EXPLORE

NUMBER 130 FEBRUARY 2006

Newsletter for the Association of Applied Geochemists

RAB Drilling and RAB Geochemistry An Australian Perspective

Introduction

For some 30 years, "Rotary Air Blast" (RAB) drilling has been a major tool for mineral exploration programs in Australia, particularly for gold in the Yilgarn Craton of Western Australia (WA). For example, in 1996 – 1997, a total of 5,000 *kilometers* of RAB drilling was reported in statutory activity statements by WA mineral explorers (later statistics do not distinguish between different drilling types but will be lower owing to a subsequent drop-off in "greenfields" exploration, in which RAB is most prevalent). The terms RAB drilling and RAB drill geochemistry are widely used and implicitly understood by Australian explorers, promoters, and financiers. In contrast, however, there appears to be a much lower awareness in other countries, where scout Reverse Circulation (RC) drilling through cover has become widely used but in the past the discovery process would have developed typically via prospecting, to soil sampling to trenching or pitting, then directly to diamond drilling or even trial mining.

In spite of its fundamental importance to the industry, RAB drilling has a very low literature profile, even in Australia. There are very few papers describing RAB equipment and methods, and even fewer on the geological and geochemical techniques that have evolved to extract maximum information from the drilling. For instance, the widely used field guide for Australian explorers, the *Field Geologists Manual* (Berkman 2001) - has no references to either RAB drilling or RAB drill geochemistry. Likewise,

Figure 1. *Photograph of typical Yilgarn weathering profile exposed in Darlot open pit (north-eastern Yilgarn). Note flat landscape. Benches height is 20 meters. Rock types are predominantly metadolerite. Profile shows thin "harpanized" soil cover (1-3 meters), mottled lake clays (only at far left in profile, thickening to about 40 meters out of field of view), residual upper saprolite (red and purple colours extending irregularly to about 30 meters, but much deeper on structures), lower saprolite (yellow and, grey-green colours, extending to about 60 meters), saprock transition (irregular zone about 5 meters wide just below 60 meter bench), and fresh rock at about 65 meters to base of pit at around 100 meters below surface.*

continued on page 4

AAG Presidential Address

Rob Bowell

I feel my first action as incoming president should be to thank Dave Kelley for his significant contribution in being our previous president. Under his leadership the association has entered a new millennium with a new name and an expanded agenda to represent applied geochemistry not only in the exploration field but throughout the natural resources industry and in very much related fields of environmental assessment and energy resources.

During the last two years, the metal mining industry has experienced a sustained growth period due to the benefit of high metal prices and uncertain world politics. This boom seems to have given birth to numerous new or junior mining and exploration companies and helped the expansion and merger of many of the larger companies.

At a time when near surface or "easy to find" (if there really were any) mineral deposits are becoming scarce, companies are looking to new geological terrains or types of geological occurrences of economic deposits of metals and minerals. Often these deposits are buried and have a diffused geological, geophysical or geochemical signature and greater knowledge is required in deciphering the information being gathered.

continued on page 2

President's Message... continued from page 1

At the same time many governments are introducing or changing legislation that requires more stringent regulation and monitoring of mining waste and emissions. Typically these are developed around numerical standards for chemical elements and compounds and understanding the data requires greater technical geochemical expertise.

In addition, in the wake of modern mining scams such as Bre-X and through greater education of investors and the public, laboratory data are being scrutinized much more carefully. Such trends in the industry should be welcomed and embraced by the geochemical community, particularly this association.

The scenarios described above should be a platform on which we promote our association and our goals. In addition areas of geosciences such as the exploration and exploitation of energy deposits, industrial minerals, development of landfill and mineral beneficiation are all more complicated for similar reasons.

I believe geochemistry has the potential to greatly aid society in these fields of human endeavour as well. In addition I believe that geochemistry has an important role to play in the search and utilization of clean drinking water. For many communities this has become of paramount importance. Geochemists with a fundamental understanding of the interactions of minerals and water, and the controls such reactions have on subsequent water quality have an important role to play in assisting in the exploration for clean drinking water in many parts of the planet.

Yet despite these growing challenges, geochemistry graduates appear to be on the decrease in line with many other geosciences. The reduction in university teaching of applied geochemistry also hampers the understanding of geologists in the application of geochemistry.

During my presidency of the association I hope that the association can help to redress the imbalance. This can be done in several ways: by funding conference attendance and possibly other activities through student bursaries from our Distinguished Geochemists Fund; by promoting awareness of our journal, *Geochemistry, Exploration, Environment and Analysis* and by submitting original research papers to enhance the benefit of the journal to our peers; by sponsoring our Distinguished lecturer at various institutes and universities to benefit students and professionals alike; and also by organizing specialist applied geochemistry workshops at other events.

In this way we can demonstrate benefits of membership of our association and make a positive impact in the global geoscience community. Please feel free to email me with any ideas or suggestions you may have to help the association or if there are events you feel we should be actively participating in. The best way to get the most out of your association is to participate in it, so that as it grows it can provide more activities, support and products. I look forward to the challenge of serving you over the next two years.

Rob Bowell

Past President's Message

The last two years have passed very quickly. It seems like only a few months ago that we officially changed our name from the Association of Exploration Geochemists and broadened our scope to include all aspects of applied geochemistry. Although I would not say that we are thriving, our membership has grown steadily due to the hard work of Robert Jackson, Brian Townley, Xueqiu Wang and many others in the Association. In addition, our Journal, *Geochemistry: Exploration, Environment and Analysis,* continues to supply top-quality papers on applied geochemistry to the geoscience community. I would like to thank Gwendy Hall, Marcia Scrimgeour and the Geological Society of London for making our Journal a success. Chris Benn has done an excellent job as editor of **EXPLORE** and I know this will continue as Beth McClenaghan takes the reins from Chris. Have you seen the website lately? If not, go to www.appliedgeochemists. org to see all the changes that Bob Eppinger and Andrew Ransom have made.

While we have made significant progress in the past two years in expanding the role of the Association, we still have a lot of work to do. The sad passing of Ken Lovstrom is a reminder that our membership is growing older, and the lack of young geochemists filling in the ranks is a grave concern. Much has been written in the last two years about the undersupply of geoscientists, yet there are still only a few Universities globally where Exploration Geochemistry remains on the syllabus. The time has come for an Endowed Chair in Exploration Geochemistry but where will it be located and who will fund it? I hope that Industry and perhaps a wealthy donor or two will come forward to make this happen.

We are well on our way to establishing the Distinguished Applied Geochemists Foundation. Carol Coope and Newmont Mining graciously allowed us to merge the Alan Coope Fund with contributions received

continued on page 4

TABLE OF CONTENTS

Past President's Message...

continued from page 3

for Paul Theobald to create the Foundation. The Foundation will honor Alan and Paul and future distinguished geochemists that inevitably will pass. Ray Lett is working with Executive Council to set this up to receive future charitable donations. Rob Bowell will be contacting some of you to help with promoting the Foundation and managing and distributing the funds.

As Rob mentions in his address, AAG-sponsored workshops will happen more frequently and will help promote the Association and fill the training void in applied geochemistry. Graham Closs and I have organized a workshop with the support of several AAG members for the Society of Economic Geologists meeting this May in Keystone, Colorado and Bill Coker will lead an AAG-sponsored workshop at Exploration 2007 in Toronto. Jorge Loredo and his committee are hard at work planning our next 23rd International Applied Geochemistry Symposium, June, 2007, in Oviedo, Spain. Start writing your abstracts now. This will not be a meeting to miss.

It has been a great honor to serve this Association for the past two years as President. I would especially like to thank Rob Bowell, Gwendy Hall, Dave Smith, Betty Arseneault and Council for their support and efforts to make the AAG what it is today.

Sincerely,

David Kelley
Newmont Mining Corporation
Malozemoff Technical Facility
10101 East Dry Creek Rd
Englewood, Colorado
USA 80112 dave.kelley@newmont.com

RAB Drilling and RAB Geochemistry ...

continued from page 1

a recent book on drilling techniques (McGoggan, 1997) devotes just two paragraphs to RAB drilling. The few papers which directly address RAB drilling and sampling (e.g. Barnes, 1987; Marjoribanks, 1997) are mostly in conference proceedings, course notes or books which do not have wide international circulation.

This paper is written to begin to redress the lack of published information about RAB drilling, primarily for the edification of Explore's readers from outside Australia who may be unfamiliar with the scene "down under". We review the development of RAB and speculate on why this is such a dominant aspect of Australian exploration. There is considerable variation as to how different companies apply the method, so we summarize typical procedures and attempt to identify modern "best practice". A follow-up paper will provide a practical example of RAB geochemistry and perhaps also a summary of the Aircore technique, a more recent development that has further advanced reconnaissance drilling.

Background

Most of Australia's major gold-bearing regions, particularly those of the Yilgarn Craton of WA, occur within arid, generally low-relief, sparsely vegetated terrain that is characteristically deeply weathered (typically >40m to fresh rock, often >100m). The nature of Australian regolith, and its challenges and benefits for exploration, have been discussed thoroughly in many recent articles (e.g. Smith *et al*,1997; Butt *et al*., 1997; Anand,1995). Suffice to say here that Australia has an extended tectonic stability and a long history of episodic lateritic weathering perhaps extending back to the time when *T.Rex* and cohorts stalked the planet. More recently, a change to arid conditions has occurred in Australian climates, with lowering of water tables and development of saline groundwater systems in many areas. The resultant weathering profiles are deep, intense and complex (Figure 1 on front page).

As in other Australian goldfields, the first gold mining

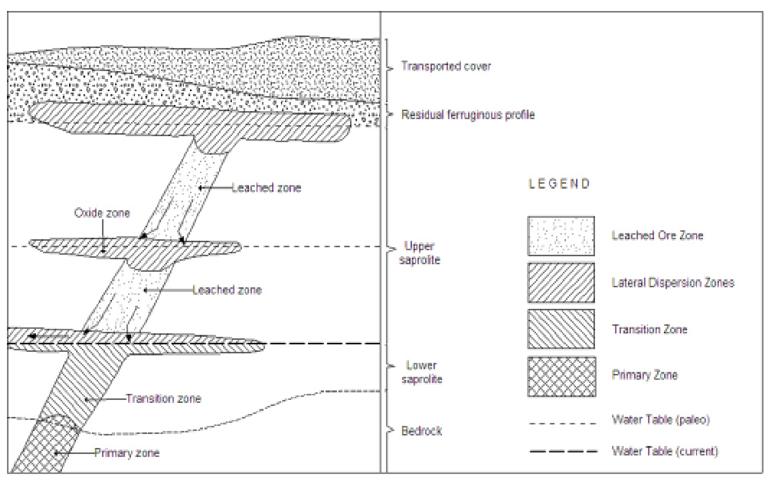


Figure 2: Schematic diagram of typical Yilgarn mineralised weathering zone showing distribution of supergene enrichment zones in relation to regolith units and hypogene ore shoots (modified after Mann, 1998). Profile is drawn as though buried without stripping. In practise, however, the first residual material below cover in a partially eroded and subsequently buried profile can be upper or lower saprolite, typically with sharp and unpredictable changes between adjacent drill holes. Dispersion zones related to palaeo-water tables may be stacked or absent.

continued on Page 5

RAB Drilling and RAB Geochemistry ... continued from page 4

boom in the Yilgarn during the 1890s developed through discoveries by conventional prospecting – the visual detection of particulate gold in drainages, colluvium and outcrop. "Dry blowing" was particularly important owing to the arid environment (water was literally worth its weight in gold during the hot Australian summers). Most of the deposits exposed in outcrop, or with shallow residual soils, were readily located because they had visible gold. Incidentally, there is no record of the Australian aborigines having recognized or attributed any significance to gold during their 40,000 year plus occupation of the continent. Hence the first European prospectors took huge advantage of undisturbed residual surface enrichment of gold accumulated over perhaps millions of years.

The early miners and prospectors proceeded through trial and error in different gold camps to decipher and exploit the uneven distribution of gold within the profile. However, much of the surrounding terrain was covered by shallow alluvium, colluvium and sheet-wash deposits. Exploration of these overburden-covered areas could only proceed by slow and costly trenching or "wildcat" pitting. Some fortunes were certainly made by speculative shaft sinking along the "line of the lode" through shallow cover, but most of the deposits concealed under more than a few meters of overburden remained undiscovered during this phase.

Several periods of renewed prospecting occurred in the next 100 years (particularly during the depression of the early 1930s), generally spurred of course by higher gold prices. Techniques were largely the same as those employed during the 1890s, and significant new discoveries were rare. However, that situation changed dramatically during the modern gold boom from the early 1980s to the mid 1990s, when a spectacular period of gold discoveries more than doubled the known gold endowment of the Yilgarn. After a lull due to low gold prices, exploration activity has again surged since 2003 but few significant new discoveries have so far been made.

There were many reasons for the 1980s-1990s gold boom (e.g. high gold prices, improved processing particularly via CIP, better pit optimizations) but a major factor behind the improved exploration success was an enhanced understanding of the distribution and remobilisation of gold in the weathering profile. As new open-pits were developed, it became apparent that many mineralised structures exhibited both significant depletion and supergene enrichment zones within the regolith. Of critical importance was the realization that above many sub-economic hypogene gold occurrences there were extensive, mushroom-shaped, flat-lying lenses of gold enrichment at various levels in the weathering zone (Figure 2). These were highly economic on account of their free-digging nature and high-grade, high-fineness, readily cyanide-leachable gold.

These in-mine observations on gold distribution were supported and underpinned by a succession of highly

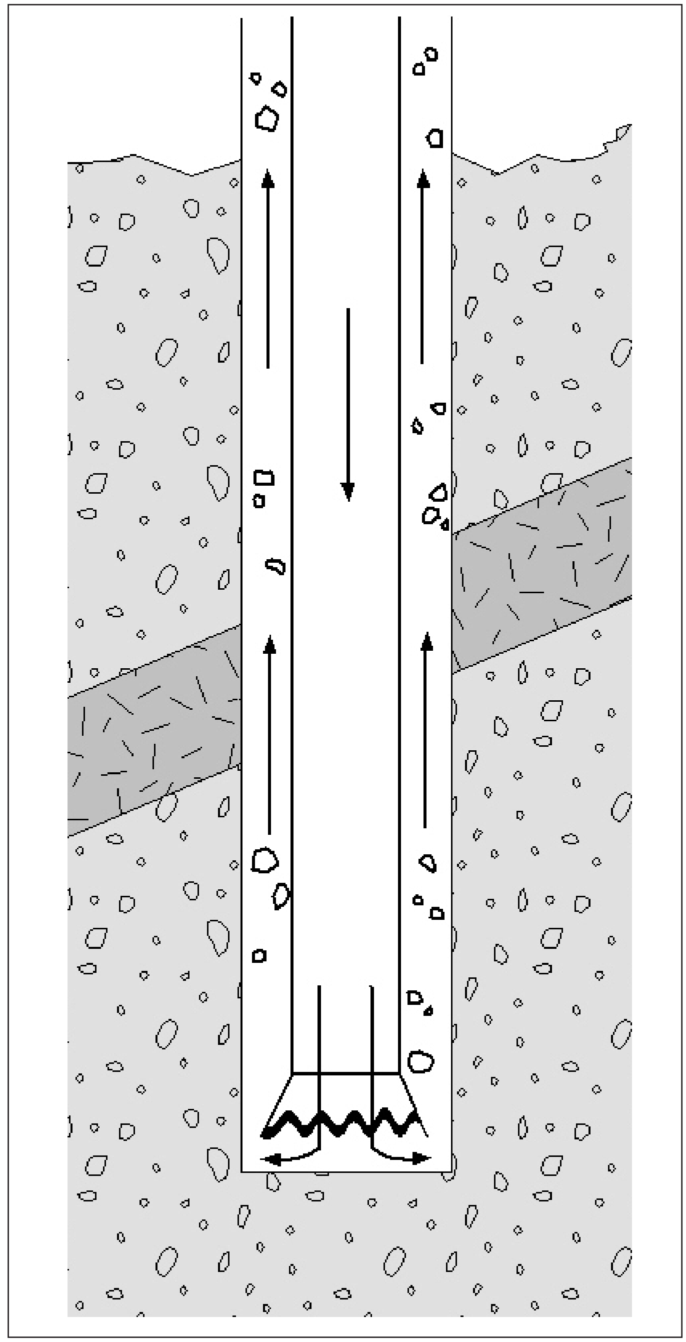


Figure 3: Schematic of RAB drilling and sample recovery. Compressed air forced down drill string results in cuttings blown to the surface for collection. Penetration is by rotation (blade) or impact (hammer).

continued on page 6

RAB Drilling and RAB Geochemistry ... *continued from page 5*

successful research projects conducted largely at the Commonwealth Scientific and Research Organization (CSIRO) and partly funded by the Australian Minerals Industry Research Association (AMIRA). The resulting insights into supergene gold re-distribution brought about significant change in the exploration process: close-spaced soil and trench sampling were abandoned in favour of early and extensive drilling.

