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President's Message


David Cohen

The theories on economic cycles espoused by Nikolai Kondratiev and Clement Juglar have again been proven correct, as the global economy decends toward another major trough. Most metal prices are following investor sentiment and the Australian dollar into the “bargain basement”. The recession will undobtedly slice into mineral exploration budgets planned for 2009 and beyond. For those experiencing their first minerals commodity cycle, it is always a great learning experience.

To some extent, identifying patterns and signals in economic cycles is not too dissimilar from picking patterns in geochemical data. Unfortunately for Kondratiev, he was found guilty of being a “kulak-professor” and purged by Stalin for his incorrect economic interpretations and modelling in 1938. Fortunately for most geochemists, we do not suffer the same fate for incorrect interpretation of geochemical data.

As observed in the last slump, while expenditure contracted for greenfields base metals and uranium exploration, brownfields exploration expenditure provided by existing producers fared better. Exploration budgets also tended to suffer proportionally lower cuts for commodities such as gold and diamonds that are not as closely linked to industrial cycles. Brownfields geochemical exploration presents a number of interesting challenges for geochemistry – revisiting old data with new ideas, or attempting to isolate geochemical signals in areas with naturally elevated metals contents or where existing mining activities have contaminated the surface environment. The other option is to apply generic geochemical skills to other fields of endeavour such as environmental analysis and management and the various issues surrounding the use of fossil fuels, including testing of the feasibility of large-scale CO_2 sequestration for which massive funding has been set aside by industry and governments.

While mineral explorers and consultants batten down the hatches, many in the university sector are looking forward to the return of our prodigal students, who were lured away from commencing graduate studies by generous salary packages and the promise that the good times are here to stay. A warning though; the last downturn saw further depletion of earth science programs and loss of departments in universities as undergraduates shied away from geology. The subsequent upturn was met by a severe lack of new graduates. On-going support of universities by industry in the next few years, through funding of research projects and PhD/MSc scholarships, will certainly help to preserve what remains of the geological and geochemical ends of the earth sciences.

In the mean time, members are encouraged to get their abstracts together and submitted to the 24th IAGS organisers, as well nominations for the 2008 student paper prize. Details are provided elsewhere in this issue of **EXPLORE.**

David Cohen
President, AAG

New National Geoscience Datasets in Australia: Geology, Geophysics and Geochemistry

In 2006, the Australian Government announced a new Energy Security Initiative, which led to the establishment, among others, of the Onshore Energy Security Program (OESP) at Geoscience Australia. This Program, which has a budget of A$58.9 million over 5 years, is deploying several data acquisition programs (seismic, radiometric, magneto-telluric, airborne electromagnetic, and geochemical) to attract investment in exploration for onshore petroleum, geothermal, uranium and thorium energy resources in Australia (Johnson 2006).

Three new, national-scale geoscience initiatives are under way in Australia with the aim to provide energy and mineral explorers with state-of-the-art pre-competitive data and information about the continent’s potential resources. (1) A digital geological map provides a seamless and consistent coverage of geological units at 1:1,000,000 scale. It is underpinned by a national stratigraphic index database to ensure uniform and consistent unit description and classification and nomenclature usage. (2) An Australia-wide airborne geophysical survey that has been used to level all of Australia’s public-domain radioelement data to a common datum. This enables interpreters to make accurate comparisons between radiometric signatures in different parts of the continent. (3) A low-density geochemical survey aims to provide a national geochemical data layer using consistent sampling medium and methods, as well as consistent sample preparation and analysis. Large-scale geochemical patterns thus revealed are hoped to point to new areas of exploration potential. The two latter projects are funded under the Australian Government’s Onshore Energy Security Program. Together, these three national geoscience datasets will help make Australia a more attractive destination for energy and mineral exploration investments.

