P. Highsmith (Chemex), P. Lechler (NBMG)

Tectonics and Ore Deposits

Leaders: E. Jones (GeoLogic Services), J. Faulds (NBMG)

Ore Deposits in Volcanic Terranes

Leaders: B. Bennett (Romarco), A. Carpenter (Nevada Colca)

Tons and Grade—Descriptive Geology of New Discoveries

Leaders: E. Lauha (Barrick Goldstrike Mines), B. Hays (Cortez Gold Mines)

General information about the Technical Sessions can be obtained from the Symposium Web site (<http://www.seismo.unr.edu/GSN>) or the Technical Program Co-chairs: J. Kelly Cluer, Cameco (U.S.) Inc., 5450 Riggins Court, Suite 6, Reno, NV 89502, 775/829-8877 or e-mail: kcluer@aol.com; Jonathan G. Price, Nevada Bureau of Mines and Geology, Mail Stop 178, University of Nevada, Reno, NV 89557-0088, 775/784-6691 ext 126 or email: jprice@unr.edu

POSTER AND CORE DISPLAYS

Posters and displays of core and rock from ore deposits and interesting geologic occurrences will be featured throughout the Symposium. Booth space will be made available for the display of rocks and specimens which are featured in posters, and exhibitors of core and rock displays are encouraged to provide complementing poster-like presentations with their specimens. Additionally, these displays will feature maps and rocks from the symposium technical program and field trips. For further information contact the Core Shack/Poster Session Chairpersons: Eric Struhsacker (775/826-1418) or Dick Hardyman (775/345-1530).

WORKSHOPS

A number of topics have been submitted for consideration as pre- and post-meeting short courses. Courses proposed include several on exploration related geochemistry, Geographic Information Systems, geophysics, exploration photogeology, giant porphyry deposits—a global perspective, environmental data needed for use in the permitting process, sampling techniques for quality assurance, and remote sensing. Additional proposals are still being accepted. Contact Workshop Chairpersons Greg French (775/856-2422) or Pam Klessig (775/827-8859) for further information.

EXHIBITORS

Exhibit booths featuring mining and exploration products and services will be present during the meeting. To reserve a booth or for further information contact Exhibitor Chairperson Cami Prens at 775/856-5700.

BEST STUDENT PAPER AWARDS

Awards will be given for the best papers authored and presented by students enrolled in degree programs.



FIELD TRIPS

Sediment-hosted Gold Deposits of China

This ten-day pre-meeting trip will visit several gold deposits including Zhenan in the Shannxi Province, Qiao-Shang deposit in the Sichuan Province and the Longshui deposit in the Schuan Province. Visits to the world famous terra cotta soldiers and the horse tomb figures in Xian and the Jin-Zhai-Gou National Park in Schuan are planned. The trip has limited registration, and interpreters will accompany you. You must sign up early and commit to about \$3500 in expenses.

Volcanic History, Structure, and Mineral Deposits of the North-central Northern Nevada Rift

This three-day post-meeting trip will focus on the relations between the northern Shoshone Range, the Sheep Creek Range, and the Snowstorm Mountains. Mine and district visits include Midas, Ivanhoe and Mule Canyon.

Structure, Volcanic Stratigraphy, and Ore Deposits of the Pah Rah Range, Washoe County, Nevada

This two-day pre-meeting trip will focus on newly discovered relationships in the structure, stratigraphy, and ore deposits of the Pah Rah Range. Visits are planned to the Pyramid and Olinghouse mining districts.

Tilted Middle Tertiary Ash-flow Calderas & Subjacent Granitic Plutons, Southern Stillwater Range, Nevada: Cross Sections of an Oligocene Igneous Center

This two-day pre-meeting trip will examine extrusive and intrusive rocks of three steeply tilted calderas in the southern Stillwater Range. Stops will examine structural and volcanic features related to the formation of calderas, field relations constraining origin and timing of extension, and features of caldera-related hydrothermal systems. The Wonder epithermal vein district will be visited.

Eocene Magmatism and its Role in Generating Sediment-hosted Gold Deposits of the Carlin Trend, Nevada

This three-day pre-meeting trip will examine Eocene volcanic and intrusive centers in and around the Carlin trend. The trip will visit the Marys Mountain-Emigrant Pass and Tuscarora volcanic fields, volcanic-hosted deposits of the Tuscarora district, and

several deposits on the Carlin trend including Post-Betze, Genesis, and Beast where Eocene intrusive rocks are associated with ore.

Ore Deposits of the Battle Mountain Area, Nevada

This two-day pre-meeting trip will focus on the geology of ore deposits hosted by Pennsylvanian and Permian sedimentary rocks that are found in the Battle Mountain area. Mine tours, supplemented by stops at other surface exposures, will examine the varying influence of structure, intrusive rocks, and lithologic variations within the Pennsylvanian-Permian strata on gold mineralization. Tours of the Marigold and Lone Tree gold mines, the Phoenix project's Au-Cu-Ag skarn (including the Fortitude open pit) at Copper Canyon, and a core shack presentation of the Red Line gold skarn are planned.