RAB was the dominant reconnaissance drilling technique in gold exploration since 1980, and RAB geochemistry has been the key discovery technique in more than 90 percent of successful case-histories for modern gold discoveries in the Yilgarn. In looking for reasons why RAB is so widely used in Australia, yet relatively uncommon or even unknown elsewhere, several contributing factors stand out:

- The extensive shallow alluvial/colluvial cover overlying very deep weathering profiles, typical of much of the prospective terrains in Australia, makes for easy drill penetration through overburden and well into clay-rich oxidized bedrock.
- The current water table is commonly deep (typically 40-60m) meaning that sample recoveries are generally acceptable via RAB drilling.
- Relatively sparse vegetation and limited relief over much of the Yilgarn facilitates easy rig access to most sites.
- A well organized, highly mobile and professional drilling industry had already evolved, and readily adapted to provide contract RAB drilling services.
- RAB costs are much lower than for RC and diamond drilling; in addition, RAB rigs are far more mobile and require less support so that it is cost-effective to use RAB for initial testing then follow up with other drilling techniques.
- Unskilled labour costs in Australia are high relative to many other countries, so that manual pitting and costeaning (trenching) are not cost-effective options to penetrate shallow cover.

RAB Drills and Drilling

What is meant by "RAB drilling"? As the name implies RAB, or Rotary Air Blast drilling, is an open-hole technique in which compressed air is injected down the drill pipe in order to recover the cuttings up the outside of the drill stem to the surface (Figure 3). RAB is thus essentially similar to blast-hole drilling in open-pit mines, except that the rigs are commonly truck-, rather than track-mounted, and generally larger and more mobile (Figures 4 and 5). In addition, the cuttings are generally piped off and collected rather than being permitted to mound around the hole aperture. Both rotation (blade) and impact (hammer) drilling methods are employed.

RAB drill rigs evolved from the earlier wagon drills and rotary percussion drills during the early 1970s, as the WA nickel boom played itself out. Within a decade of their introduction, the highly mobile RAB rigs had largely replaced auger, air-track and rotary percussion rigs for first-pass exploration drilling, though "vacuum" rigs remain popular in some districts.

The all-up capital cost of current-generation of RAB rigs is of the order of $400,000 to $600,000, including support vehicles and mobile accommodation (these and all subsequent costs are quoted in US dollars, at current exchange rates of $1 AUD = $0.74 US). Most rigs are manufactured in WA. Typically, they are mounted on four or six-wheel-drive trucks for a total weight of 10 to 15 tonnes, and can to access sites with minimal disturbance of vegetation and topsoil. Hydraulics are used to drive the drill string and a compressor supplies high volume (500-

continued on page 7

RAB Drilling and RAB Geochemistry ... continued from page 6

Figure 4: Photograph of typical RAB rig (view from rear) showing sample delivery through "stuffing box" at collar along flexible tube under pressure to cyclone (at right) for collection. Note hard hats and safety boots for all personnel- a recent safety change to replace caps and thongs!

750 cfm), high pressure (250 – 350 psi) air for recovery of cuttings. Power for the hydraulics is provided by auxiliary diesel engines around 250 – 300 Horsepower. In modern rigs a single turbo-charged diesel drives both the compressor and hydraulic pump. Blade bits (tungsten carbide) with diameters of 9 to 11.5 cm (3.5 - 4.25 inches), account for 90 – 95% of meterage drilled, although down-the-hole hammers are used for unusually hard formations such as silcretes, quartz veins, cherts and banded iron formations.

Although a few exploration companies have used in-house drilling teams in the past, the vast bulk of RAB drilling is carried out by specialist drilling contractors. Base drilling charges are currently around $4.50 – 6.50 per meter for blade drilling, $8.50 – 12.50 per meter for hammer and $13 – 16.50 per meter for Aircore (a modification in which the cuttings recovery system is more akin to RC, with air blown down the outer tubes of the drill stem leading to "sticks" of semi-consolidated cuttings being delivered up the inner drill tube).

The Australian drilling industry is highly competitive and the actual dollar cost of RAB has remained remarkably stable over several decades. In fact, allowing for inflation, the cost of drilling in constant dollars has fallen by perhaps 15 - 20% over the last 15 - 20 years, assisted by continued developments in equipment and operating techniques. The major technological advance in this period has been improved air supply, which enables drillers to penetrate perched water tables with relative ease and often, while retaining essentially dry sample recoveries, to take blade holes to some 25m below the major water table (which is commonly on or around the weathered–unweathered bedrock interface).

Under "average conditions" a RAB crew – the driller and one or two assistants ("offsiders"), can drill about 300 - 500m in a single 10 –12 hour shift although up to 800m per day is not unheard of. Drill rates vary according to nature of cover and depth to water, with RAB blade to depths of 120m possible in some circumstances. Typically, the exploration companies are responsible for providing a geologist (colloquially known as a "RAB jockey") and a sampler, to composite and collect geochemical samples. The geologist has to oversee sampling, confirm hole locations, determine required drill depth, and log the hole by identifying the position of the overburden interface, nature of regolith units, and bedrock lithologies (including of course visual signs of mineralization such as

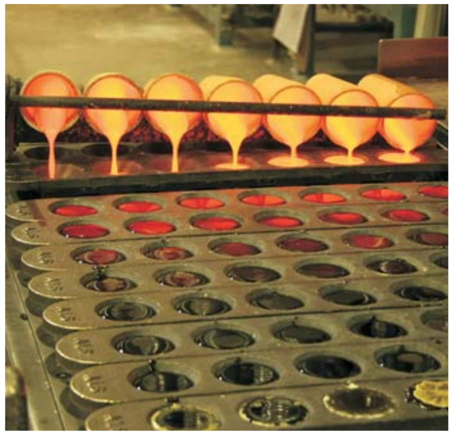
Figure 5: RAB rig showing manual rod handling and minimal site preparation. The operator has switched to hammer drilling on account of quite fresh bedrock unexpectedly encountered beneath only shallow cover (1m) and minimal oxidized profile (2-3m). Photo courtesy of Leon Marsh.

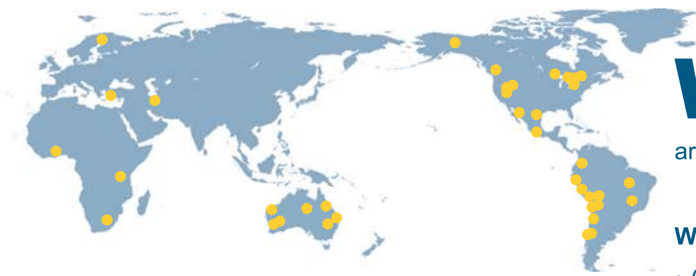
continued on page 9

ALS Laboratory Group

ANALYTICAL CHEMISTRY & TESTING SERVICES

Mineral Division - ALS Chemex





We are a global analytical testing company serving the mining and mineral exploration industry in 17 countries around the world.

We specialise in:

- Assaying and geochemical analysis for mining and mineral exploration projects
- On-site contract mine laboratory management
- Environmental monitoring for mining operations
- Acid mine drainage studies

Contact the ALS Chemex laboratory nearest to you to find out how we can help you with all of your project's analytical needs. Detailed contact information for individual locations can be found on our website.

www.alschemex.com

Right solutions....
....Right partner

Paid Advertisement

RAB Drilling and RAB Geochemistry ... continued from page 7

alteration, quartz veining and sulphides or their weathered products). Maintaining control of all these aspects is no small feat at high drilling rates.

RAB Drill Geochemical Surveys

RAB Drilling is used mostly in the early stages of exploration to:

- Provide a first-pass drill test of known surface (e.g. soil) geochemical anomalies;
- Probe for below-surface geochemical dispersion and, in particular, to collect preferred regolith sampling media such as pisolites and duricrust materials which can define extensive multi-element anomalies around supergene gold systems within intact laterite profiles or on "Redox" barriers in the profile (e.g., Smith *et al.,* 1997; Mann, 1998).
- Test the nature and prospectivity of structural, geophysical or geological targets beneath shallow cover- such as the continuation of known lodes, or interpreted mineralized shear zones evident in aeromagnetic imagery.
- Map the 3-D distribution of regolith and bedrock units where negligible outcrop otherwise precludes conventional mapping techniques (typically the RAB rig provides ground truth for an interpretative framework of lithotype distribution and location of major structures, built up from detailed aeromagnetic imagery)
- Prospect for concealed paleochannel-hosted placer and remobilised gold deposits within transported regolith.

Around 90% of holes in reconnaissance are drilled vertically. This is because the principal targets for the geochemical surveys are sub-horizontal zones of dispersed gold and pathfinder elements within the regolith profile. Vertical holes allow deeper penetration and more rapid site occupation, which are acceptable trade-offs against reduced coverage of bedrock features (in any case, the attitude of bedrock litho-structural trends, and hence optimum drilling direction, is often not known in covered areas). Sections or "drill fences" of overlapping angle holes (e.g. -60^o) are more common for follow-up programs or for testing specific targets whose orientation is known.

The unfocussed, broad-brush RAB geochemical surveys which were popular amongst the more speculative company directors and their brokers in the 1980s and early 1990s, are now rare. Today's RAB drill geochemical programs are generally tightly focussed on targets developed from prior geological, geophysical, and geochemical surveys. Drill spacing and grid patterns of reconnaissance RAB programs vary according to the definition and potential of target zones, or the explorer's perceived geological model. In first-pass programs over highly prospective structures, the initial pattern might be holes 100m apart along lines no more than 400 - 500m apart, though remote areas might be initially screened at 800 x 200m (or even 1600 x 400m), with immediate follow-up in anomalous or geologically prospective zones.

RAB drill holes (diameter 12 cm) are typically drilled uncased or with a temporary casing to prevent hole "bell-out". In the past, most holes were left open and unrehabilitated. However, environmental concerns (principally death of small marsupials seeking water) have resulted in directives from Government Mines Departments that all holes must now be plugged and sample spoils raked over or removed. While admirable from the environmental perspective, this latter requirement has caused concern due to the potential loss of valuable geological information. RAB spoil piles can remain intact for up to ten years after drilling, thus offering new generations of explorers access to bedrock and profile information during reconnaissance in areas where no trace of bedrock could otherwise be accessed without further drilling. There are even documented discovery histories from re-sampling of previous drilling where operators were focussed on different commodities. Bounty Gold Mine in the Southern Cross Belt (approximately 1Moz total mined resource) is the best known of these and resulted directly from gram-level assays in spoil taken from a 1970s nickel RAB hole which had not been analysed for gold (discovery history not well documented, but see for example, Lintern 2005). This loss of sub-surface information has been viewed by many experienced geologists as nothing short of "geological vandalism". However, there is little prospect for any revision of policy by Australian regulators.

In its initial usage during the 1970s and early 1980s, standard RAB drilling practise was to penetrate overburden then take a single "bottom-of-hole" sample in the first recognizable interval of *in situ* regolith. It is now clear that much of this exploration phase was highly ineffective. Even if the cover-bedrock interface was accurately identified (no small feat in many Australian profiles), resultant samples included lateritic duricrust (high multi-element and gold backgrounds), upper saprolite (normally severely leached), and lower saprolite or saprock. This was a classic case of comparing apples and oranges, and with lemons as well: In many cases, unrecognized older transported units were sampled by mistake!

In most exploration reports from the late 1980s to early 1990s, RAB holes are recorded to penetrate to 40 or 50m, commonly to a pre-set depth about "42m" (no doubt guided by Douglas Adams' answer to the ultimate question about life, the universe and everything in *The Hitch Hikers Guide to the Galaxy*). Of note, as recently as

continued on page 10

RAB Drilling and RAB Geochemistry ... continued from page 9

the late 1980s, one of Australia's largest company explorers undertook extensive geochemical surveys based on RAB holes drilled to a preset 18m depth, with a standard two 9m composite samples per hole. With hindsight, the effectiveness of this approach is highly questionable given variable depths of transported cover and variable stripping of the underlying residual regolith. In fact, much of the ground written off after 1980's style RAB drilling is now regarded as ineffectively tested and potentially still prospective.

With further insight into regolith processes, and with the advent of high volume, high pressure air systems, it became more common for RAB holes to be drilled to the limit of blade penetration – colloquially known as "blade refusal". This is typically well into lower saprolite and close to the base of weathering (i.e. fresh rock). Some holes may be abandoned at shallower depths because of excessive groundwater inflow, caving formations, plastic clay or hard layers such as silcrete. These "failed holes" need to be identified and flagged during interpretation because they may not constitute a satisfactory test for the presence of mineralisation. Where the weathering profile is deep, RAB rigs commonly penetrate to more than 100m and, exceptionally, to 140m. A variety of foams and additives can be used to facilitate sample recovery (geochemists beware!). However many, if not most, of the larger RAB rigs now carry the equipment, drill strings and bits to enable a switch to Aircore drilling when groundwater prevents dry open hole RAB drilling.

Sampling and Analysis

It is stressed that RAB drilling comes with a multitude of "challenges" from the perspectives of good geochemical sampling practise. It is prone to contamination from the hole walls or the surface, mineralized intercepts are commonly "smeared out", and sample recovery is problematic in poor ground conditions or where water inflow has occurred. For these reasons, RAB results should be considered as "indicative of mineralisation" only, and not a quantitative description of grade or width. In particular, RAB sampling is not a viable methodology for resource estimation. Should any

continued on page 11

Figure 6: Photograph of RAB spoil with geologist logging. Top of hole marked by stake at centre left. Spoil piles each representing 1 meter of drilling in rows of 10. Profile shows about 8 meters of cover underlain by leached upper saprolite (white, red and purple colours) then sharp change at 39-40 meters to lower saprolite (yellow-brown-green colours). Last sample at 41-42 meters is wet and contains some fresh mafic chips. A decision is required by the geologist on a switch to hammer drilling to penetrate fresh rock if water flow can be contained so as to ensure a sample of adequate quality.

RAB Drilling and RAB Geochemistry ... continued from page 10

economic or sub-economic mineralisation be located, this should be immediately confirmed and defined using the more expensive but inherently superior reverse circulation (RC) and diamond drilling.

With these caveats in mind, we will outline the procedure involved in RAB sampling and highlight some of the pitfalls. As noted above, RAB holes are drilled dry wherever possible. High pressure/volume air is forced down the centre of the drill string in order to flush cuttings up the sides of the hole. The returned cuttings pass through a "stuffing box" at the collar which maintains air pressure within the holes and directs the cuttings via compressed air for collection at a cyclone in a bucket or plastic bag. Cuttings recovered from each 1m interval typically weigh about 15 - 20kg. These are laid out on nearby flat ground as separate piles in rows each representing 10 meters of drilling (Figure 6). Wet samples - usually a sludge, are poured into shallow shovel holes dug into the soil within their rows and allowed to drain. Recovery of wet samples into open-weave polypropylene bags or plastic "garbage bins" is becoming more common in order to minimize contamination from topsoil. However the water associated with wet samples is commonly allowed to drain away, along with much suspended clay, which potentially further compromises sample quality.