The purpose of this paper is to bring the international exploration community up to date with three new national-scale geoscience datasets. These are intended to enhance

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the global attractiveness of Australia as an investment destination for energy and mineral explorers by lowering geological risk. The three new datasets that are the focus of this presentation are:

- a seamless 1:1,000,000 scale digital surface geology map of Australia;
- an Australia-wide airborne geophysical survey (magnetics and radiometrics) that has been used to level all of Australia's public-domain radiometric data to a common datum; and
- a low-density, internally consistent, surficial geochemistry coverage of greater than 90% of Australia.

The first of these datasets (geological map of Australia) has been ongoing since 2001, whilst the two others (airborne geophysics and geochemistry) were initiated as part of the OESP funding.

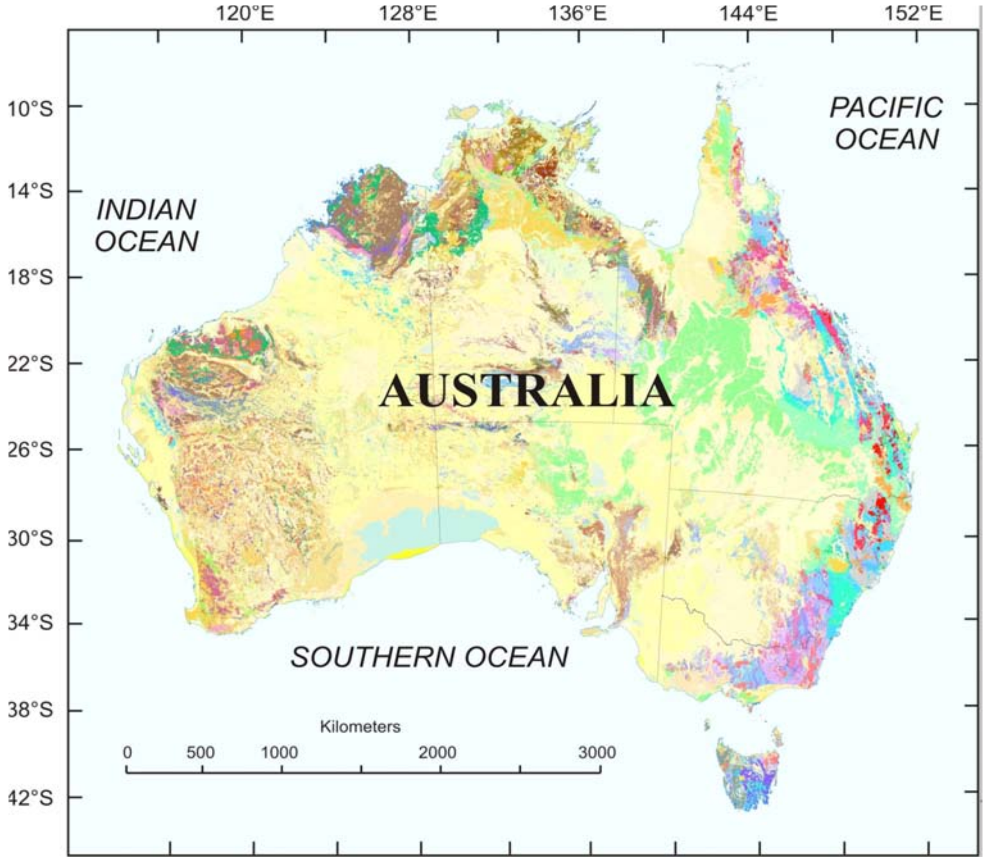

Figure 1. *Overview of the new digital surface geology dataset of Australia*

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Digital Geological Map of Australia
Compilation

The compilation of a seamless, digital, surface geology map of Australia at 1:1,000,000 scale (Fig. 1) was commenced in 2001. The new data are the most detailed, informative and consistent national geology coverage available. They provide invaluable baseline datasets for large scale regional and national evaluation of resource potential, environmental issues, and land use. The aim of the project was to provide a more detailed and better attributed digital dataset of the surface geology of Australia to replace the 1:2,500,000

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Notes from the Editor

The December issue of **EXPLORE** (No. 141) includes two articles. Patrice de Caritat, Brian Minty and Ollie Raymond describe three new, national-scale geoscience initiatives that are under way in Australia. In the second article, Inez Kettles, Andy Rencz, and Peter Friske report on the Canadian portion of the North American Tri-National Soil survey. Nigel Radford has contributed a review of the CRC LEME guide for mineral exploration through the regolith in the Cobar Region. Scientific and technical editing assistance for this **EXPLORE** issue was provided by Ray Lett, British Columbia Geological Survey, Harvey Thorleifson, Minnesota Geological Survey and Roger Paulen, Geological Survey of Canada.