Giant Sedimentary-rock-hosted Mineral Systems of the Carlin Trend: Gold Quarry and Post-Betze Deposits, Nevada

This two-day post-meeting trip will focus on the geologic settings and attributes of the giant Gold Quarry and Post-Betze mineral systems on the Carlin Trend. The trip will include presentations on the geology and mineral deposits of the greater Gold Quarry and Goldstrike areas, tours of the Gold Quarry and Post-Betze open pits, and core and cross-section displays of the refractory "roots" to these systems (e. g. Deep Sulfide Feeder, Deep Post/Meikle). Visits to peripheral occurrences at Dee and Rossi are also planned.

Cortez to Eureka Gold Deposits

This two-day pre-meeting trip will visit some of the sediment-hosted gold deposits on the Battle Mountain to Eureka Mineral Belt. Major stops include tours of the Pipeline, Gold Acres, Cortez, Tonkin Springs, Gold Bar and Ruby Hill mines.

Geology and Ore Deposits of the Getchell Gold Trend, Osgood Mountains, Humboldt County, Nevada

This two-day post meeting trip will examine the stratigraphy and structural geology of the Osgood Mountain region, and tour the gold mines of the Trend. These mines include Getchell, Twin Creeks, Pinson, and Preble.

Comparisons of Various Types of Volcanic-hosted Ore Deposits in South Central Nevada

This three-day, post-meeting trip will examine different styles of mineralization, host rocks and structural controls of several of the classic deposits in south central

Nevada. Tours include the Rawhide Au/Ag system with mineralization occurring as sheeted and stockworked quartz/adularia veinlets; the Ag/Au vein systems of the historic Tonopah mining district, with a short presentation proposing a magmatic source for the mineralization, followed by examination of the outcropping stoped veins and alteration system; a fracture controlled/disseminated deposit at Three Hills; mineralization in the high sulfide caldera related system at Goldfield; and a tour through the world-class deposit at Round Mountain, where mineralization occurs as quartz-adularia veinlets, disseminations and high-grade veins.

Copper Deposits of the Great Basin, Nevada

This three-day post-meeting trip will focus on the different types of copper deposits found in the Great Basin. Visits are planned to Yerington district, Robinson Project near Ely, and the new Tonopah Copper SX-EW mine.

Cenozoic Tectono-Magmatic Evolution of White Pine County: Core Complexes, Eocene-Oligocene Volcanic Centers, Episodic Extensions and Shortening, and Disseminated Gold Deposits, Nevada

This three-day post-meeting trip will examine new geologic and geochronologic evidence for the timing, magnitude, and structural style of Mesozoic (?) crustal shortening and episodic large magnitude Cenozoic extension, volcanism, lake deposition, and epithermal gold deposits in the eastern Great Basin. A geologic transect across the White Pine, Egan, Schell Creek, and Snake Ranges will serve as the basis for examining the evolution of many tectonic, structural, and hydrothermal features found in the eastern Great Basin.

Paleozoic Tectonics of Nevada

The goal of this three and a half day field trip is to stimulate new thinking about how Paleozoic tectonic events in Nevada can be interpreted and to explore the relationships of the many important events to ore deposits in Nevada and elsewhere. We will examine exposures of Paleozoic rocks and structures in northern and central Nevada to give participants a first hand look at the controlling geologic evidence for interpretations of the Paleozoic tectonic history of Nevada. The field trip will visit deformed and undeformed rocks of the Lower Paleozoic miogeocline; the Roberts Mountains terrane, deformed and displaced lower Paleozoic clastic facies in the Osgood block, and the Pennsylvanian overlap assemblage and unconformity.

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Technical Note

Continued from Page 14

method provided reasonably accurate results for this comparison with few exceptions. Turn-around for the analyses provided by this method was 3 months at a cost of US\$125 / sample. Similar methods at other labs, as well as alternative methods, provided a complete array of analytical results. Some error in platinum and palladium results may be attributed to sampling error in the higher concentration standards.

The Au determinations were erroneous, particularly when samples contained significant platinum group element concentrations. Gold was consistently reported high in the blank samples submitted.

Selection of an analytical procedure and laboratory for PGE analyses requires discussion with the laboratory chemist prior to submitting samples to the laboratory. Vigilant use and evaluation of quality control sample data is crucial. Complexity of the PGE determination requires care in sampling design, sample collection, sample preparation, and a custom analytical procedure, all of which should be carefully monitored.

Mary E. T. Doherty

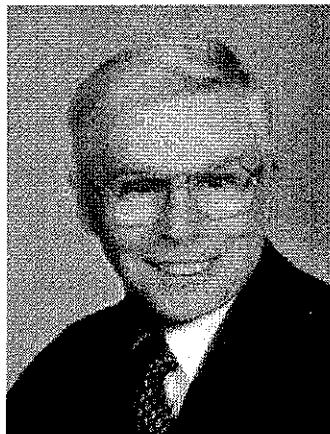
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TECHNICAL NOTE

"Near-total" Acid Digestions

by *Gwendy E.M. Hall*



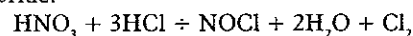
Dedicated to the memory of John Lynch, Geological Survey of Canada, 1955-1998

This article is prompted by various remarks made during the recent Nevada field trip, associated with the 19th IGES held in Vancouver, which focussed on the application of partial extractions in mineral exploration. There seems to be a trend, probably invoked by the use of weak leaches, to label the aqua regia digestion "near-total", a term which I

think is more appropriately reserved for the "three or four acid" digestion, HF-HClO₄-HNO₃-HCl. Ears pricked up, for example, when several colleagues apparently understood barite to be largely decomposed by aqua regia! I thought it might be worthwhile to revisit the properties of these two digestions and to evaluate the effectiveness of aqua regia using control reference material (CRM) datasets published by the late John J. Lynch of the Geological Survey of Canada. Useful sources of information on digestion of geological materials are Dolezal et al. (1968), Bock (1979) and Chao and Sanzolone (1992).