The dry (or air-dried) cutting piles for each 1m drilling return are usually sub-sampled by trowel or plastic "sampling spear" (a polythene tube with the sampling end cut obliquely, which is pushed through the spoil pile) to produce composites weighing 1.5 – 3.0 kg. Compositing is semi-quantitative, and the aim is to reduce analytical costs while still identifying any mineralized intervals for individual re-sampling. There are varying company procedures on composite lengths, but 4-5m is quite common, and up to 8 or even 10m composites may be used in leached upper saprolite. Increasingly, regolith and/or bedrock geological contacts are being used to determine variable-length composite sample boundaries. In this approach, important regolith units are identified and more closely sampled (e.g., 1-2m composites). Examples include lateritic duricrust, "Redox" boundaries (sharp changes from oxidized to reduced material, commonly recognized by iron precipitation even where the reduced zones have been subsequently oxidized), or suspected shear zones. By contrast, enclosing zones of cover or upper saprolite might be composited more widely.

In the past most companies did not sample transported overburden. However now most operators will composite and analyse overburden sequences, in order to identify possible dispersion trails including placer or hydromorphic mineralisation in palaeochannels, or plumes of geochemical dispersion extending upwards or laterally into old transported cover units.

After freighting to the laboratory, reconnaissance RAB samples are generally processed and analysed in dedicated "low-contamination" facilities used exclusively for exploration work. Each composite is dried then the entire sample is typically ground to a nominal 90% minus 75 micron by "SSMG" (Single Stage Mix and Grind) in a large diameter bowl pulverizer such as a Labtechnics LM5. A 250-300g pulp is then taken directly from the pulverizer bowl, the remainder being archived or discarded.

Gold analysis is generally by aqua regia digestion of 30-50g pulps, though some companies prefer fire assay collection (50-100g). In either case, the preferred analytical method is now direct aspiration of aqua regia into ICP-MS, this having replaced graphite furnace AAS after pre-concentration by solvent extraction into an organic phase. Realistic detection limits of 1 ppb can be achieved, though there can be digestion and/or analytical difficulties with high-Fe samples, or where graphite or charcoal is present.

The argument that Au is the best, and by inference, "the only useful" indicator of significant gold mineralization dies hard with some old-school exploration managers. However, attitudes are changing because there is now overwhelming evidence for gold leaching and a growing awareness that multi-element secondary dispersion haloes (e.g. Smith, *et al.,* 1997) can give a larger and more distinctive geochemical "footprint" than those defined by gold-alone assays. In some districts, there is a strong and direct association of Au and pathfinders (e.g. As, Sb, W). The common better preservation of pathfinders, in particular, W and As relative to gold in some regolith units, provides a means of identifying and mapping significant mineralized systems especially in upper saprolite from which gold has been substantially leached.

Although it is now quite common to analyse for pathfinders, the extent and nature of element suites varies widely between companies and regions. In notable contrast with geochemical surveys for gold-pathfinders elsewhere in the world, the alkali and alkaline earth elements are typically not analyzed, owing to their great mobility in the Australian regolith. However, Fe is widely analyzed as a pointer to regolith units. Elements most commonly analysed are As, Cu, Pb, Zn, and Ni (in part reflecting a subsidiary net cast for base metal occurrences as well as gold), together with a sub-set of other pathfinders like Sb, W, Co, Ag, Bi, Te and Mo. However, the use of W has to be reviewed critically because of the tungsten carbide tips on the drill blade. Other issues can arise from Mo in lubricants and Ag in solder.

It is quite common for the pathfinder suite to be determined from the same digest as the Au (i.e. on 30-50g samples) in order to save on analytical costs, even though results are substantially inferior to those obtainable through a re-digest using conventional higher acid: sample ratios or a separate mixed-acid digest. Analytical finish is typically by ICP-OES and/or ICP-MS depending on the analytical suite and required detection limits.

Selected samples (e.g., bottom of hole composites) may be further analysed by XRF, INAA or ICP-MS (after

continued on page 12

RAB Drilling and RAB Geochemistry ... continued from page 11

fusion or mixed acid digest) for "least mobile" elements like Ti, Zr, Cr, Sc and Nb. The purpose is to assist with rock-type identification (e.g. see Hallberg, 1984), which can be surprisingly difficult in many Yilgarn weathering profiles.

In terms of rig-site procedures, it is now widely acknowledged that close geological supervision is vital for successful RAB programs. Most companies instruct geologists to ensure that lowermost regolith has been intersected in all holes, generally with at least one in ten holes continued using a hammer bit well into fresh rock so as to ensure the profile and nature of bedrock is understood. Regolith materials are carefully logged, and the entire profile is sampled on fixed or (preferably) geologically-determined composites. The composite gold results are regarded as purely indicative: there will be immediate re-sampling of individual spoil piles for any intervals of anomalous gold.

Careful logging of regolith and bedrock is generally accepted as critical for both effective sampling and subsequent interpretation. The logging ideally takes place in real-time in order to control drilling depth and composite sampling strategy. It is based on the field geologist's observations with a hand lens or small binocular microscope of screened and washed cuttings. Both diligence and experience are required. Reference material is typically collected from representative regolith units and placed in plastic "chip trays" for later office reference. Geophysical logging is uncommon, other than the almost universal hand-held magnetic susceptibility readings from chip piles. Geologist's field logs are generally coded for later office entry into a digital database. On-site data entry tools (e.g. data loggers) are used by some companies but are not generally suited for reconnaissance programs.

The variable and often poor quality of RAB drill logs is a recognized problem in the industry. Leaving aside the obscuring effects of dust, mud, grease, blood, sweat, tears and squashed insects, terminology and logging codes are highly variable, and many important regolith features are cryptic and subjective. In addition, most first-pass logging is done by the least experienced geologists in the company, their lot being to manage the RAB rig. However, the 1980s – 1990s regolith studies by CSIRO and more recently by CRCLEME (Cooperative Research Centre for Landscape Evolution and Mineral Exploration), together with various Universities are now bearing fruit for the industry. There is a notable improvement of field interpretation and recording for RAB drill programs on account of increased graduation of "regolith-aware" young geoscientists, together with the participation of many experienced company geologists in short courses on regolith geology.

Interpretation of Surveys

Preliminary geochemical results usually become available 2 to 3 weeks after RAB drilling and sampling. Hence, plotting and interpretation of data is usually a post-campaign exercise because typical drill campaigns last only 2 to 4 weeks.

Theory and practice for data interpretation vary widely. However there is now widespread consensus that best practice requires careful evaluation of the analytical results in the context of the regolith. As mentioned above, the models of gold re-mobilization in the lateritic profile of the Yilgarn Shield that were developed in the late 1980s and 1990s are now well substantiated through numerous drilling campaigns and open-pit mining operations. The flat-lying dispersion plumes of Au and/or pathfinder elements are interpreted to reflect "redox" fronts or protracted still-stands in the water table (e.g. Mann, 1998), and they provide a broad geochemical footprint for locating primary and supergene deposits.

Data interpretation typically begins with interpretation of the regolith profile, initially from hand-drawn field sections, and continued on computer-generated drill sections. Anomalous gold values are plotted on the sections and interpreted in context of their position in the regolith profile, likely precursor rock type and proximity to interpreted structural features (e.g. shear zones). Stacked drill sections, showing assays, bedrock lithology interpretations and regolith units (including cover depth) are the most common and useful portrayal of first-pass RAB drilling data. In addition, summary plans of gold (highest composite value in each hole, or length-accumulated gold) are normally produced for comparison with regolith maps, magnetic images and interpreted bedrock geology. Imaging and GIS techniques are increasingly used for data integration. Hence, a well-structured and maintained, computerised geochemical database is essential.

Criteria for identifying and following up anomalous zones vary widely, depending on the area, the company and the individual. However, experienced campaigners will typically insist that any composites >100 ppb Au are re-sampled from the drill site, with all 1m chip piles within and adjacent to the anomalous interval, being submitted for individual assay. If the anomalous interval is repeated then the zone will be tested by both infill and step-out drilling, in which the type, spacing and orientation is determined by depth, geological knowledge and profile conditions. It should be re-stressed however, that the RAB drilling stage is for discovery, not measurement: Once the broad outlines of a mineralized zone have been established by the RAB rig, other drilling methods such as reverse circulation (RC) and diamond will be used to outline and quantify the resource and explore at depth.

In interpreting the significance of often spotty high Au values in an otherwise largely depleted profile, more weight is given to sections where the high values correspond with visual indications for mineralization (including quartz stringers, weathered sulphides or shearing textures). Specific regolith units such as lateritic duricrust, ferruginous clay "mottled" zones or "Redox" zones, or the transition zone from saprolite to bedrock (saprock) are also ranked higher. Length-weighted grade

continued on page 13

RAB Drilling and RAB Geochemistry ... continued from page 12

accumulations (grade x drill intercept) are commonly used as measures of significance, but it is important to bear in mind the inherent problems of sample recovery in RAB drilling. There is endemic contamination of the interval being drilled, by material higher in the hole. Although contamination can be substantially reduced by the skill of the driller, 'smearing' of high values down the hole is normal even in dry conditions, and almost inevitable in wet drilling conditions. There are many documented examples of RAB drilling producing false impressions of the width of mineralized intervals, but both high- and low-grade bias can be revealed after follow-up with RC or diamond core. Likewise, the sample collection and compositing operations are highly error-prone. Without doubt, the quality of laboratory operations viz. preparation, digestion, instrumental measurements, limits of detection etc and precision of determinations far exceeds the quality of the field sample recovery and sub-sampling.

Most explorers follow experience-based rules of thumb for determining significant gold "numbers" in RAB composites. Although levels vary between different geologists, companies and regions, most explorers would consider a gold value of 2 - 5 g-m/t (gram-meter/tonne) in one or two composites from a broad reconnaissance program as a significant result, and a 10 g-m/t interval as distinctly encouraging. Results of 100 g-m/t (e.g. 10m at 10 ppm, or 20m at 5 ppm) are exciting but not atypical within well-mineralised zones.

Outlook

Despite the relatively low per meter drilling charges, RAB drill geochemistry is a significant cost, often the largest single component, in most first-pass gold exploration programs in regolith-covered areas of the Yilgarn Shield. Even at a broad reconnaissance spacing, a RAB geochemical survey typically costs about AUD \$20,000/km^2, often almost an order of magnitude higher than the combined costs of the preceding phases of geological mapping, surface geochemical surveys and multi-client aeromagnetic interpretation. Hence, there is an incentive to improve the effectiveness of RAB geochemical surveys and/or to develop other techniques allowing better definition of drill targets. Some research and operational developments relevant to RAB drilling and RAB drill geochemistry are:

- Aeromagnetics – close spaced (down to 25m) and low level (15 m over salt lakes) surveys, particularly using helicopters, for more detailed "mapping" of cover and bedrock.
- Rigs - increased depth of penetration and improved dry sample recovery from deeper holes.
- Sampling - automatic sample splitting.
- Logging – more systematic and less individualistic geological and regolith codes, so that drill logs can be re-interpreted and used by others with greater confidence.
- Instrument logging e.g. using hand-held spectrometers like the "PIMA" (Portable Infa-red Mineral Analyser) for differentiation of clay minerals, and in future hopefully cheaper and more robust probes for down-the-hole logging - e.g. magnetic susceptibility, gamma calipers etc.
- Analysis – sub-ppb Au determinations and increased and more effective use of multi-element geochemistry.
- Improved data management and "visualisation" software for presenting and interpreting RAB geochemical data in context of regolith position and proximity to interpreted structures.

Most of these offer at best moderate improvements, albeit for only modest increases in costs. However, since most current RAB drilling programs proceed on a campaign basis with separate follow-up, a significant reduction in total survey costs could be achieved through a robust, cost effective system for in-field sample preparation and gold analysis at sub-ppb levels. This would allow drill patterns to be modified during the program, with immediate focus on any anomalous zones encountered. In spite of some promising developments, this goal of "real-time analysis" - where latest results drive on-going exploration, has not yet been achieved. It should also be noted that changes in the regulatory framework in WA now require submission of detailed drill programs for environmental approval. Sadly, this obstructs the geologist's ability to modify drilling patterns "on-the-fly", in order to follow up immediately on signs of mineralization. One of the key benefits of RAB drilling, namely its flexibility, is therefore becoming lost to the industry.

Will RAB drilling maintain its significance to the Australian exploration process, and will the procedure be adopted increasingly elsewhere? We believe so on both counts. Already in South America and Central and West Africa, some companies are adopting a RAB-focussed approach to exploring mineralised shear zones in regolith that has many similarities to parts of Australia.

Within the Australian scene, three different approaches have evolved over the past few years, namely:

- *Partial leach geochemistry;*
- *Selective sampling*; and,
- *Deep drilling*.

The ***Partial Leach Geochemistry*** adherents are using widespread near-surface, relatively cheap and non-invasive geochemical sampling combined with innovative partial and selective digestions (e.g. proprietary methods like MMI, Enzyme Leach, Regoleach, Deep Leach) to detect subtle geochemical dispersion even through transported cover. Their aim is to reduce significantly first-pass drill budgets and to achieve direct target drilling on discrete geochemical anomalies.

Working counter to this, however, is a growing realization that, under Yilgarn regolith conditions, it can be exceedingly difficult to identify the depth or complexity of transported cover without the benefit of drill profiles (thus raising questions about the effectiveness of near-surface sampling). Furthermore, it is now well

continued on page 14

RAB Drilling and RAB Geochemistry ... continued from page 13

documented that gold can be significantly leached from some parts of the bedrock profile, with lateral and vertical re-distribution.

Several minor successes have been reported, particularly in areas of shallow cover, and the potential is of course enormous. However, the jury is decidedly still out as to whether there are robust near-surface partial leach anomalies in areas of >10m cover in Yilgarn-type regolith environments.

The ***Selective Sampling*** approach is essentially a modification of the highly successful RAB-based approach of the last 5 or so years. Shallow drilling using a lightweight RAB or vacuum rig is used to specifically target and sample particular regolith materials such as ferruginous lateritic residuum or detritus, as well as base-of-hardpan (boh), base-of-cover (boc), or even upper saprolite. Drilling costs are perhaps only 25-30% of a conventional RAB geochemical survey, in which all holes penetrate to refusal and the entire profile is sampled by composite units.

There have been some notable successes using this approach, particularly in northern parts of the Yilgarn under cover thicknesses of 10-30m, though a serious question remains as to whether it constitutes an effective test in areas where lateritic profiles are largely stripped. Unfortunately, the widespread presence of stripped but buried profiles can normally be deduced only with hindsight- and the drilling budget cannot be refunded for a change in tactics!

The ***Deep Drilling*** approach is based on the belief that the only effective test of a potential gold system in the Yilgarn is to drill it systematically down to fresh rock, using RAB, Aircore or RC techniques as required by ground conditions. Within several Australian gold camps, some of today's most successful explorers have adopted this approach by negotiating access through Joint Venture or short-term Options to the most prospective terrain, then exploring the interpreted favorable sites for mineralisation by the use of intensive drill campaigns in which all holes penetrate through the regolith to fresh rock.

There have been some notable successes, but only time will tell if the skill of target generation and quality of resources justifies the rate of expenditure that such deep systematic drilling requires. A graphic recent example is provided by the Mt Pleasant area, NW of Kalgoorlie. Previous exploration generated several moderate-to-small gold resources (Mazzuchelli, 1996) using a conservative surface geochemical approach amounting to some 40,000 samples. However, the group who took control of the properties in late 1995 favoured an aggressive deep drilling approach. Focussing on interpreted geological features from magnetic interpretations and essentially ignoring the previous surface geochemistry, they reportedly located and defined in excess of 2.5 Moz of new gold resources within a twelve month period (Forster *et al.,* 1997). However, it should be noted that the conversion of these "resources" to reserves by subsequent operators was substantially less than expectations.