As 2008 comes to a close, I would like to thank all authors, contributors, book reviewers and scientific/technical editors who contributed to **EXPLORE** in 2008. I would like to acknowledge the special efforts of Graham Closs for providing the AAG bibliographic listings for each issue, Dave Cohen for his presidential messages and Sarah Lincoln, the **EXPLORE** Business Manger.

Seasons Greetings!

Beth McClenaghan

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scale dataset published in 1998. The project has been conducted in collaboration with all Australian State and Northern Territory geoscience agencies who provided their most recent map data for the national compilation. Individual state portions of the national dataset have been released as they were completed, starting with Tasmania and Victoria in 2004 (https://www.ga.gov.au/products/servlet/controller?event=PRODUCT SELECTION&keyword=%22surface+geology22). Updated editions of some of the earlier released states (Tasmania, Victoria, Queensland and New South Wales) have also been produced as compilation standards have evolved during the national project. The national coverage will be completed in November 2008 with the release of the Western Australian data. Updated editions of the dataset will be released on an irregular basis.

Initially, the plan was to compile the map from the existing regional geological maps of between 1:500,000 to 1:2,000,000 scale. However, it became clear early in the project that these regional maps were typically fairly old (1970's and 1980's) and that the geological information on them was of poor quality considering the geological mapping programs undertaken by the Federal, State and Northern Territory geoscience agencies in the last 20 years. In particular, these regional maps did not include the new generation of digital geological maps at 1:100,000 and 1:250,000 scales produced in the 1990's with the aid of new high-resolution aeromagnetic and gamma-ray spectrometric images, satellite imagery and new geochronological (especially U-Pb zircon) data (Jaques *et* al. 1997). As a result, much of the new Australian geology coverage has been compiled from the most recent 1:250,000 scale mapping, and even 1:100,000 or 1:50,000 scale in some areas where the 1:250,000 maps were out of date. Although compiled from detailed geological maps, the national data have been simplified for use at 1:1,000,000 scale and have a spatial accuracy of between 200 m and 1 km depending on the quality of the original source data.

An important and time-consuming task for the compilation team was matching the geological information between maps which could be up to 40 years apart in age. Considerable time was invested in resolving stratigraphic mismatches across map tile and political boundaries. At times, satellite imagery and geophysical data, such as gamma-ray spectrometry and magnetics, were also used to resolve edge-matching discrepancies and to reposition poorly located geological data on older maps.

Standardisation of unit classification and descriptions was particularly important for the unconsolidated regolith materials, which cover a large proportion of the Australian continent. Regolith mapping has advanced considerably over the last few decades, particularly with the advent of remote sensing imagery, and a simple standard scheme for regolith unit compilation, based largely on the classification of Grimes (1983), was used for the new national map.

The new dataset contains comprehensive descriptions of several thousand geological units (Fig. 2). These unit