Aqua regia

This mixture of 3 parts HCl to 1 part HNO₃ owes its strong oxidising power to the formation of nascent chlorine and nitrosyl chloride:



It is an efficient solvent for: numerous metal sulphides (e.g. galena, sphalerite, molybdenite, pyrite, marcasite); many sulphates (except barite); arsenides, selenides, tellurides; native Au, Pt and Pd; minerals belonging to the group of simple oxides (e.g. U) and their hydrates (e.g. Fe-Mn); phosphates (e.g. apatite); carbonates; and organically-bound elements. Silicates which are attacked include zeolites, the nepheline group, leucite, silicates containing carbonate or sulphate anions, the majority of Fe silicates (some sedimentary Fe silicates of the leptochlorite group are difficult to decompose) and transition metal silicates, some garnet types and Fe-containing mica types, in addition to lesser known minerals of REEs, Zr and Th. However, most silicates and oxides (e.g. of Al) remain only slightly attacked (see Foster, 1971). HF can be added to aqua regia to promote silicate decomposition but this is not regular practice in commercial laboratories.

Decomposition with aqua regia is usually carried out in borosilicate test-tubes or beakers placed in or on a heating block, hot plate or water bath. It is normal practice to heat the sample in aqua regia for several hours and to dilute the solution prior to analysis. Evaporation to dryness is not normally carried out and thus elements such as Hg, As, Sb, Se, Te and Bi are not lost by

Continued on Page 16



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Acid Digestions *Continued from Page 15*

volatilisation. There is sufficient Cl^- ion to complex Ag (AgCl_2^-) for most geological samples so that results for Ag are not low due to precipitation of AgCl . Similarly, in typical geochemical exploration materials there is usually not enough SO_4^{2-} (formed by oxidation of sulphides) or Pb^{2+} present to precipitate PbSO_4 . Upper limits for elements such as Ag and Pb , however, are quoted by some laboratories, which is informative. Almost every commercial laboratory has its own aqua regia procedure. Some add HNO_3 first as an initial oxidant, whereas others might add HCl first to attack oxide or basic nitrate films. Some even add water to the 3:1 mixture, an action which prompted the statement "there is no such reagent as dilute aqua regia" (Chao and Sanzolone, 1992, p.70). The ratio of sample weight to volume of aqua regia varies (e.g. 1 g to 6 ml, 0.5 g to 4 ml), as does the time of digestion (e.g. 1-3 h) and temperature (e.g. 95-120°C). It is hardly surprising that biases are detected when comparing datasets generated by different laboratories. Perhaps this is an area where standardization of procedures would benefit the users of these data.

In spite of only partial decomposition for numerous minerals, many elements are reported off an aqua regia digestion as the information is available from the analytical technique(s) (ICP-AES and ICP-MS) and this can be extremely useful. Elements commonly determined include Ag , *Al*, As , (Au - separate analysis), *B*, *Ba*, *Be*, *Bi*, *Ca*, *Cd*, *Co*, *Cr*, *Cu*, *Fe*, *Ga*, *Hg* (separate analysis), *K*, *La*, *Mg*, *Mn*, *Mo*, *Na*, *Ni*, *P*, *Pb*, *S*, *Sb*, *Sc*, *Sr*, *Th*, *Ti*, *Tl*, *U*, *V*, *W* and Zn . Those shown in italics are indicated by various laboratories to be partial in their extraction.

HF-HClO₄-HNO₃-HCl

This "three or four acid" digestion actually incorporates the first three acids for the decomposition stage and HCl for dissolution of the salts remaining following evaporation. The acids, HClO_4 and HNO_3 , provide the oxidising power while HF breaks up the strong Si-O bond to form SiF_4 which volatilises upon heating. Mineral phases which are resistant to attack (as they would be also by aqua regia), to varying degrees, include cassiterite, rutile, monazite, ilmenite, garnet, wolframite, spinels, sphene, beryl, zircon, tourmaline and high concentrations of barite. Ignoring this fact can lead to misinterpretation of data and subsequently to incorrect hypotheses, as indicated in a study of REE fractionation by Hall and Plant (1992).

Decomposition involving HF is carried out in PTFE or Pt beakers on a hot plate so that reaction products can be fumed off and the sample taken to insipient dryness prior to solubilization in the final acid medium. Fuming to white fumes of HClO_4 not only breaks down insoluble fluorides (e.g., those of the REEs and Ca) but also eliminates Si (as SiF_4) which would otherwise hydrolyze and precipitate on standing, thereby removing some trace elements from solution. To achieve this end, repetitive fuming with HClO_4 is preferable to single action rapid evaporation. Some procedures specify addition of HF alone initially while others call for the three acids to be added at once. This order of addition and attack can have an impact on loss of elements by volatilization. For example, the presence of HClO_4 can inhibit volatilization by oxidizing elements such as As and Sb to their less volatile V valency state. Other elements which can be lost through volatilization of their fluorides include B , Ti , Nb , Ta and Ge ; Au and Cr may be lost by volatilization of

their chlorides.