We cannot identify any technological change that offers significant improvement to current RAB drilling practises, but any development would be rapidly taken up by the industry owing to the potential for huge savings. The advent of Aircore drilling has provided a significant benefit particularly in areas of thick and clay-rich cover, so perhaps a follow-up article on this technique is warranted at some point. Australia's exploration drilling industry has shown itself to be innovative and quick to take up new technologies (e.g. reverse circulation, face sampling bits). For geochemists, challenges remain to extract maximum benefit from RAB drill samples that are relatively cheap, but often with problematic quality. Much remains to be done in this area.

Clearly, great savings are possible if we can confidently screen out much of the non-prospective "kangaroo pasture" and thus focus on prospective target zones without having to resort to grid-style RAB drilling. Improved techniques in geochemistry, geophysics and geology can all play a part here. In particular, near-surface geochemical methods (e.g. partial extractions and biogeochemistry) offer some promise, but many pragmatic explorers are not yet convinced of the reliability of these techniques as "area sterilisation tools", in new areas with poorly constrained regolith depth and profile. By contrast, the RAB rig is seen as a reliable, or even diagnostic, first-pass confirmation, be that positive or negative.

The immediate proximity of a RAB rig is not a pleasant working environment: it is typically hot or chilly, dusty and/or muddy, noisy and invariably hectic. However, this is the place where the geologist's knowledge of regolith materials and processes is put to its most severe test, and it will remain the place to be for Australian explorers who want to experience the adrenalin rush that comes from discovering new ore bodies.

We appreciate the input from colleagues in particular Nigel Radford, Tim Mueller, Carl Brauhart and Peter Morant for helpful discussions and reviews. Figures were drafted by Pegi De Angelis. We also thank Beth McClenaghan and Chris Benn for offering further comment on the paper.

References

Anand, R.R., 1995: Genesis and classification of ferruginous regolith materials in the Yilgarn Craton of Western Australia: Implications of mineral exploration. Explore, 89, 3-7.

Berkman, D.A., 2001: Field Geologists Manual. Aus. I.M.M. Monograph Series No 9, Fourth Edition. Aus.I.M.M., Melbourne.

Barnes, J.F.H., 1987: Practical methods of drillhole sampling. A.I.G. Bulletin No 7, 145-170.

Butt, C.R.M., Lintern, M.J., and Anand, R.R., 1997: Evolution of regoliths and landscapes in deeply weathered terrain- implications for geochemical exploration. In Gubbins, A.G. (Ed): Proceedings of

continued on page 29

GOOGLE SCHOLAR: Some Implications for Scientific Research and Publishing

In his recent book *The World is Flat: A Brief History of the Twenty-first Century*, Thomas Friedman attributes much of the surge in the worldwide dispersion of knowledge to the ubiquitous Google search engine and its ability to rank in order of relevance. In terms of general knowledge and information, it is helping to “flatten” the earth. Now, Google is doing the same for academic research. In November, 2004, Google released the beta version of Scholar. It provides a searchable database of peer-reviewed papers, theses, books and abstracts from commercial and society publishers and similar materials stored on university and other websites. The database has been developed from lists provided by publishers and from Google’s proprietary methods of “web-crawling”.

As of January 2006, Scholar is still in its beta form and is incomplete. For example, articles published in the *Journal of Geochemical Exploration* prior to about 1982 are not listed unless they are cited in later articles. But Scholar is growing rapidly and it is mind-boggling that so much information has been accumulated in such a short time. I recently searched using a single word. The papers returned included one in the most recent issue of GEEA (v. 5/4). Moreover, this word was not present in either the abstract or title or list of keywords, so Scholar is storing and indexing the entire text: a far more effective method of searching. It is good news for GEEA authors that a freely-available search engine is as likely to identify a paper in this young journal as one in a journal that is longer established. Another feature that adds to Scholar’s power is that it scans and indexes the reference list of each publication. A search returns papers in order of relevance, which is mainly determined by the number of citations, and the citing papers are listed.

Prior to Scholar there were two methods of searching for scientific information. The first was a keyword or author search on a database such as Georef. The second was to pick two or three key papers on the topic of interest and search for later articles that cited these papers. A citation search required, for example, the database of the Institute of Scientific Information (since incorporated into Thomson Scientific’s Web of Science). Now Scholar provides these two methods within the same database. Of equal importance is the academic scope of Scholar. Many other bibliographic databases are confined to one discipline, e.g., Georef. An applied geochemist may obtain useful information from a variety of disciplines.

The arrival of Scholar as a free service provides a challenge for the publishers of subscription-based bibliographic databases. The American Chemical Society (ACS) sells its Chemical Abstracts service to approximately 1,000 universities and colleges. In December, 2004, a month after Scholar was released, ACS filed a suit claiming that Google is infringing on its own product Scifinder Scholar. When the full version of Scholar is complete, Google will presumably recover its costs plus profit by targeted advertising.

An abstract is provided for papers identified by the Scholar search. Then, for the full paper, the reader is usually directed to the publisher website, where the article can be purchased and downloaded. Costs are in the order of US$30 per article, which discourages the usual library practice of browsing. Persons who are associated with major universities and institutes in developed countries can, of course, go to their library or access online journals. For others there is another, partial option. For about a quarter of the papers of interest to me I have been able to download the complete article at no cost. A few journals, such as the Canadian Journal of Earth Sciences, permit free access. Other papers are available on personal websites at universities, which Scholar identifies. Most academics now have their own sites and, for obvious reasons, are glad to make their papers generally available. Prior to Scholar and its web-crawling methods, the location of a paper on a specific site would not be generally known. Whereas in the past papers on personal sites were not a major issue for publishers, presumably this must now be causing unease.

The model for access to the academic literature was set by conditions that applied for several hundred years. Journals were expensive to print and distribute and to house in libraries. Thus large institutions had large libraries, small institutions small libraries, and individual scientists one or two journals. When online databases and journals came into being these conditions were no longer relevant, yet the same hierarchical allocation was applied: try to get an individual subscription to Georef or Geoscience World.

Thus Scholar is likely to accelerate changes already taking place in scientific publishing, most notably “Open Access”. This topic is the subject of a myriad of articles and blogs and the interested reader is directed to Open Access News (www.earlham.edu/~peters/fos/fosblog.html). A strong force behind open access is the National Institutes of Health in the United States. Their contention is that if research funded by government is to achieve its maximum benefit, it must be made freely available. This is now being codified into law as part of the *Cures* bill introduced into the US Senate by Senator Joseph Lieberman with bipartisan support. The relevant part of the bill requires that papers derived from health research funded by government be delivered to an online repository at the time of acceptance. Then, six months after deposit, the papers will be made available online to all. Open access, either in the formal form envisaged by the *Cures* bill, or in the personal websites of scientists revealed by Scholar, will change the economic rationale for scientific publishing. In the twenty-first century typesetting, printing, distribution and marketing will be displaced by online journals. Doubtless many will miss the printed page and glossy cover, but will be compensated by an abundance of colour illustrations.

Eion Cameron
Eion Cameron Geochemical,
865 Spruce Ridge Road, Carp, Ontario, K0A 1L0
eioncam@attglobal.net

Obituary

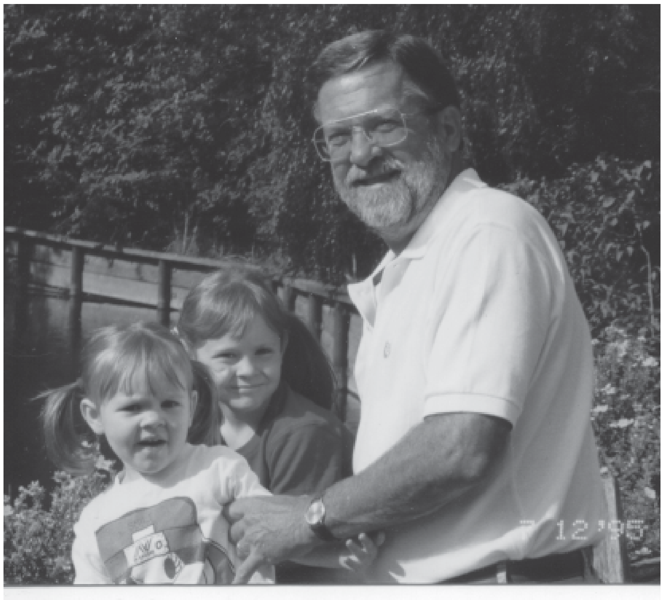
Kenneth A. Lovstrom (1943-2005)

On December 17, 2005, the Association lost a truly great geochemist and member. Ken served on Council starting in 1977, became Vice President in 1980, and served as President for the 1981-1982 term. He was also an active participant in several committees and most recently served on the Awards Committee that granted Ian Nichol Honorary Membership in the Association in September, 2005.

After graduating from the University of Arizona with a B.S. degree in Geosciences in 1969, Ken began a career that would ultimately lead him around the globe several times and lead to significant mineral discoveries. Early in his career he was influenced by the great Lyman Huff, who's 1962 paper entitled "A geochemical study of copper deposits hidden beneath an alluvial cover in Pima County, Arizona" undoubtedly wet his appetite for exploring through cover. This served Ken well as his later work with biogeochemistry led to important Cu and Au discoveries in Arizona and Nevada. Hired as a consultant by Goldfields in the mid-'80s, Ken conducted a sage survey over the recently discovered outcropping Chimney Creek deposit in Humboldt County, Nevada and extended the survey south into the gravel covered area to the edge of the Goldfields claims. In addition to a very robust Au anomaly in sage over the Chimney Creek system, an isolated 8-point anomaly also occurred in the southern-most part of the grid and was open to the south. The anomaly was not initially drilled as it was thought to be related to contamination from the Getchell smelter, or perhaps erosion off the Chimney Creek system. Goldfields eventually tested the anomaly, leading to the discovery of the giant, completely covered, Twin Creeks deposit. Ken recently discussed the discovery history and mentioned that the survey in the flats was conducted on horse back. Use of biogeochemistry under Ken's direction also led to the discovery of the completely blind Sol Cu deposit in Arizona in the early '70s.

Ken was Chief Geochemist for Amax Exploration for 16 years and was a key contributor to Amax's industry-leading effort to understand porphyry molybdenum deposits and how to explore for them. Shortly after leaving Amax he returned as a consultant to study their covered Sleeper Au discovery in Nevada and systematically sampled the gravel benches as the overburden was being stripped. This work demonstrated that Au and pathfinder elements migrate vertically through overburden.

Ken's consulting business thrived due to his knowledge, experience and especially his friendly and helpful personality. He was a key consultant for Phelps Dodge and recently signed-on with Newmont.



During a trip to Southeast Alaska for Phelps Dodge with Roger Steininger, they became stranded on a beach for 3 days when their helicopter failed to return. While both were confident of their survival, their families and associates had no idea of their situation. Undoubtedly, Ken developed a greater appreciation for life, family, and friends out of that incident.

Ken's enthusiasm and passion for exploration geochemistry was contagious. His breadth of expertise in exploration geochemistry was unparalleled and he stayed current with the latest technology. From developing standards, applying the latest methods, or testing the latest analytical technology, Ken was a geochemist who could do it all. Ken will be sorely missed by his colleagues, friends and family.

He leaves his wife of 40 years, Jean, daughter Kathy (Financial Analyst - Tucson, Arizona), son Eric (Business Owner - Anchorage, Alaska) and grandchildren Caelan and Ryleigh.

An endowed scholarship fund has been established at the University of Arizona to honor Ken Lovstrom. To contribute to this fund, please contact:

Craig Barker
University of Arizona Foundation
1111 N. Cherry Avenue
Tucson, Arizona 85721
(520)-621-3340

David Kelley
Roger Steininger
Shea Clark Smith
Greg Hill

Obituary

Alfred A Levinson (1927-2005)

Alfred A Levinson passed away on Monday, December 12, 2005, at the age of 78, after a long private battle with lung cancer. Al was best known in exploration geochemical circles for his text book “Introduction to Exploration Geochemistry” first published in 1974, and republished with an extensive supplement in1980, and as co-author of “Practical Problems of Exploration Geochemistry” published in 1987. More recently, he turned his considerable intellectual talents to the challenges of diamond exploration, publishing a number of papers and contributing a chapter entitled “Diamond Sources and Their Discovery” to the 1997 book “The Nature of Diamonds”.

Al Levinson was born on Statten Island, New York, and first became interested in geology while at high school, developing a fascination for volcanoes, earthquakes and the mysteries of geological time. Al served in the U.S. Navy during World War II and subsequently obtained his doctorate degree in mineralogy from the University of Michigan in 1952. His distinguished career as a geochemist/geologist/mineralogist included positions as assistant professor at Ohio State University, and research mineralogist with Dow Chemical and Gulf Research, before joining the University of Calgary in 1967 as Professor of Geology.

During his tenure at Calgary, he not only taught thousands of students, but he also served on the editorial boards of several major geological journals (notably as executive editor of Geochemica et Cosmochemica Acta). In addition, he edited the first scientific volumes on the rocks recovered during the 1969 Apollo 11 voyage to the moon, and authored a number of books. Shortly before his retirement from the University of Calgary in 1994, Al developed an interest in gemology that he pursued as author, as editor of Gems and Gemology, and as a lecturer, until his death. In 2001, a new mineral species, levinsonite, a rare-earth mineral, was named in his honor in recognition for developing the “Levinson modifier” for the nomenclature of rare-earth minerals.

Al Levinson had a long and exceptionally productive career, making substantial and lasting contributions to geology, mineralogy, gemology, and exploration geochemistry. Not least, he inspired a large number of students and, through his books, papers and numerous presentations, educated and encouraged several generations of academic and industry professionals to reach for excellence in the practice of geoscience.

Peter Bradshaw

Nominations sought for geoscience research medal

CRC LEME in collaboration with the CSIRO are currently seeking nominations for the 2006 Butt Smith Medal.

Awarded every two years, the Butt Smith Medal recognises outstanding and sustained research excellence in the field of geoscience.

The medal acknowledges Dr Charles Butt and Dr Ray Smith, who have made invaluable contributions to mineral exploration geochemistry, regolith geology and ore deposit research, through their lifelong association with the CSIRO and CRC LEME.

They have played a significant role in the development of the Australian mineral industry in the past three decades. Dr Butt and Dr Smith have won international respect as outstanding scientists tackling the enormous topic of the Australian regolith and providing exploration solutions.

Thanks to them, we now understand simple but vital messages based on complex concepts – metals can be dispersed in the regolith, some materials are more important than others to sample, and different landform settings require different exploration strategies.

Winner of the inaugural Butt Smith Medal in 2004 was Perth geoscientist, Dr Richard Mazzucchelli. Dr Mazzucchelli’s innovative geochemical research led to resource companies such as WMC Resources successfully adopting his pioneering mineral exploration techniques.

“As an employee of WMC Resources, I was in a unique position to document dispersion of elements associated with nickel sulphides in rock, gossan, soil and stream sediment before others, and develop cost-effective exploration methods,” Dr Mazzucchelli said.

“WMC was also the first company to recognise the importance of calcrete uranium deposits and I exploited this to demonstrate the effectiveness of hydrogeochemistry in exploration.”

Dr Mazzucchelli said he was delighted to be the first recipient of such a prestigious award.

“I felt honoured to be recognised and have my name linked with those of Charles Butt and Ray Smith. Apart from my PhD research in the 1960s at Imperial College London, my work has consisted of developing applications entirely within industry, so I felt fortunate to receive a research award,” Dr Mazzucchelli said.

“I am sure this award will continue to play an important role in recognising the work that geoscientific researchers play in discovering the mines of tomorrow.”

The winner of the Butt Smith Medal receives a $15,000 grant and opportunities to present a commemorative address.

Nomination forms for the Butt Smith Medal can be downloaded from the CRC LEME website (http://crcleme.org.au).

CALENDAR OF EVENTS

These events also appear on the web page at www.appliedgeochemists.org

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

■March 27-29, 2006 SME Annual Meeting, St.Louis, Missouri. Website: www.smenet.org/AnnualMeeting2006/index.cfm

■April 3-7, 2006 **Backbone of the Americas – Patagonia to Alaska**, Co-sponsored by the Geological Society of America and the Association Geologica Argentina. Mendoza, Argentina. Website www.geosociety.org/meetings/06boa/index.htm

■April 10-12, 2006 **Scientific Conference – Topical Problems of Ore Formation and Metallogeny**. Russian Academy of Sciences, Institute of Geology,. Novosibirsk, Russia. Website: www.uiqqm.nsc.nu/conf/conf100

■April 5-16, 2006. **Modular Course in Exploration for Magmatic Ore Deposits**, Sudbury, Ontario, Canada.. Email: mlesher@laurentian.ca, Website: http://earthsciences.laurentian.ca.

■May 8-10, 2006 **IASME/WSEAS International Conference on Water Resources, Hydraulics & Hydrology** (WHH'06), Evia island, Greece. Website www.wseas.org

■May 14-16, 2006 **Wealth Creation in the Minerals Industry**, **SEG 2006 Conference** in Keystone, Colorado. Website www.seg2006.or

■May 14-17, 2006 **GAC-MAC Annual Meeting "206 is the International Year of the Planet"**, Montreal, QC, Canada. Website www.er.uquam.ca/nobel/gacmac/welcome.html

■May 14-17, 2006 **CIM's VANCOUVER 2006** – "Creating Value with Values". Website www.cim.org/vancouver2006

■May 14-18, 2006 International conference on Continental Volcanism, Guangzhou. Website www.iavcei2006.org

■June 5-7, 2006 **Coastal Environment 2006 – Sixth International Conference on Environmental Problems in coastal Regions including Oil and Chemical Spill Studies**, Rhodes Island, Greece. Website www.wessex.ac.uk/conferences/2006/coast06/index.html

■**2006 Precious Metals Symposium**. Hosted by the Society for Mining, Metallurgy and Exploration. See website for details: www.iseg.2006.com/welcome.tm

■June 6-8, 2006 **Geo-Environmental & Landscape Evolutiom 2006 – 2^{nd} International Conference on Geological Environment and Landscape**. Rhodes island, Greece. Website www.wessex.ac.uk/confernces/2006/geoenv06/index.html

■July 2-7, 2006 **18^{th} AGC:Australian Earth Science Convention 2006** Melbourne Exhibition and Convention Centre, Melbourne, Australia. Website www.earth2006.org.edu.org

■July 3-7, 2006 Protection and Restoration of the Environment VIII. Chanoa island, Crete, Greece. Website www.pre8.enveng.tuc.gr

■11-13 September 2006 Envoronmental Toxicology 2006 – 1st International Conference on Environmental Toxicology. Mykonos island, Greece. Website www.wessex.ac.uk/conferences/2006/toxic06/index.html

■13-15 September 2006 First International Seminar on Mine Closure, Perth, Western Australia. Website www.acq.uwa.edu.au

■27 Aug – 1 Sept., 2006 **16^{th} Annual VM Goldschmidt Conference 2006** Melbourne Exhibition and Convention Centre, Melbourne, Australia. Website www.goldschmidt2006.org

■24-29 September **2006 IGCP 486 Au-Ag-telluride-selenide deposits.** Field Workshop, Izmir, Turkey. Email ismet.ozgenc@deu.edu.tr

■Sept 25-27 2006 Advances in Mineral Resources Management and Environmental Geotechnology (AMIREG 2006). Chania, Crete, Greece. Website http:/heliotopos.conferences.gr/amireg2006

■Sept 25-30. 2006 **7^{th} International Symposium on Environmental Geochemistry (2006)** Beijing, China

■September 18 - 29th, 2006. **Modular Course in Mineral Exploration in Volcanic Terrains (Field-Based)**. Sudbury, Ontario, Canada. Information: **Harold Gibson**, Mineral Exploration Research Centre, Department of Earth Sciences, Laurentian University, Willet Green Miller Centre, 933 Ramsey Lake Road, Sudbury, ON, Canada, P3E 6B5; Ph. +1.705.675.1151 x2371, Fax. +1.705.675.4898. Email: hgibson@laurentian.ca. Website: http://earthsciences.laurentian.ca.

■December 6-15, 2006. **Modular Course in Exploration Geochemistry**. Sudbury, Ontario, Canada. Information: **Steve Piercey**, Mineral Exploration Research Centre, Dept. of Earth Sciences, Laurentian University, Willet Green Miller Centre, 933 Ramsey Lake Road, Sudbury, ON, Canada, P3E 6B5; Ph. +1.705.675.1151 x2364, Fax. +1.705.675.4898. Email: spiercey@laurentian.ca. Website: http://earthsciences.laurentian.ca.

■June 17-20 2007 **Third International Conference on Sustainable Development Indicators in the Minerals Industry (SDIMI 2007)**. Milos Island, Greece. Website http://milos.conferences.gr/index.php?id=3184

■June 2007 23^{rd} **International Applied Geochemistry Symposium, Oveido, Spain**

■September 1-15, 2007. **Modular Course in Structure, Tectonics, and Mineral Exploration (Field-Based)**. Sudbury, Ontario, Canada. **Bruno Lafrance**, Mineral Exploration Research Centre, Dept. of Earth Sciences, Laurentian University, Willet Green Miller Centre, 933 Ramsey Lake Road, Sudbury, ON, Canada, P3E 6B5; Ph. +1.705.675.1151 x2264, Fax. +1.705.675.4898. Email: blafrance@laurentian.ca Website: http://earthsciences.laurentian.ca.

Please send details of your events to:

Chris Benn, *BHP Billiton*
Suite 800 – Four Bentall Centre, 1055 Dunsmuir Street
Vancouver V7X 1L2 BC Canada
TEL: 604 632 1493 FAX: 604-683 4125
e-mail: Chris.Benn@bhpbilliton.com

RECENT PAPERS

This list comprises titles that have appeared in major publications since the compilation in **EXPLORE** Number 128. Journals routinely covered and abbreviations used are as follows: Economic Geology (EG); Geochimica et Cosmochimica Acta (GCA); the USGS Circular (USGS Cir); and Open File Report (USGS OFR); Geological Survey of Canada papers (GSC paper) and Open File Report (GSC OFR); Bulletin of the Canadian Institute of Mining and Metallurgy (CIM Bull.): Transactions of Institute of Mining and Metallurgy, Section B: Applied Earth Sciences (Trans. IMM). Publications less frequently cited are identified in full. Compiled by L. Graham Closs, Department of Geology and Geological Engineering, Colorado School of Mines, Golden, CO 80401-1887, Chairman AEG Bibliography Committee. Please send new references to Dr. Closs, not to **EXPLORE**.

Anand, R.R. and de Broekert, P (eds.), 2005. Regolith Landscape Evolution across Australia. CRCLEME (Cooperative Research Center for Landscape Evolution and Mineral Exploration). 352 p.

Baker, P.M. and Waugh, R.S., 2005. The Role of surface geochemistry in the discovery of the Babel and Nebo magmatic nickel-copper-PGE deposits. Geochemistry: Exploration, Environment, Analysis 5(3): 195-200.

Beaufort, D., et al., 2005. Clay Alteration Associated with Proterozoic Unconformity-Type Uranium Deposits in the East Alligator Rivers Uranium Field, Northern Territory Australia. EG 100(3): 515-536.

Bowell, R.J. and Parshley, J.V., 2005. Control of pit-lake water chemistry by secondary minerals, Summer Camp pit, Getchell mine, Nevada. Chem. Geol. 215(1-4): 373-386.

Brown, J., et al., 2005. Measurement of labile metals in acid rock drainage springs, New Zealand: Field application of anodic stripping voltammetry. Applied Geochem. 20(8): 1533-1455.

Butt, C.R.M., Robertson, I.D.M., Scott, K.M., and Cornelius, M. (eds.), 2005. Regolith Expressions of Australian Ore Systems. CRCLEME. 423 p.

Cameron, E.M. and Leybourne, M.I., 2005. Relationship between groundwater chemistry and soil geochemical anomalies at the Spence copper porphyry deposit, Chile. Geochemistry: Exploration, Environment, Analysis 5(2): 135-145.

Chang, C.W., et al., 2005. Rapid determination of chemical and physical properties in marine sediments using a near-infrared reflectance spectroscopic techniques. Applied Geochem. 20(9): 1637-1647.

Chouinard, A., et al., 2005. Geology and Genesis of the Multistage High-Sulfidation Epithermal Pascua Au-Ag-Cu Deposit, Chile and Argentina. EG 100(2): 463-490.

Chung, E.H., et al., 2005. Environmental contamination and bioaccessibility of arsenic and metals around the Dongjeon Au-Ag-Cu mine, Korea. Geochemistry: Exploration, Environment, Analysis 5(1): 69-74.

Cicchella, D., De Vivo, B., and Lima, A., 2005. Background and baseline concentration values of elements harmful to human health in the volcanic soils of the metropolitan and provincial areas of Napoli (Italy). Geochemistry: Exploration, Environment, Analysis 5 (1): 29-40.

Cornelius, M., et al., 2005. Laterite geochemistry applied to diamond exploration in the Yilgarn Craton, Western Australia. Geochemistry: Exploration, Environment, Analysis 5(4): 291-310.

Dalrymple, I.J., Cohen, D.R., and Gatehouse, S.G., 2005. Optimization of partial extraction chemistry for buffered acetate and hydroxyl lamine leaches. Geochemistry: Exploration, Environment, Analysis 5(3): 279-285.

Day, S.J. and Bowell, R.J., 2005. Atypical and typical zinc geochemistry in a carbonate setting, Sa Dena Has mine, Yukon Territory, Canada. Geochemistry: Exploration, Environment, Analysis 5(3): 255-266.

Deb, M. and Goodfellow, W.D. (eds.), 2004. Sediment-Hosted Lead-Zinc Suphide Deposits, Attributes and Models of Some Major Deposits in India, Australia, and Canada. Narosa Pub. (New Delhi, India). 367 p.

Entwistle, J.A., et al., 2005. Determination of selected actinides (U, Pu, & Am) in Belarus soils using high resolution inductively coupled plasma mass and gamma spectrometry. Geochemistry: Exploration, Environmental, Anaylsis 5 (1): 11-19.

Fletcher, W.K. and Muda, J., 2005. Dispersion of gold in stream sediments in the Sungai Kuli region, Sabah, Malaysia. Geochemistry: Exploration, Environmental, Analysis 5(3): 211-214.

Fordyce, F.M., et al., 2005. GSUE: urban geochemical mapping in Great Britain. Geochemistry: Exploration, Environmental, Analysis 5(4): 325-336.

continued on page 20

RECENT PAPERS

continued from Page 19

Frimmel, H.E., 2005. Archean atmospheric evolution: Evidence from the Witwatersrand gold fields, South Africa. Earth Sci. Reviews 70(1-2): 1-102.

Garrett, R.G. and Lalor, G.C., 2005. The Fe/Na ratio, a framework for modeling trace element distributions in Jamaican soils. Geochemistry: Exploration, Environmental, Analysis 5(2): 147-157.

Giere, R. and Stille, P. (eds.), 2004. Energy, Waste, and the Environment: A Geochemical Perspective. Geol. Soc. Spec. Pub. 236. 688 p.

Gregory, M.J., Wilde, A.R. and Jones, P.A., 2005. Uranium Deposits of the Mount Isa Region and Their Relationship to Deformation, Metamorphism, and Copper Deposition. EG 100(3): 537-546.

Hall, G.E.M. and Pelchat, P., 2005. The design and application of sequential extractions for mercury. Part 2. Resorption of mercury onto the sample during leaching. Geochemistry, Exploration, Environmental, Analysis 5(2): 115-121.

Hall, G.E.M., Pelchat, P., and Percival, J.B., 2005. The design and application of sequential extactions for mercury. Part 1 Optimization of HNO_3 extraction for all non-sulphide forms of Hg. Geochemistry: Exploration, Environmental, Analysis 5(2): 107-113.

Hammarstrom, J.M., et al., 2005. Secondary sulfate minerals associated with acid drainage in the eastern US: Recycling of metals and acidity in surficial environments. Chem. Geol. 215(1-4): 407-432.

Harmon, R.S., et al., 2005. Laser-induced breakdown spectroscopy (LIBS) – an emerging field-portable sensor technology for real-time, in-situ geochemical and environmental analysis. Geochemistry: Exploration, Environmental, Analysis 5(1): 21-28.

Hedenquist, J.W., Thompson, J.F.H., Goldfarb, R.J., and Richards, J.P., (eds.), 2005. Economic Geology 100^{th} Volume. 1146 p.

Hou, Z. and Fletcher, W.K., 2005. Transportation and deposition of magnetite and gold in Harris Creek, south-central British Columbia. Geochemistry: Exploration, Environmental, Analysis 5(3): 215-221.

Johnson, C.C., et al., 2005. G-BASE: baseline geochemical mapping of Great Britain and Northern Ireland. Geochemistry: Exploration, Environmental, Analysis 5(4): 347-357.

Kairies, C.L., Capo, R.C. and Watzlaf, G.R., 2005. Chemical and physical properties of iron hydroxide precipitates associated with passively treated coal mine drainage in the Bituminous Region of Pennsylvania and Maryland. Applied Geochem. 20(8): 1445-1460.

Keimowitz, A.R., et al., 2005. Naturally occurring arsenic: Mobilization at a landfill in Maine and implications for remediation. Applied Geochem. 20(11): 1985-2002.

Khar'kiv, A.D., Roman'ko, E.F. and Zubarev, B.M., 2005. Kimberlites of Zimbabwe: Abundance and Composition. Russian Geol. and Geophysics 46(3): 317.

Lax, K. and Selinus, O., 2005. Geochemical mapping at the Geological Survey of Sweden. Geochemistry: Exploration, Environmental, Analysis 5(4): 337-346.

Lee, L. and Helsel, D., 2005. Baseline models of trace elements in major aquifers of the United States. Applied Geochem. 20(8): 1560-1570.

Lee, P.K., et al., 2005. Sulfide oxidation and the natural attenuation of arsenic and trace metals in the waste rocks of the abandoned Seobo tungsten mine, Korea. Applied Geochem. 20(9): 1687-1703.

Lightfoot, P.C. and Keays, R.R., 2005. Siderophile and Chalcophile metal variations in Flood Basalts from the Siberian Trap, Noril'sk Region: Implications for the Origin of the Ni-Cu-PGE Sulfide ores. EG 100(3): 439-462.

Lorado, J., Alvarez, R., and Ordonez, A., 2005. Release of toxic metals and metalloids from the Los Rueldos mercury mine (Asturias, Spain). Science Total Environ. 340(1-3): 247.

MacFarlane, W.R., et al., 2005. Continuous leach inductively coupled mass spectrometry: applications for exploration and environmental geochemistry. Geochemistry: Exploration, Environmental, Analysis 5(1): 123-134.

Makinen, J., 2005. A comparison of the geochemistry of aquatic and the fine (<63 um) till fraction in Finland. Geochemistry: Exploration, Environmental, Analysis 5(2): 159-167.

Makinen, J. and Pajunen, H., 2005. Correlation of carbon with acid-soluble elements in Finnish lake sediments: two opposite composition trends. Geochemistry: Exploration, Environmental, Analysis 5(2): 169-181.

Mann, A.W., et al., 2005. Vertical ionic migration: mechanisms, soils anomalies, and sampling depth for

continued on page 21

RECENT PAPERS

continued from Page 12

mineral exploration. Geochemistry: Exploration, Environmental, Analysis 5(3): 201-210.

Marker, B.R., et al. (eds.), 2005. Sustainable Minerals Operations in the Developing World. Geol. Soc. Spec. Pub. 250. 256 p.