There are many variations of the $\text{HF-HClO}_4\text{-HNO}_3\text{-HCl}$ procedure but normally the mixed acids are evaporated to dryness and the residue dissolved in HCl (0.5-1 M) for analysis. Although closed-system decomposition under elevated conditions of pressure and temperature in a microwave oven has the advantages of a much stronger attack on refractory minerals and a reduction in volatilization loss, its much lower productivity and higher cost have inhibited its adoption by commercial laboratories. In addition to the elements listed above for aqua regia, a "package" based on the four-acid decomposition will often include Ce , Cs , Ge , Li , Nb , Rb , Ta and Zr , though not necessarily as a total analysis.

Continued on Page 17

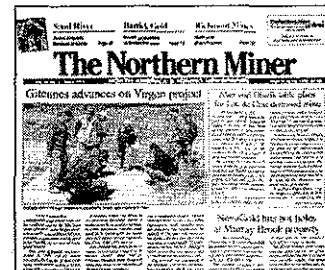
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Acid Digestion

Continued from Page 16

Effectiveness of aqua regia decomposition for the LKSD, STSD and TILL series of the GSC

Three publications by John Lynch (1990, 1996, 1999), late of the GSC, allow us to evaluate the effectiveness of the aqua regia decomposition for 12 international CRMs which he prepared and certified. The lake sediment (LKSD 1-4), stream sediment (STSD 1-4) and till (TILL 1-4) samples were sieved to <80-mesh, ball-milled and again sieved to <200-mesh (74 µm). Complete descriptions of these samples, homogeneity testing and John's approach to data compilation and statistical treatment can be found in his publications. Initially, about 35 laboratories took part in the round-robin but eventually data from about 22 laboratories (with multiple replicates of each CRM) were used in establishing recommended values. The LOI (surrogate for C content), SiO₂, CaO and S contents of the 12 CRMs are given in Table 1.

Table 1. LOI, SiO₂, CaO and S contents of the 12 CRMs; data in %.

	LOI	SiO ₂	CaO	S		LOI	SiO ₂	CaO	S
LKSD-1	23.5	40.1	10.8	1.57	STSD-3	21.6	48.6	3.3	0.14
LKSD-2	12.3	58.9	2.2	0.14	STSD-4	10.2	58.9	4.0	0.09
LKSD-3	11.8	58.5	2.3	0.14	TILL-1	7.3	60.9	2.8	<0.05
LKSD-4	40.8	41.6	1.8	0.99	TILL-2	8.2	60.8	1.3	<0.05
STSD-1	29.7	42.5	3.6	0.18	TILL-3	4.6	69.1	2.7	<0.05
STSD-2	8.7	53.7	4.0	0.06	TILL-4	5.7	65.1	1.3	0.08

LOI can be taken as a guide for the organic carbon content, for example LKSD-1 contains 12.3% C whereas LKSD-2 contains 4.5%.

The elements for which we have both aqua regia and 'total' data are Ag, Al, As, Ba, Ca, Cd, Co, Cr, Cu, Fe, Mg, Mn, Mo, Ni, P, Pb, Sb, Sr, Ti, V and Zn. Only a few CRMs have both sets of data for Ag and Mo as concentrations are often below detection limits. Total data were derived by application of the techniques of INAA and XRF, and by solution-based techniques following LiBO₂/Li₂B₄O₇ fusions or HF-based acid digestions. Low results were evident for Cr, Y, Zr, Tb, Er, Yb and Lu by the HF-based digestions and so were not included in the calculation of recommended values. The aqua regia digestions varied in heating time, from 2 to 4 h (usually at 90°C), and in contact time prior to heating from 1 h to overnight. Several laboratories employed the Lefort aqua regia, reversing the ratios of HNO₃ and HCl, but as the results agreed well (within expected analytical limits) with those by aqua regia, they were included in the compilation. The reader may glean an appreciation of typical precision across the labs from selected data in Table 2.

Table 2. Data, compiled by Lynch (1990, 1996, 1999), randomly selected to show typical precision of aqua regia based results.

Element	Mean ± SD	Element	Mean ± SD
Al, %	1.87±0.25, LKSD-2	Mn, ppm	950±70, TILL-1
As, ppm	23±6, LKSD-2	Ni, ppm	44±4, LKSD-3
Ba, ppm	110±5, STSD-2	P, ppm	1290±99, LKSD-2
Ca, %	1.64±0.07, STSD-1	Pb, ppm	40±7, LKSD-2
Cd, ppm	1.2±0.3, LKSD-1	Sb, ppm	2.0±1.0, STSD-1
Co, ppm	11±1, STSD-4	Sr, ppm	41±5, LKSD-2
Cr, ppm	30±3, TILL-1	Ti, ppm	1070±202, STSD-4
Cu, ppm	43±3, STSD-2	V, ppm	48±8, TILL-1
Fe, %	2.0±0.1, TILL-3	Zn, ppm	192±11, STSD-3
Mg, %	0.92±0.10, LKSD-3		

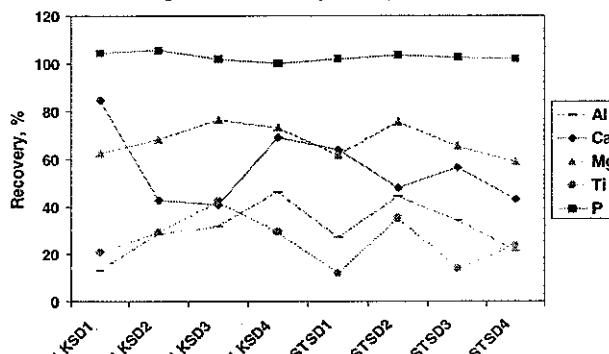
The recoveries of these elements by the aqua regia extraction, as a percentage of the total concentration, are shown in Figs. 1 (Al, Ca, Mg, Ti, P), 2 (Ba, Co, Fe, Mn, Ni), 3 (Ag, Cd, Mo, Sb, Sr) and 4 (As, Cr, Cu, Pb, V, Zn). The range in recoveries is summarised in Table 3. A wide range is evident for most elements, particularly for Ba at only 9% in TILL-1 to 64% in STSD-4. Recoveries are well below 50% for Al, Sr and Ti and below 64% for Ba, Cr and V. Majors Ca and Mg show ranges in recovery of 41-85 and 59-77%, respectively (Fig. 1). Iron and Mn tend to exhibit similar extraction efficiencies in the LKSD series, at about 60-90%, but their behaviour diverges for the other CRMs (Fig. 2).

Table 3. Range in recoveries by aqua regia for elements in LKSD, STSD and TILL series of CRMs. Only LKSD and STSD data available for Al, Ca, Cd, Mg, P, Sb, Sr and Ti.

Element	Range, %	Element	Range, %
Al	13-46	Mn	53-95
As	72-97	Ni	69-100
Ba	9-64	P	100
Ca	41-85	Pb	55-100
Cd	75-100	Sb	49-100
Co	67-100	Sr	15-37
Cr	32-64	Ti	12-42
Cu	92-100	V	46-67
Fe	62-93	Zn	71-100
Mg	59-77		

Phosphorus is fully extracted from all LKSD and STSD samples (Fig. 1). While Cd and Cu appear to show low results for a few CRMs, the mean values are within the limits set by the standard deviations of the data and hence they can be considered to be completely extracted. For example, Cu in STSD-2 is 43±3 ppm by aqua regia, compared to the total value of 47±5 ppm. Cobalt and Zn are significantly low in TILLS 1 and 3 and Zn is in STSD-4, at 82±8 ppm compared to 107±12 ppm. Although As and Ni are significantly low only in LKSD-1 (e.g. for As, 30±6 compared to 40±2 ppm), they tend to be low by aqua regia for all 12 CRMs (Figs. 2, 4). Results for Pb in the lake and stream sediments by aqua regia are in agreement with total values; it is only in the tills where they are low (e.g. at 22±3 cf to 12±1 ppm in TILL-1). Aqua regia results for Sb are in agreement with total values for the LKSD series but tend to be low in the STSD series and there, just significantly in STSD-4, at 3.6±2.5 ppm compared to a total value of 7.3±0.7 ppm. In terms of trends, there is a significant decrease in recovery in the TILL series (cf to lake and stream sediments) for Ba (Fig. 2) and Pb (Fig. 4), and to a lesser extent, for Mn (Fig. 2) and Zn (Fig. 4). Similarly, recoveries for Sb, and to a lesser degree, for Fe, Co, Cr and V, are lower in the stream sediments than in the lake

Fig. 1. Recovery in aqua regia



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Acid Digestion *Continued from Page 17*

sediments. Earlier work by Hall and Pelchat (1997a, b) demonstrated that low results were obtained for Sb, and to a greater degree for Se and Te, by aqua regia digestion of some of the Chinese rock (GSR series) and stream (GSD series) CRMs.

In John Lynch's compilations, there is another set of data reported under the category "dilute HNO₃-dilute HCl". These data are based on a variety of acid strengths: two laboratories used 6M HCl-2.7M HNO₃; two others employed 1M HCl-4M HNO₃; and a fifth laboratory used 5M HCl-3M HNO₃. Heating