Matosova, G.G., et al., 2005. The use of magnetic methods in an environmental study of areas polluted with non-magnetic wastes of the mining industry (Salir region, Western Siberia, Russia). Geochemistry: Exploration, Environmental, Analysis 5(1): 75-89.

McClenaghan, M.B., 2005. Indicator mineral methods in mineral exploration. Geochemistry: Exploration, Environmental, Analysis 5(3): 233-245.

McDonald, I., et al. (eds.), 2005. Mineral Deposits and Earth Evolution. Geol. Soc. Spec. Pub. 248. 280 p.

Montero, I.C., et al., 2005. Characterization of waste rock associated with acid drainage at the Penn mine, California, by ground-based visible short-wave infrared reflectance spectroscopy assisted by digital mapping. Chem. Geol. 215(1-4): 453-472.

Okujeni, C.D., et al., 2005. Controls of element dispersion in Aeolian sand and calcrete-dominated regolith associated with gold mineralization in the Kraaipan greenstone belt, South Africa. Geochemistry: Exploration, Environmental, Analysis 5(3): 223-231.

Otero, N., et al., 2005. Fertiliser characterization: Major, trace and rare earth elements. Applied Geochem. 20(8): 1473-1488.

Palacios, C., et al., 2005. Copper geochemistry in salts from evaporate soils, coastal Range of the Atacama Desert, northern Chile: an exploration tool for blind Cu deposits. Geochemistry: Exploration, Environmental, Analysis 5(4): 371-378.

Pellicori, D.A., Gammons, C.H., and Pulson, S.R., 2005. Geochemistry and stable isotope composition of the Berkeley pit and surrounding mine waters, Butte, Montana. Applied Geochem. 20(11): 2116-2137.

Peng, X., et al., 2005. The vertical variations of hydrocarbon pollutants and organochlorine pesticide residues in a sediment core in Lake Taihu, East China. Geochemistry: Exploration, Environmental, Analysis 5(1): 99-104.

Piani, R., Covelli, S., and Biester, H., 2005. Mercury contamination in Marano Lagoon (Northern Adriatic sea, Italy): Source identification by analyses of Hg phases. Applied Geochem. 20(8): 1546-1559.

Pratas, J., et al., 2005. Plants growing in abandoned mines in Portugal are useful for biogeochemical exploration of arsenic, antimony, tungsten, and mine reclamation. J. Geochem. Explor. 85(3): 99-108.

Pye, K. and Croff, D.J., 2004. Forensic Geoscience: Principles, Techniques, and Applications. Geol. Soc. Spec. Pub. 232. 328 p.

Ranasinghe, P.N., Dissanayake, C.B., and Rupasinghe, M.S., 2005. Application of geochemical ratios for delineating gem-bearing areas in high grade metamorphic terrains. Applied Geochem. 20(8): 1489-1495.

Rao, N.V.C., 2005. A petrological and geochemical reappraisal of the Mesoproterozic diamoniferous Majhgawan pipe of central India: evidence for transitional kiberlite-orangeite (group II kimberlite) – lamproite rock type. Min. and Petrol. 84(1-2): 69.

Reimann, C., 2005. Sub-continental-scale geochemical mapping: sampling, quality control, and data analysis issues. Geochemistry: Exploration, Environmental, Analysis 5(1): 311-323.

Reimann, C., 2005. Geochemical mapping – techniques or art. Geochemistry: Exploration, Environmental, Analysis 5(1): 359-370.

Saether, O.M., Roberts, D., and Reimann, C., 2005. Structural control of strontium concentrations in stream sediments: an example from major fault zones in Central Norway. Geochemistry: Exploration, Environmental, Analysis 5(2): 183-188.

Sajn, R., 2005. Using attic dust and soil for the separation of anthropogenic and geogenic elemental distributions in an old metallurgical area (Celje, Slovenia). Geochemistry: Exploration, Environmental, Analysis 5(1): 59-67.

Sako, A., et al., 2005. Variations in otolith elemental compositions of two clupeid species, Stolothrissa tanganicae and Limonothrissa miodon in Lake Tanganyika. Geochemistry: Exploration, Environmental, Analysis 5(1): 91-97.

Sarala, P., 2005. Till geochemistry in the ribbed moraine area of Perapohjola, Finland. Applied Geochem. 20(9): 1714-1736.

Schreck, P., et al., 2005. Multi-metal contamination stream sediment in the Mansfield mining district: metal provenance and source detection.

continued on page 22

RECENT PAPERS

continued from Page 21

Geochemistry: Exploration, Environmental, Analysis 5(1): 51-57.

Scott, K.M., 2005. Rutile geochemistry as a guide to porphyry Cu-Au mineralization, Northparkes, New South Wales, Australia. Geochemistry: Exploration, Environmental, Analysis 5(3): 247-253.

Seal, R.R., II, Jambor, J.L., and Alpers, C.N. (eds.). Special Issue on the Geochemistry of Sulfate Minerals in High- and Low-temperature Environments. Chem. Geol. 214(1-4). 535 p.

Singer, D.A., et al., 2005. Porphyry Copper Deposit Density. EG 100(3): 491-514.

Slowey, A.J., et al., 2005. Speciation of mercury and mode of transport from placer gold mine tailings. Environ. Sci. and Tech. 39(6): 1547.

Tardy, Y., et al., 2005. The Amazon Bio-geochemistry applied to river management. Part I. Hydro-climatology, hydrograph separation, mass transfer valences, stable isotopes, and modeling. Applied Geochem. 20(9): 1746-1829.

Tarvainen, T., Hellmuth, K.H., and Backman, B., 2005. Natural geochemical concentrations and fluxes of Cu, Th, and U in Finland. Geochemistry: Exploration, Environmental, Analysis 5(1): 41-50..

Tassi, F., et al., 2005. Light hydrocarbons as redox and temperature indicators in geothermal field of El Tatio (northern Chile). Applied Geochem. 20(11): 2049-2062.

Taylor, G. and Pain,C., 1999. New Approaches to an Old Continent (Regolith '98: Australian Regolith and Mineral Exploration). CRCLEME. 341 p.

Van Moort, J.C. and Pwa, A., 2005. The use of quartz concentrate (acid-insoluble residue) as a sample medium in lithgeochemistry and regolith exploration studies: development of a method. Geochemistry: Exploration, Environmental, Analysis 5(3): 267-277.

Velikoslavinskii, S.D. and Glebovitskii, V.A., 2005. A new discriminant diagram for classification of island-arc and continental basalts on the basis of petrochemical data. Doklady Earth Sci. 401(2): 308-314.

Whiteley, J.D. and Murray, F., 2005. Determination of platinum group elements (PGE) in environmental samples by ICP-MS: a critical assessment of matrix separation for the mitigation of interferences. Geochemistry: Exploration, Environmental, Analysis 5(1): 3-10.

Wilkinson, J.J., et al., 2005. Zinc Isotope Variation in Hydrothermal Systems: Preliminary Evidence from the Irish Midlands Ore Field. EG 100(3): 583-590.

Zhang, C. and O'Connor, P., 2005. Comparison between heavy metal concentrations in sediments analyzed by two methods: Analysis on detection limits and data quality. Applied Geochem. 20(9): 1737-1745.

Zhang, C., et al., 2005. Statistical characterization of a large geochemical database and effect of sample size. Applied Geochem. 20(10): 1857-1874.

ioStipend

In-kind Analytical Research Fund for BSc(Hons), MSc and PhD students

Much has been said and written about the broadening gulf between the demand for qualified explorationists and the supply coming out of our colleges, technical institutes and universities. One merely has to attend any geo-conference and gaze out over the sea of grey to fully grasp the situation our industry faces. This is all the more evident in the field of exploration geochemistry whose members have always been in short supply.

As consultants and service industries, we owe our livelihood to mining and exploration and thus have a vested interest in its development. We believe that any aid to promote fresh faces into our sector is helping to secure our future.

Acme Analytical Laboratories Ltd. and **ioGlobal** are taking the bold initiative of directly aiding students in the geosciences via the **ioStipend**. The **ioStipend** is a grant available to students conducting exploration-related geochemical studies at a recognized educational institution. The grant is in the form of analytical services using any package provided by Acme Analytical Laboratories Ltd. Students and/or their teachers/advisors can apply for the grant by submitting the application to ioGlobal who will vet the proposals.

The grant is intended to promote the collection of high quality, base-line data for comparison with more “esoteric data” (eg, isotopic data, partial digests, non-standard sample media) generated during the course of research, and to promote broad training in fundamental geochemical principals across the geosciences.

The **ioStipend** allows for amounts of approximately $5,000 (AUD, CAD or equivalent) for in-kind analytical work. Successful applicants will also be provided with 3 academic licences of **ioGAS**, the new exploratory data analysis software package available from ioGlobal.

The application form is available at www.ioglobal.net.

It is envisaged that three or four of these awards will be made each year.

Applications are reviewed by an expert group of ioGlobal’s geochemists

Eligibility Criteria

Preference will be given to:

- students with no other source of funding
- students working on exploration geochemistry projects
- projects no or very minimal confidentiality requirements

The ioStipend is international. Applications are welcome from qualified institutions globally.

Some technical input may be provided by ioGlobal on request.

Requirements for receiving the ioStipend

Firstly, there are minimal strings attached. Recipients would have to agree to

1. Have their project promoted on the ioGlobal web site in an area devoted to R&D carried out under the program (couple of passport photo shots, brief description)
2. Acknowledge ACME Labs and ioGlobal for support in technical and public presentations of results
3. Write a short article for Explore describing the project outcomes, and allow this to be published on the ioGlobal web site.

David Lawie, John Gravel

Publication gives Australian regolith research snapshot to geoscientists and environmental managers

The latest ground breaking research into understanding the processes at work within the Australian landscape are highlighted in the recently released *Regolith 2005 - Ten Years of CRC LEME* publication.

Containing the proceedings of the 2005 Regional Regolith Symposia, *Regolith 2005* provides a snapshot of Cooperative Research Centre for Landscape Environments and Mineral Exploration (CRC LEME) research activities throughout Australia during 2005.

CRC LEME assists mineral explorers and environmental managers by generating and applying new research about the blanket of soil, sediment and weathered rock in Australia known as regolith.

Regolith 2005 Editor and Minerals Council of Australia Lecturer at the Australian National University, Dr Ian Roach said the publication contains papers presented at the CRC LEME Regional Regolith Symposia in Canberra and Adelaide during November 2005.

"There are more than 70 case study summaries related to the different fields of landscape evolution, regolith geochemistry and inland acid sulfate soil research throughout Australia," Dr Roach said.

"The findings within these papers have direct impact for mineral explorers searching for new deposits and environmental managers wanting a better understanding of the processes at play within the regolith."

Research themes covered by *Regolith 2005* include improving the understanding of regolith processes and landscape evolution, making exploration geochemistry work in areas of transported material, developing new techniques to interpret regolith structures, using regolith knowledge to increase mineral prospectivity and developing new methods to map and predict salinity, acid sulphate soils and other environmental problems.

"*Regolith 2005* is a valuable tool for mineral explorers, natural resource managers, researchers and students alike who want a guide to the different kind of regolith research projects underway in Australia," Dr Roach said.

Regolith 2005 can be downloaded as a series of PDFs for free from http://crcleme.org.au. A hard copy version can be purchased for $55 for the volume $27.50 for the CD (incl GST), plus P&P (For students $27.50 for volume and CD, plus P&P) by downloading the order form from the CRC LEME website.

Media Contact: Greg Lawrence, tel: +61 8 6436 8786, fax: +61 8 6436 8560, mob: 0438 492 467, email: gregory.lawrence@csiro.au, mob: 0438 492 467, website: http://crcleme.org.au

Orientation Partial Digest Geochemistry Over Navan Zn-Pb Mine , Ireland.

by Ed Dronseika, Nick Walker and Ann Evers. (Nov 2005).

Summary

A nine-step sequential leach was used to identify which, if any, partial digestion would indicate the presence of deeply buried mineralisation at Navan. Partial digest techniques appear to detect mineralisation which is not apparent using conventional (total digest) techniques.

Geological Setting

The stratabound Navan deposit (90+ million tonnes) lies within Lower Carboniferous (Mississippian) limestones in Central Ireland approximately 50 km north-west of Dublin.

The orebody is hosted by bioclastic/oolitic grainstones, sandy calcarenites and micrites of the Navan Group. The deposit is overlain by shaley bioclasitc calcarenites, calcsiltites, shales and sandstones. The ore is composed of fine-grained sphalerite, galena, minor pyrite/ marcasite and barite lenses (Ashton J. et al 2003).

Soils are residual fluvisols and podsols within a flat or slightly undulating terrain. No changes in regolith along the traverse are apparent. Samples were collected over land reserved for pasture which produces feed for domestic animals. The site is considered uncontaminated by mining activity.

Sample Locations

Twelve samples (A to L) of <1-mm soils were screened along a single line traverse which passes directly over buried mineralisation (Figure 1). The Tara orebody is located 400 m to 450 m below this traverse.

Analyses

All analyses were carried out at Genalysis Laboratory in Perth, Australia. Reagents were all AR grade or better. Blank values for reagents and de-ionised water used were all below detection limit. Analyses for zinc, cadmium and lead were carried out on a Varian Spectra 55 Atomic Absorption Spectrometer. Sulphur was read on a Perkin Elmer Optima 3300 ICP-OES.

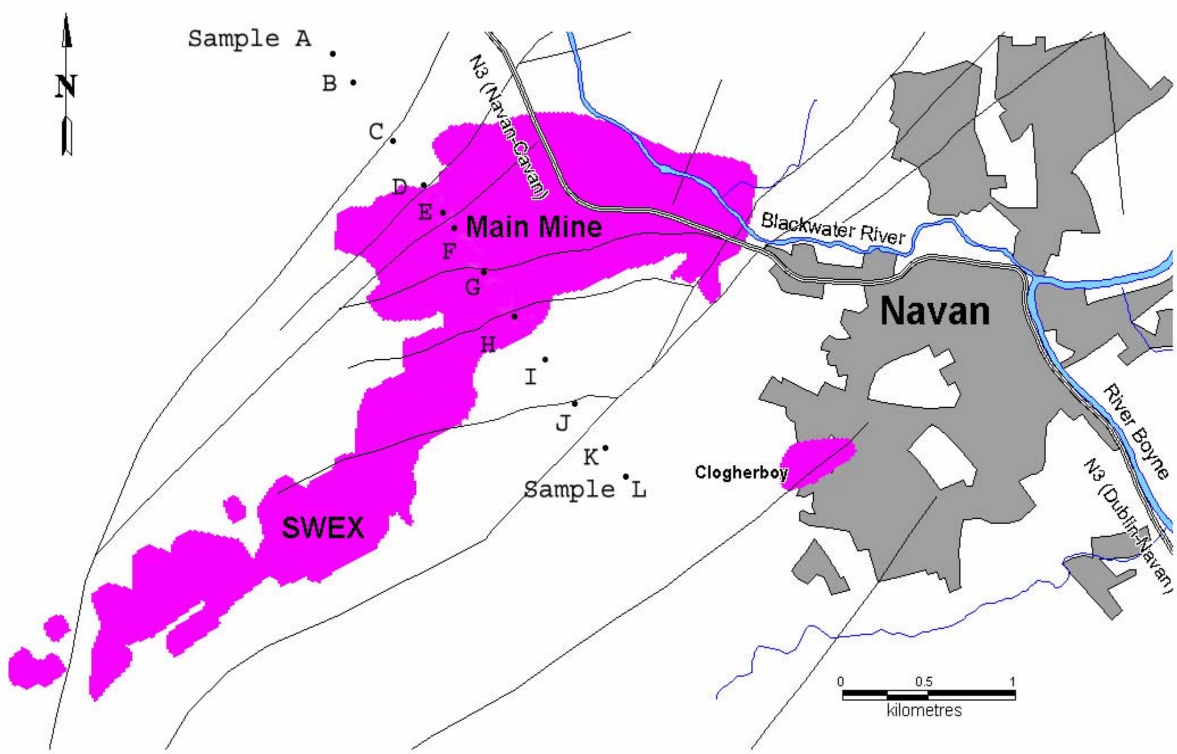
All samples were heated to 121 ^{0}C for four hours to satisfy Australian quarantine requirements.