Fig. 2. Recovery in aqua regia

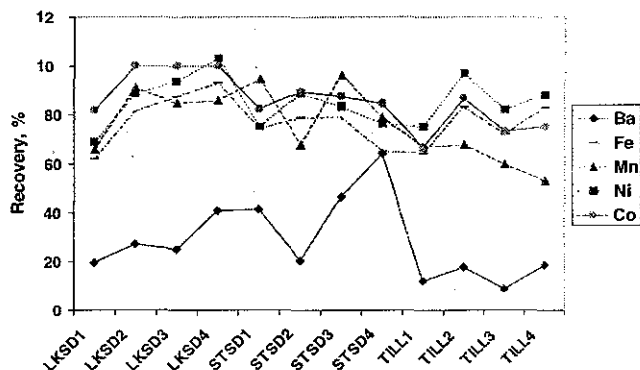


Fig. 3. Recovery in aqua regia

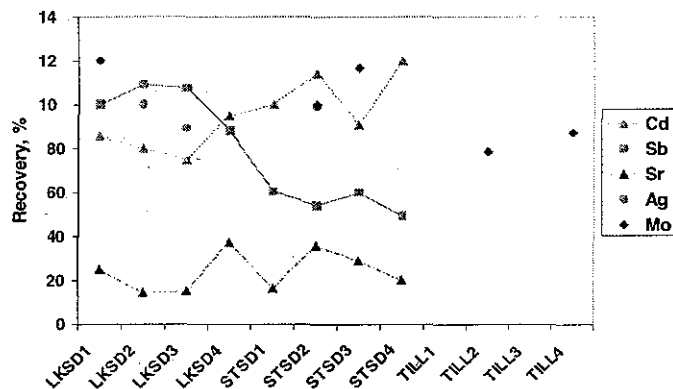
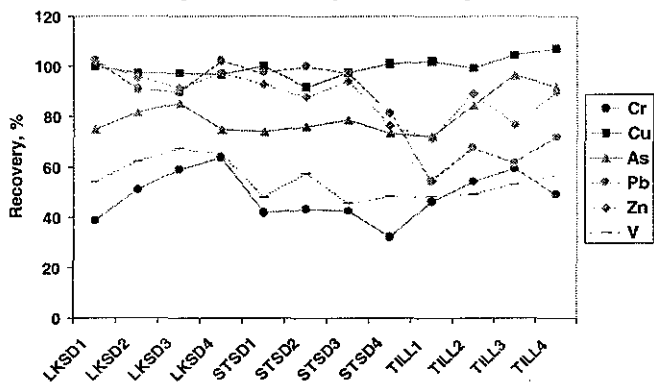


Fig. 4. Recovery in aqua regia



times varied from 1 to 3 h. It is interesting that the results were in such good agreement given these different conditions. Furthermore, values obtained by these "dilute" digestions for the 12 CRMs agreed with those by aqua regia for the elements Ag,

Co, Cu, Fe, Mn, Mo, Ni, Pb and Zn.

Additional elemental data were available for the lake and stream sediment series and again agreement with aqua regia was good for As, Ca, Cd, Cr, Mg and Sr. Barium results for STSD-3 and 4 were significantly lower than by aqua regia, at 589 ± 17 and 906 ± 35 ppm, respectively, compared to 692 ± 62 and 1280 ± 81 ppm (the others were in agreement). Results for Al tended to be low by the dilute acid digestions but were within experimental limits. Like Al, P was lower in these dilute acid extractions but this time, mean values were outside the standard deviation limits, as seen in Table 4. That trend is curious given that P is the element where the aqua regia digestion shows complete recovery (Fig. 1) for all the sediment CRMs.

Table 4. Results for P taken from Lynch (1999); SD - standard deviation.

CRM	Mean \pm SD, pp		
	Total	Aqua regia	Dilute HCl and dilute HNO ₃ *
LKSD-1	700 \pm 40	731 \pm 47	575 \pm 28
LKSD-2	1220 \pm 130	1290 \pm 99	1010 \pm 38
LKSD-3	1090 \pm 40	1110 \pm 160	803 \pm 32
LKSD-4	1440 \pm 130	1440 \pm 180	1080 \pm 51
STSD-1	1660 \pm 90	1690 \pm 220	1260 \pm 64
STSD-2	1400 \pm 90	1450 \pm 130	1040 \pm 47
STSD-3	1570 \pm 40	1610 \pm 220	1150 \pm 42
STSD-4	960 \pm 40	979 \pm 90	718 \pm 4

* The superior precision shown here is probably related to the fewer number of laboratories contributing these particular data (rather than a feature of the decomposition)

In summary, these data on the 12 CRMs of different matrices demonstrate that the elements Al, Ba, Ca, Cr, Sr, Ti and V show markedly low recoveries by the aqua regia decomposition, as would be expected from their mineralogy. To a lesser degree, distinctly low results were found also for Mg, Fe, Mn, As, Pb (in tills only) and Sb (in stream sediments). Recoveries across the different sample types were generally better than 75% for Ag, Cd, Co, Cu, Mo, Ni, P and Zn.

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Lynch, J.J., 1999. Additional provisional elemental values for LKSD-1, LKSD-2, LKSD-3, LKSD-4, STSD-1, STSD-2, STSD-3 and STSD-4. *Geostand. Newsl.* (in press).

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Some ancient partial extractors (see *J. Geochem. Explor.* Vol 8, 1977 pp 483 - 494) discuss the current resurgence of interest in selective extraction techniques in exploration geochemistry. Left to right Simon Gatehouse, Dave Russell and Jan van Moort.

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CALENDAR OF EVENTS

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

■ July 7-10, 1999, **Geocongress '98**, University of Pretoria, South Africa. INFORMATION: P.O. Box 798, Pretoria, 0001 South Africa, fax: 012-841-1221, e-mail: caucamp@geoscience.org.za.

■ July 11-15, 1999, **Biogeochemistry of trace elements**, International conference, Vienna, Austria. E-mail: icobte@edvl.boku.ac.at.

■ August 12-20, 1999, **5th International Symposium on the Geochemistry of the Earth's Surface (GES-5)**, Reykjavik, Iceland. INFORMATION: S. R. Gislason or G. Xander, GES-5 Conference Secretariat, Science Institute, University of Iceland, Dunhagi 3, 107 Reykjavik, Iceland. TEL: +354 525 4800, FAX: +354 552 8911, e-mail: ges5@raunvis.hi.is.

■ August 22-25, 1999, **Society for Geology Applied to Mineral Deposits 5th Biennial Conference**, London, UK. INFORMATION: Dr. Chris J. Stanley, Associate Keeper of Mineralogy, Department of Mineralogy, Natural History Museum, Cromwell Rd., London, SW7 5BD, UK, Tel 44-171-938-9361. E-mail: cjs@nhm.ac.uk.