Sequential Digest Scheme.

The sequential digest procedure was selected to identify the most effective partial digest technique.

The technique removes metal ions from specific sites within the soil matrix using the same samples starting with the softest digest, i.e. water and ending with a total digest, i.e. four acid. If no anomalous response is detected then one can infer that no ions are present or that the ions present are below the detection limit of the analytical system.

Figure 1. Plan projection of Tara ore-body and location of samples.



continued on page 26

Orientation Partial Digest Geochemistry...

continued from page 25

The sequential digest scheme used here is similar to those by Tessier et al. (1979) and Hall et al. (1996). It differs from others by the addition of extra steps at the 'soft' end of the procedure.

1. *H_2O. 4 hrs.* Water soluble component.
2. *0.01M $Ca(NO_3)_2$. 4 hrs.* Weak cation exchangeable.
3. *1M $MgCl_2$. 4 hrs*. Strong cation exchangeable.
4. *0.03M HNO_3. 4 hrs*. Protonateable adsorption sites. If carbonates are present the final solution pH should be adjusted to pH 1.75.
5. *0.0027M (0.1%) EDTA. 4 hrs*. Non-specific strongly adsorbed. Acetic acid added to give a final pH value to 4.
6. *0.1M $Na_4P_2O_7$. 4 hrs*. Organics and some oxy-anions. The solution pH should not fall below 9.5. The solution should be centrifuged in closed vessels for 1 hour to remove suspended Fe and Mn oxides.
7. *0.25M $NH_2OH.HCl$ in 0.25M HCl. 4 hrs. 60 deg C.* Amorphous Fe and Mn oxides. If oxide soil matrix species are intergrown then dissolution may not be complete.
8. *1M $NH_2OH.HCl$ in 25% acetic acid. 4 hrs. 90 deg C.* Crystalline Fe and Mn oxides.
9. *HF-$HClO_4$-HNO_3-HCl.* – A four - acid 'total' digest. Silicates and some refractory minerals.

Points to note:-

- The scheme needs to be flexible to accommodate specific metals. For example, the cation used in the exchangeable phase should have a similar hydrated ionic radius to the targeted metal to enhance exchangeable efficiency. Cations can be the same for both the weak and strongly exchangeable extractions.
- The optimum pH for the extraction of different elements using weak acid alone (protonateable sites) may vary with the element.
- A 0.1M $NH_2OH.HCl$ in 0.015M HNO_3 digest can be included between stages 6 and 7 if predominantly exposed amorphous Mn oxides are targeted.
- If residues are observed after the four acid digest then fusion of these is recommended.

Twelve samples (A to L inclusive) were selected to represent a simplified traverse across a central buried mineralized zone. The solutions were read for Zn only and results are shown in Figure 2. On all profiles samples start with "A" on the left and finish with "L" on the right hand side of the profile. Results shown are for individual extractions and are not aggregated with previous softer digests.

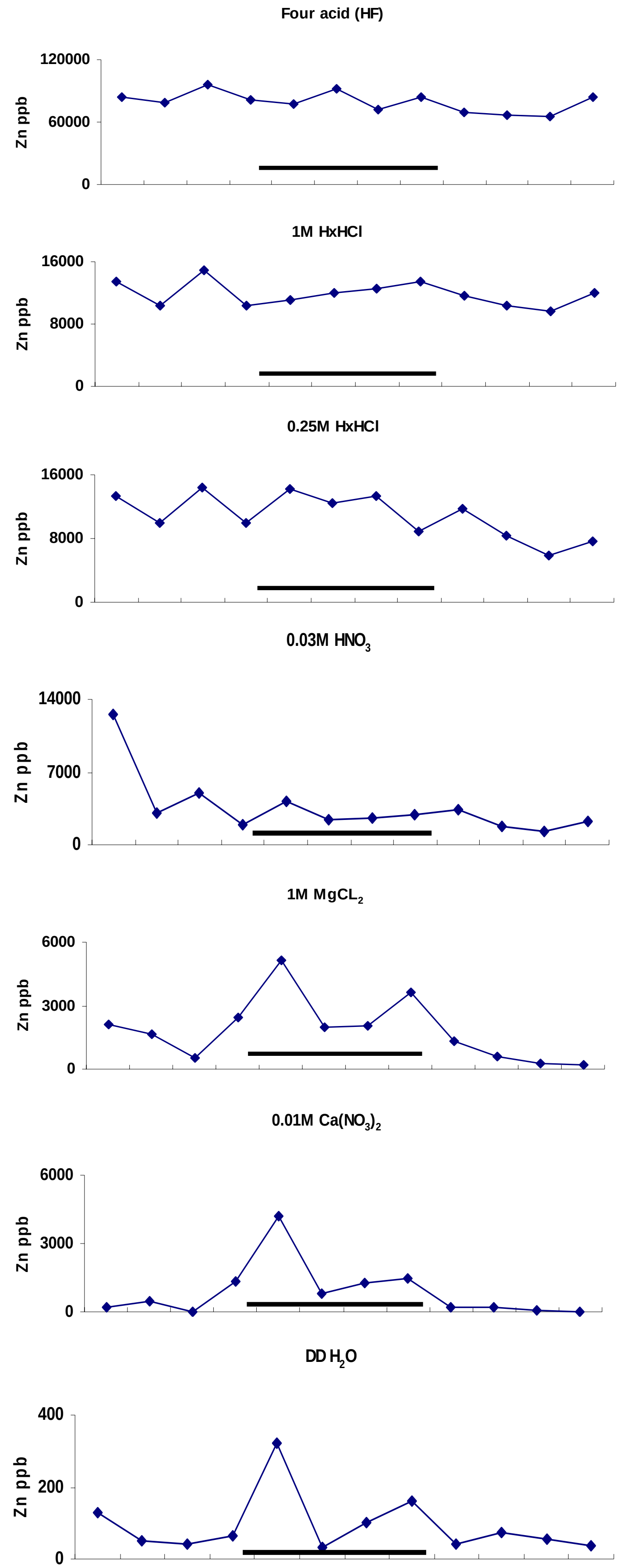


Figure. 2. Sequential digest results. Solid bar denotes surface projection of buried orebody.

continued on page 27

Orientation Partial Digest Geochemistry...

continued from page 26

Variable Reagent Concentration Tests

To determine the effect of reagent concentration on the anomaly profile, the 12 orientation samples were digested under different concentrations of the same reagent. Three reagents utilized: the cation exchange salt ($Ca(NO_3)_2$), a general non specific complexing agent (EDTA), and a protonating reagent (HNO3). The 12 samples were grouped into those over mineralization i.e. the anomalous group, and those over background. The average zinc assay of the anomalous group was divided by the average response of the background group to establish an overall anomaly contrast ratio. The anomalous samples were E, F, G and H. The remaining eight were considered background samples. Anomaly contrast results are shown in Figure 3.

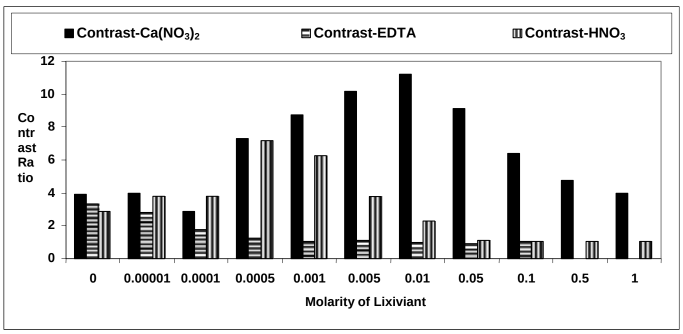


Figure 3. Anomaly to background ratios for 12 key samples.

Samples were initially dissolved in water (lixiviant molarity =0) and increasing strength of reagent added after an aliquot was extracted. The variance at molarity = zero reflects result reproducibilty of the water digest. Because of the limited solubility of EDTA no concentrations above 0.1 M were achieved for that reagent. The calcium nitrate extraction of around 0.01M appears to produce the greatest contrast.

Soil pH Over the Orebody

Lower pH directly above the orebody at surface suggests that it may be contributing hydrogen ions as well as base metal ions (Figure 4). This is consistent with observations by Smee (2003) and Govett (1984). Soil pH measurements may therefore produce an additional data set with which to rate future anomalies provided soils are not extremely acidic or extremely alkaline.

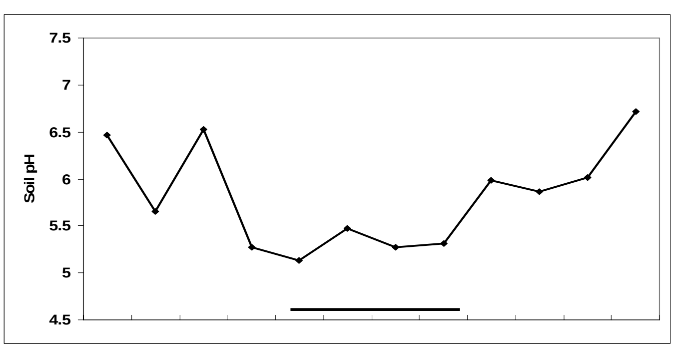


Figure 4. Soil pH (1:5). Solid bar denotes surface projection of buried orebody

Seasonal Variations

Samples were collected from the same location on a monthly basis. The “barren” sample was close to site C and the “ore” sample was close to site G in Figure 1. However, neither sample was considered close enough to reliably reproduce the results actually from sites C and G.

Variations during the season are evident in Figure 5. The ore and background samples are changing in a systematic fashion during the year. The contrast ratio is

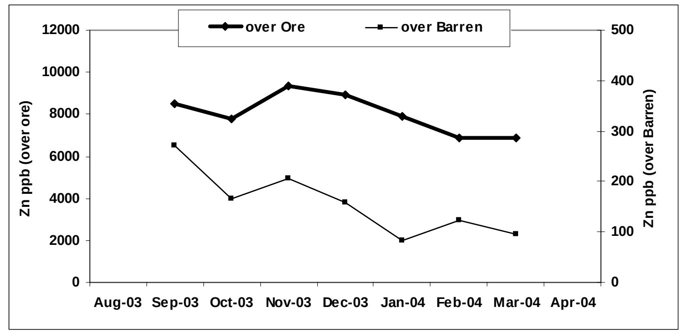


Figure 5. Monthly variation in Zn ppb on re-sampled sites over ore and background. 0.01M $Ca(NO_3)_2$ digest.

also changing (Figure 6). This has implications for sampling at any time of the year. It may require an additional data set that is created by normalising all assay results to an individual survey background.

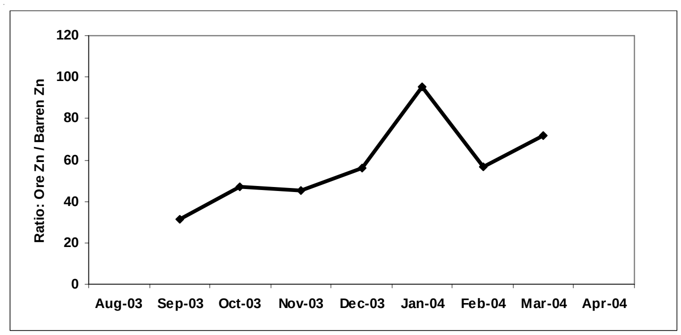


Figure 6. Monthly variation on re-sampled sites. Anomaly to Background Contrast Ratio

We speculate that solar radiation, air temperature and to a lesser extent vapour pressure and wind speed enhance evaporation of soil moisture and the subsequent accumulation of metal ions within the upper portion of the soil profile.

Only subtle seasonal variations are evident with soil pH (Figure 7) although the trend hints of a hydrogen ion increase in sympathy with zinc.

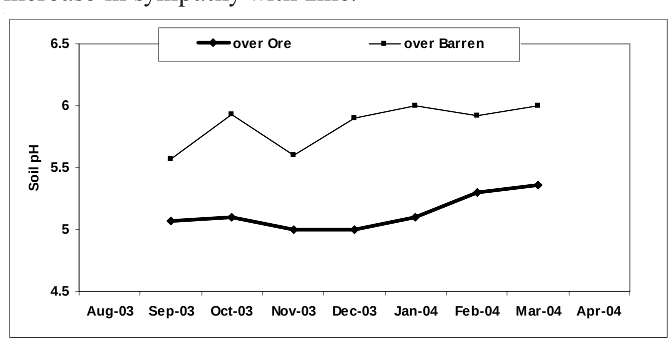


Fig. 7. Monthly variation in soil pH on re-sampling of sites over ore and background.

continued on page 28

Orientation Partial Digest Geochemistry...

continued from page 27

Lead, Cadmium, Sulphur and Iron Analyses

The dissolution and oxidation of galena, sphalerite and pyrite/marcasite could lead to accumulations of lead, cadmium, iron and sulphur within the soil over the Tara orebody in a manner similar to zinc.

Analyses of the calcium nitrate digest are shown in Figure 8.

Iron, cadmium and possibly lead are slightly anomalous. A very low level broad feature is also apparent for sulphur. We speculate that if sulphur is present as a sulphate species then it may have dispersed laterally to form this feature.

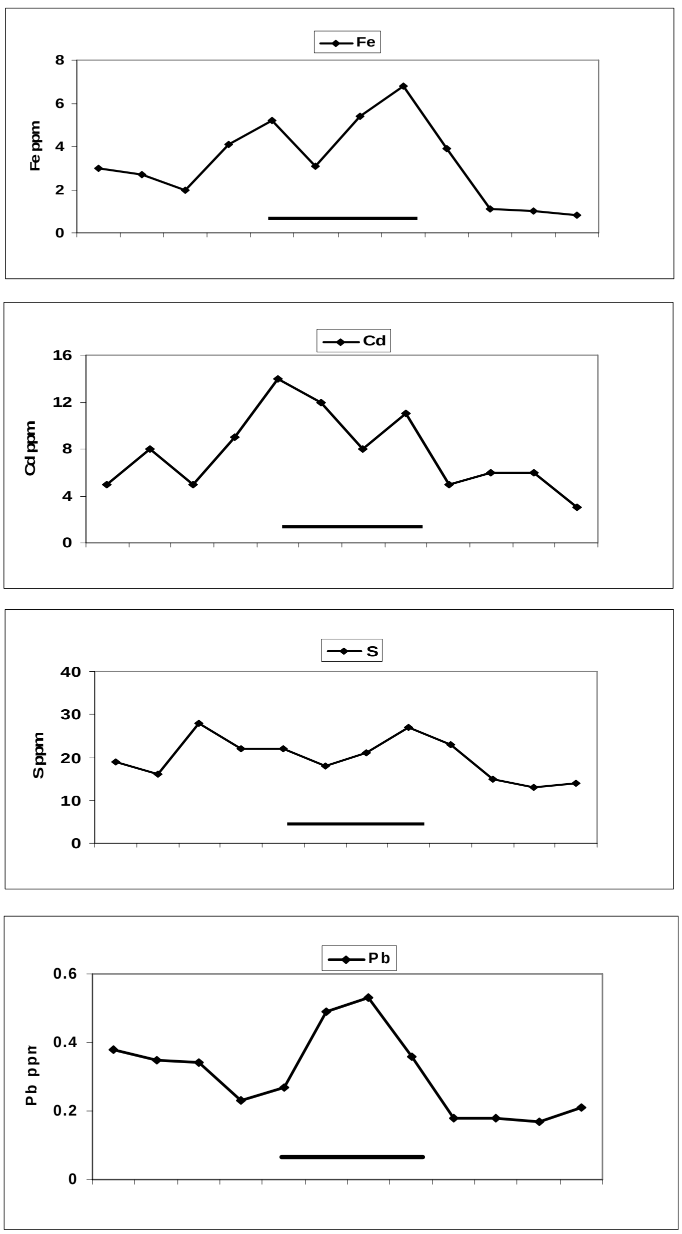


Fig 8. 0.01M $Ca(NO_3)_2$ digest. Fe, Cd, S and Pb. Solid bar represents the buried orebody projection of the orebody.

Analysis of Rye Grass

Dr Kevin Tiller, CSIRO, Division of Soils, South Australia (pers.com. 1995) recommended the use of calcium nitrate to remove soluble and weakly adsorbed metal ions. Calcium nitrate and potassium nitrate solutions have been used in agricultural science to determine the levels of metal ions available in soils as plant nutrients.

The elevated concentration of ions detected by the calcium nitrate digest should therefore be available to the rye grass growing over the Tara orebody.

Very crude grab sampling of rye grass was conducted along an extended line in close proximity to the initial orientation line. The rye grass was quarantine heat treated on arrival in Australia to a temperature of 121 ^{0}C for four hours.

The samples were then digested in concentrated AR grade nitric and perchloric acid to a maximum hot plate temperature of 150 ^{0}C. This oxidative digest destroys plant tissue leaving virtually no residue. Zinc was subsequently measured on an AAS.

Although there is significant sample to sample variance there is an increase in the zinc concentration of grass over the buried ore-body (Figure 9).

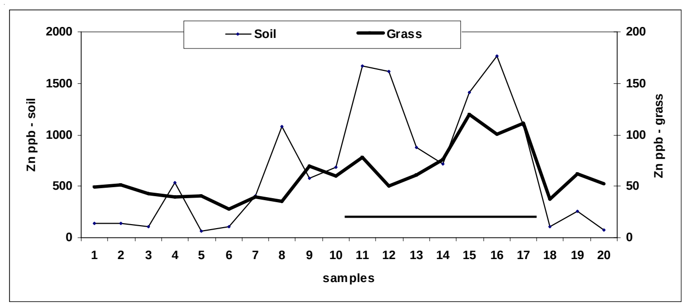


Figure 9. Analysis of soil and rye grass over buried mineralisation. Solid bar denotes surface projection of buried orebody. 0.01M $Ca(NO_3)_2$ digest on soil.

Conclusion. **WORK COMPETED TO DATE**

Partial digests have been successful in identifying buried mineralisation at Tara Mine not apparent in total digest geochemistry (Figure. 10).

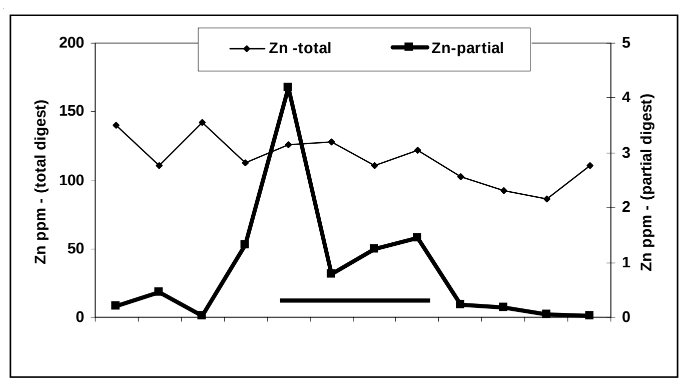


Figure 10. Total and partial digest Zn ppm.

continued on page 29

Orientation Partial Digest Geochemistry...

continued from page 28

A weak calcium nitrate digest (0.01M $Ca(NO_3)_2$) appears to generate the best anomaly to background contrast for this specific site.

Zinc is strongly anomalous. Soil pH is also anomalous. Cadmium, iron and lead show low level anomalism. Additional work is required to confirm that sulphur is also anomalous.

Seasonal variations may necessitate the re-sampling of a single line that contains anomalous samples. This may be useful in normalising data between survey campaigns carried out over changing seasons.

The authors would like to thank the management of Tara Mine for permission to publish and in particular former Chief Geologist, Mark Holdstock for encouraging this project.

References

Hall, G.E.M., Gauthier, G., Pelchat, J.C., Pelchat, P. and Vaive, J.E. 1996. Application of a sequential extraction scheme to ten geological standard reference materials for the determination of 20 elements. Journal of Analytical Atomic Spectrometry, 11, 787-796.

Tessier, A., Campbell, P.G.C. and Bisson, M. 1979. Sequential extraction procedure for the speciation of particulate trace metals. Anal. Chem., 51, (7), 844-851.

Govett, G. J. S., Dunlop, A. C. and Atherden, P. R., 1984. Electrogeochemical techniques in deeply weathered terrains in Australia.. Jour. Geochem. Explor. 21. 311 – 331.

Smee, B. W., 2003. Theory behind the use of soil pH measurements as an inexpensive guide to buried mineralisation, with examples. Explore, No 118.

Ashton, J.H., Holdstock, M.P., Geraghty J.F., O'Keeffe, W.G., Martinez, N., Peace, W. and Philcox, M.E. 2003. The Navan orebody – discovery and geology of the South West Extension. In 'Europe's Major Base Metal Deposits' IAEG Dublin.

Ed Dronseika
Genalysis Laboratory Services, Perth, Australia
dronseikaev@genalysis.com.au
Nick Walker
Vulcan Resources , Perth, Australia.
Ann Evers
Genalysis Laboratory Services, Perth, Australia
Envirolab@genalysis.com.au

RAB Drilling and RAB Geochemistry ...

continued from page 14

Exploration '97, 323-334.

Forster, P., Hellsten, K., Radonjic, A., and Toms, B., 1997: Discovery and evaluation of the Quarters deposit, Mt Pleasant. Conference Proceedings, New Generation Gold Mines '97. Australian Mineral Foundation, Glenside, S.A., Section 14.

Hallberg, J.A., 1984: A geochemical aid to igneous rock type identification in deeply weathered terrain. J. Geochem. Explore., 20, 1-8.

Lintern, M.J., 2005: Bounty gold deposit, Forrestania greenstone belt, W.A., In Butt, C.R.M., Cornelius, M, Scott, K.M. and Robertson, I.D.M. (eds) Regolith Expression of Australian Ore Systems, Cooperative Research Centre for Landscape Environments and Mineral Exploration (CRCLEME), published online August, 2004, 225-227.

Mann, A.W., 1998: Oxidised gold deposits: relationships between oxidation and relative position of the water-table. Aust. J Earth Sci., 85, 97-108.

Marjoribanks, R.W., 1997: Geological Methods in Mineral Exploration and Mining. Chapman and Hall, 115pp.

Mazzuchelli, R.H., 1996: The application of soil geochemistry to gold exploration in the Black Flag area, Yilgarn Block, Western Australia. J. Geochem. Expl., 57, 175-185.

McGoggan, G., 1997: History of drilling in Australia. Aus. I.M.M. Spectrum Series, 2/96, 173pp, Aus.I.M.M., Melbourne.

Smith, R.E., Anand, R.R., and Alley, N.F., 1997: Use and implications of palaeoweathering surfaces in mineral exploration. In Gubbins, A.G. (Ed): Proceedings of Exploration '97, 335-346.

Alan Marshall
Xplore Pty Ltd,
21 Viewway, Nedlands WA 6009, Australia
E-mail: qestore@it.net.au

Leigh Bettenay
Sipa Resources Limited, L2,
87 Colin St, West Perth WA 6005, Australia
E-mail: leigh@sipa.com.au

Website Update by **Andrew Ransom** - *Webmaster*

The members-only area of the AAG website has recently undergone some major behind-the-scenes changes. Access to the member area is now more secure, and a new, online database system has been implemented. Now all updates and changes will take effect immediately - no more long waits for new members to be able to log in!

A significant benefit is that members are now able to update their contact information online. Log in and click on the 'My Profile' link in the upper right corner of the member's home page to access your profile. In order to address privacy concerns, you will be able to opt-out of being included in member search results.

Meeting photos and PDF files of the talks given at the 22nd IGES are now available from the home page. Other updated pages include the Memorials, Periodic Tables, and Councils and Committee memberships. Look for more changes soon, including the ability to search for members based on interest and specialty, and an updated Links page!

Association of Applied Geochemists
APPLICATION FOR MEMBERSHIP*

Please complete only the relevant section for membership. See below for mailing instructions.

I, ____, wish to apply for election as a ___Member / ___Student Member of the Association of Applied Geochemists. I have read the Code of Ethics of the Association and in the event of being elected a Member/ Student Member agree to honour and abide by them.

MEMBER: *State Employer and Employee title*
I am actively engaged in scientific or technological work related to applied geochemistry exploration and have been so for the past two years.
____ as a ____.
(employer) (employment title)

STUDENT MEMBER: *Student status must be verified by a Professor of your institution or a Fellow of the AAG*
I certify that the applicant is a full-time student at ____ in pure or applied science.
(institution)

____ ____
(Professor/ AAG Fellow Signature) (Printed Name and Title)

Witness my hand this ______ day of____________, 20______. ____
(Signature of applicant)

NAME AND ADDRESS: PLEASE PRINT (to be completed by applicant)

Name: ____ Telephone bus: ________________________

Address: ____ fax: ____________________________

____ home: ____________________________

____ e-mail: ____

Annual Dues :

All applications must be accompanied by annual dues . All payments must be in US funds. Select one of the four listed below.

1	2006 member dues	US$	100	____________
2	2006 student member dues		10	____________
	- If receipt required, include a self-addressed envelope and add		2	____________
	- If your check is not drawn from a U.S.A. or Canadian bank, add		15	____________
			TOTAL	____________

Payment by check, International Money Order, UNESCO Coupons, International Postal Orders, VISA, American Express and Master Card are acceptable. For credit cards users, minor variations in your billing may reflect currency exchange rate fluctuations at time of bank transaction.

Type: VISA ___ American Express ___ Master Card ___ Credit card account number: ____
Expiry date: ______________ Name: ____ Signature: ____________________________________

Application for voting membership requires the sponsorship of three voting members. Request a voting member application from the Association office.

Please note: Your application form will be acknowledged upon receipt. The Admissions Committee reviews all applications and submits recommendations to Council, who will review these recommendations at the next Council Meeting or by correspondence. If no objection is raised the names, addresses and positions of candidates will be listed in the next issue of the AAG Newsletter. If after a minimum of 60 days have elapsed following submission of candidate information to the membership no signed letters objecting to candidates admission are received by the Secretary of the Association from any Member, the Candidate shall be deemed elected, subject to the receipt by the Association of payment of required dues. Send completed application, together with annual dues to:

Association of Applied Geochemists
P.O. Box 26099, 72 Robertson Road, Ottawa, Ontario, CANADA K2H 9R0
TEL: (613) 828-0199, FAX: (613) 828-9288, email: office@appliedgeochemists.org WEBSITE: http://www.appliedgeochemists.org

EXPLORE

Newsletter No. 130 FEBRUARY 2006

Editor: Chris Benn (Chris.Benn@BHPBilliton.com)

Associate Editor:
Selwyn Benn

Assistant Editors:
Rob Bowell (rbowell@srk.co.uk/srk003@aol.com)
Richard Carver (RichardCarver@gcxplore.com)
Patrick Highsmith
Barry Smee (bwsmee@attglobal.net)
Neil Adshead (neil_adshead@placerdome.com)

Business Manager:
David Seneshen, (303) 277-1694
(dseneshen@directgeochemical.com)
Back Issues contact: Betty Arseneault
(office@appliedgeochemists.org)

EXPLORE is published quarterly by the Association of Applied Geochemists, P.O. Box 150922, Lakewood, CO 80215-0922, USA.

Type and layout of EXPLORE: Vivian Heggie, Heggie Enterprises, Thornton, CO (303) 288-6540; <vjmheggie@comcast.net>

ADVERTISING RATES

Full page (Black & White)	241h x 190w mm	(9.5h x 7.5w in)	US $ 970
Full page (Color)			US$1165
Half page (Black & White)	241h x 89w mm	(9.5h x 3.5w in)	US $ 530
or	124h x 190w mm	(4-7/8h x 7.5w in)	
Half page (Color)			US $635
Third page (Black & White)	241h x 51w mm	(9.5h x 2w in)	US $420
or	178h x 89w mm	(7h x 3.5w in)	
Third page (Color)			US $505
Quarter page (B&W)	124h x 89w mm	(4-7/8h x 3.5w in)	US $300
or	241h x 41w mm	(9.5h x 1-5/8w in)	
Quarter page (Color)			US $360
Eighth page (Black & White)	60h x 89w mm	(2-3/8h x 3.5w in)	US $190
Eighth page (Color)			US $230
Business Card (B&W)	51h x 89w mm	(2h x 3.5w in)	US $ 50
Business Card (Color)			US $ 60

Please direct advertising inquiries to:
DAVID SENESHEN, DIRECT GEOCHEMICAL
130 CAPITAL DRIVE, SUITE C • GOLDEN, CO 80401 • USA
(303) 277-1694 Fax: (303) 278-0104 (dseneshen@directgeochemical.com)

LIST OF ADVERTISERS

THE ASSOCIATION OF APPLIED GEOCHEMISTS

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

OFFICERS

January - December 2006

Robert J. Bowell, *President*
SRK Consulting
Windsor Court, 1 Windsor Place
Cardiff, Wales CF10 3BX
TEL: 442920348150
FAX: 442920348199
email: rbowell@srk.co.uk

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

Gwendy E.M. Hall, *Treasurer*
Geological Survey of Canada
601 Booth Street, Room 561
Ottawa, ON K1A 0E8, CANADA
TEL: (613) 992-6425
FAX: (613) 992-6425
email: ghall@nrcan.gc.ca

COUNCILORS

Councilor Emeritus
Sherman Marsh

2005-2006
Robert Eppinger
David Seneshen
Phil Baker
Allan Kelly
David Cohen
Stephen Cook
Jorge Loredo
Olle Selinus

2006-2007
Ray Lett
Cliff Stanley
David Lentz
David Garnett
William Coker

Brazil
Germano Melo Jr.
Chile
Brian Townley
China
Xueqiu Wang

Europe
J. B. De Smeth
Northern Countries
Vacant
Southeast Asia
Iftikhar A. Malik

Southern Africa
Charles Okujeni
UK and Republic of Ireland
Deirdre M. A. Flight

COMMITTEES

Australian Geoscience Council Representative
David Garnett

Awards and Medals Committee
Chair: William Coker
Robert G. Garrett
Günter Matheis
Barry W. Smee

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

Distinguished Lecturer Committee
Jeffrey Jaacks, *Chair*

Election Official
Sherman Marsh

EXPLORE
Chris Benn, *Editor*
email: Chris.Benn@BHPBilliton.com
Rob Bowell, *Assist. Editor*
Barry Smee, *Assist. Editor*
David Seneshen, *Bus. Manager*

Geochemistry: Exploration, Environment, Analysis
Gwendy E.M. Hall, *Editor-in-Chief*
e-mail: Ghall@nrcan.gc.ca

Admissions Committee
Nigel Radford, *Chair*
Paul Morris
Cliff Stanley

New Membership Committee
Robert Jackson, Chair

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

Regional Councillor Coordinator
Robert Bowell

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

Student Paper Competition
Chair: Vacant
J.B. de Smeth
Paul Morris
Owen Lavin

Symposium Committee
Paul Morris, *Co-Chair*
Nigel Radford, *Co-Chair*
Eion Cameron
Mario Desilets
Philippe Freyssinet
Gwendy Hall
Virginia McLemore
Barry W. Smee
Graham F. Taylor

Web Site Committee
Robert Eppinger, *Chair*
Webmaster: Andrew Ransom

Betty Arseneault, *Business Manager*
P.O. Box 26099, 72 Robertson Road, Nepean, ON K2H 9R0 CANADA,
TEL: (613) 828-0199 FAX: (613) 828-9288, e-mail:
office@appliedgeochemists.org

EXPLORE

Newsletter for The Association of Applied Geochemists

P.O. Box 150922, Lakewood, CO, 80215-0922, USA

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

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