■ September 13-16, 1999, **Modern approaches to ore and environmental mineralogy**, Pretoria, South Africa. INFORMATION: Dr. M. Cloete, Council for Geoscience, Private Bag X112, Pretoria 0001, South Africa. E-mail: mcloete@geoscience.org.za.

■ October, 25-28, 1999, **Annual Meeting of the Geological Society of America**, Denver, Colo. INFORMATION: TEL 1-800-472-1988, meetings@geosociety.org.

■ November 2-4, 1999, **2nd Asia Pacific Symposium on Environmental Geochemistry**, Seoul, Korea. INFORMATION: Prof. Hyo-Taek Chon, School of Civil, Urban and Geosystem Engineering, College of Engineering, Seoul National University, Seoul 151-742, Korea. TEL: +82-(0)2-880-7225/7236. Fax: +82-(0)2-871-7892/8938. Email: chon@plaza.snu.ac.kr.

■ November 3-5, 1999, **International Symposium on Geochemical and Mineralogical Tracers in Mining Exploration ORSTOM**, Santiago, Chile. INFORMATION: Department of Geology, University of Chile. ORSTOM, Casilla 53390, Correo Central Santiago 1, Chile. Tel +562.2363464, Fax +562.2363463. E-mail: orstom@netline.cl.

■ December 13-17, 1999, **AGU Fall Meeting**, San Francisco, CA. INFORMATION: AGU Meeting Department, 2000 Florida Ave., NW, Washington, DC 20009, TEL: 202-462-6900. FAX: 202-328-0566. E-mail: meetings@kosmos.agu.org.

■ March 6-9, 2000, **Annual meeting of Society for Mining, Metallurgy, and Exploration (SME)**, Salt Lake City, Utah. INFORMATION: P.O. Box 625002, Littleton, Colo., 80162-5002, 303-973-9550. E-mail: smenet@aol.com.

Calendar of Events *Continued from Page 19*

■ April 16-19, 2000, 8th International Symposium on Experimental Mineralogy, Petrology and Geochemistry (EMPG VIII), Bergamo, Italy. INFORMATION: EMGG VIII Organizing Committee, Dipartimento Scienze della Terra, Università di Milano, Via Botticelli 23, 20133 Milano, Italy. <http://imiucca.csi.unimi.it/~spoli/empg.html>.

■ April 24-28, 2000, 5th International Symposium on Environmental Geochemistry, Cape Town, South Africa. INFORMATION: SISEG, Department of Geological Sciences, University of Cape Town, Private Bag, Rondebosch, 7701, South Africa, FAX 27-21-650-3783. Email: Siseg@geology.uct.ac.za.

■ May 15-18, 2000, Geology and ore deposits 2000: The Great Basin and beyond, Reno/Sparks, Nevada, USA. INFORMATION: Geological Society of Nevada. 702-323-3500, ax 702-323-3599, e-mail: gsnsymp@nbgm.unr.edu.

■ May 21-24, 2000, ICARD 2000, 5th International Conference on Acid Rock Drainage, Denver, Colo. INFORMATION: SME, PO Box 625002, Littleton, Colo. 80162-5002. E-mail: davis@smenet.org.

■ May 31-June 3, 2000, AGU Spring Meeting, San Francisco, CA. INFORMATION: AGU Meeting Department, 2000 Florida Ave., NW, Washington, DC 20009, TEL: 202-462-6900. FAX: 202-328-0566. E-mail: meetings@kosmos.agu.org.

■ August 6-17, 2000, 31st International Geological Congress, Rio de Janeiro, Brazil. INFORMATION: Secretariat Bureau, Casa Brazil 2000, Av. Pasteur, 404 Urca, Rio de Janeiro-RJ-Brazil, CEP 22.290-240, phone 55 21 295 5847, fax: 55 21 295 8094. E-mail: 3ligc@3ligc.org, <http://www.3ligc.org>.

■ September 3-8, 2000, Goldschmidt 2000. Oxford, UK. INFORMATION: P Beattie, Cambridge Publications, Publications House, PO Box 27, Cambridge, UK CB1 4GL. TEL: 44-1223-333438, FAX: 44-1223-333438, E-mail: gold2000@campublic.co.uk.

■ November 13-16, 2000, Annual Meeting of the Geological Society of America, Reno, Nev. INFORMATION: TEL 1-800-472-1988, meetings@geosociety.org.

■ December 14 - 19, 2000, Pacificchem 2000, Honolulu. INFORMATION: Congress Secretariat, c/o American Chemical Society, 1155 16th St. N.W., Washington, D.C. 20036, fax: 202-872-6128. E-mail: pacificchem@acs.org.

■ December 15-19, 2000, AGU Fall Meeting, San Francisco, CA. INFORMATION: AGU Meeting Department, 2000 Florida Ave., NW, Washington, DC 20009, TEL: 202-462-6900. FAX: 202-328-0566. E-mail: meetings@kosmos.agu.org.

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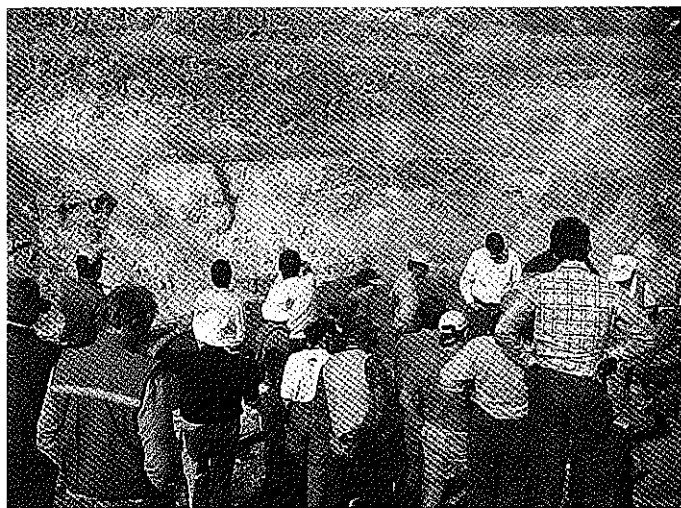
Seen at the recent IGES Conference...



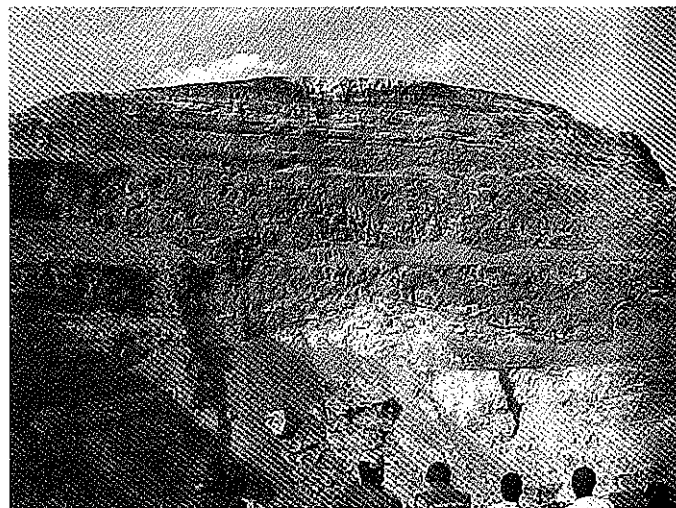
Tour of Chemex labs in Vancouver after drinks and dinner.



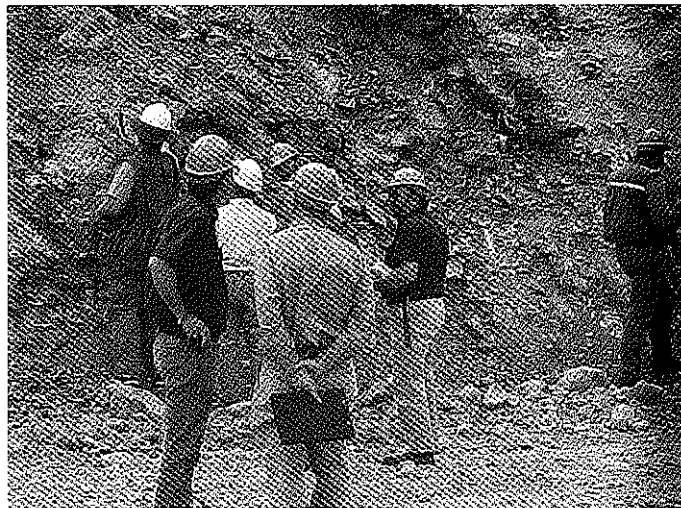
Getting oriented at the Ivanhoe (Hollister) geochemical test area: N. Sergeev, J. Abbott, I. Robertson and others look at the challenge.



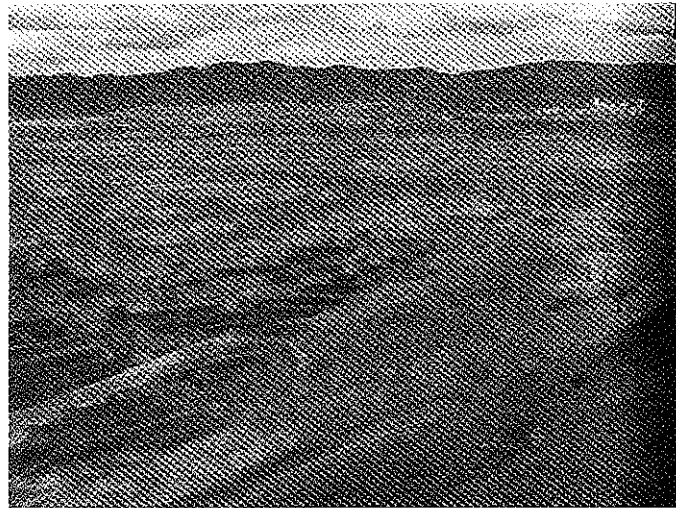
East Hollister pit that operated in early 1990's; Jim Oliver of Great Basin Gold describes the bedrock target.



Altered volcanic rocks that cover ore: this is what the surface methods must 'see through'.



Alan Coope chats with mine geologist at Gold Quarry (who is the teacher?) while Nigel Radford bags the real thing.



Looking at the Gold Quarry pit: a deposit this big must be easy to find (just follow the trucks).

RECENT PAPERS

This list comprises titles that have appeared in major publications since the compilation in **EXPLORE** Number 102.

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**.

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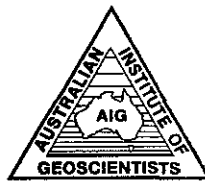
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