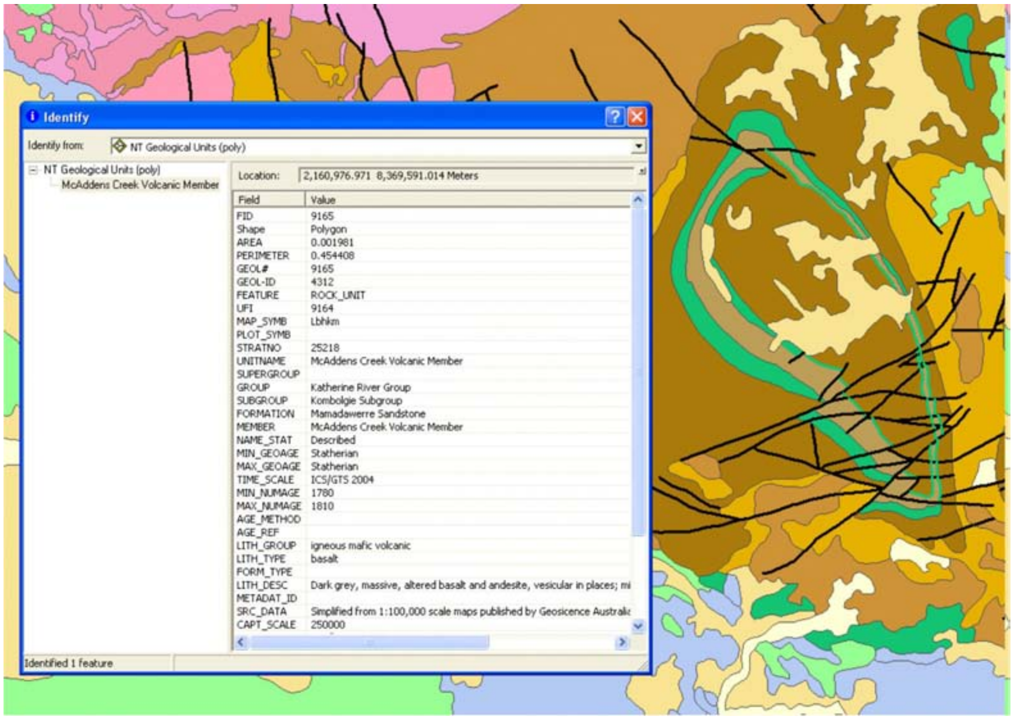

Figure 2. *An example of attribute data for a geological unit in the 1:1,000,000 scale surface geology of Australia dataset.*

descriptions include a unique stratigraphic name and number which provides a link to the Australian Stratigraphic Units Database (http://www.ga.gov.au/oracle/stratnames/index.jsp), which is the authoritative repository of Australian geological unit descriptions. Other digital attributes include a stratigraphic parent-child hierarchy, a text description of the unit, maximum and minimum ages, and lithology classifications. Faults and stratigraphic boundaries are also coded in the data. The data also come with comprehensive metadata describing the origins of the source data.

Data Delivery

The new data are designed primarily as a digital tool for GIS applications. There are no plans to issue a printed map – a paper map of Australia at 1:1,000,000 scale would be almost 4 m tall. Currently the data are available through download from the Geoscience Australia website (www.ga.gov.au) in ESRI export file and shapefile formats. The data are also available to view on the OneGeology portal website (portal.onegeology.org) where the map can be displayed as a Web Map Service (WMS) together with the national geological coverages of many other nations. Geoscience Australia will be moving towards providing the

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data as a Web Feature Service (WFS) using the GeoSciML data standard (GeoScience Markup Language; Simons *et al*. 2008) in the near future.

Australia-wide Airborne Geophysical Survey

Australian Governments have systematically surveyed the Australian continent for over 40 years using airborne geophysical surveys. The airborne survey coverage of the continent is now 100% for airborne magnetic surveys and about 75% for airborne gamma-ray spectrometric surveys (Fig. 3). The gamma-ray spectrometric surveys are used to derive estimates of the concentrations of potassium (K), equivalent uranium (eU) and equivalent thorium (eTh) at the Earth's surface. All the public-domain magnetic survey data have been digitally merged into a single continental scale compilation (Tarlowski *et al*. 1992, 1996; Minty *et al*. 2003). However, the individual surveys that comprise Australia's national gamma-ray spectrometric radioelement database are not all registered to the same datum. Older survey results are presented in units of counts/sec, which depend on factors such as survey flying height and detector volume. Even recent surveys can have a significant mismatch along common borders due to limitations in spectrometer calibration and data processing procedures, as well as environmental effects that result in temporal changes in the gamma-radiation fluence rate at the Earth's surface. These problems limit the usefulness of the national radioelement database as it is difficult to compare radiometric signatures observed in different parts of the continent.

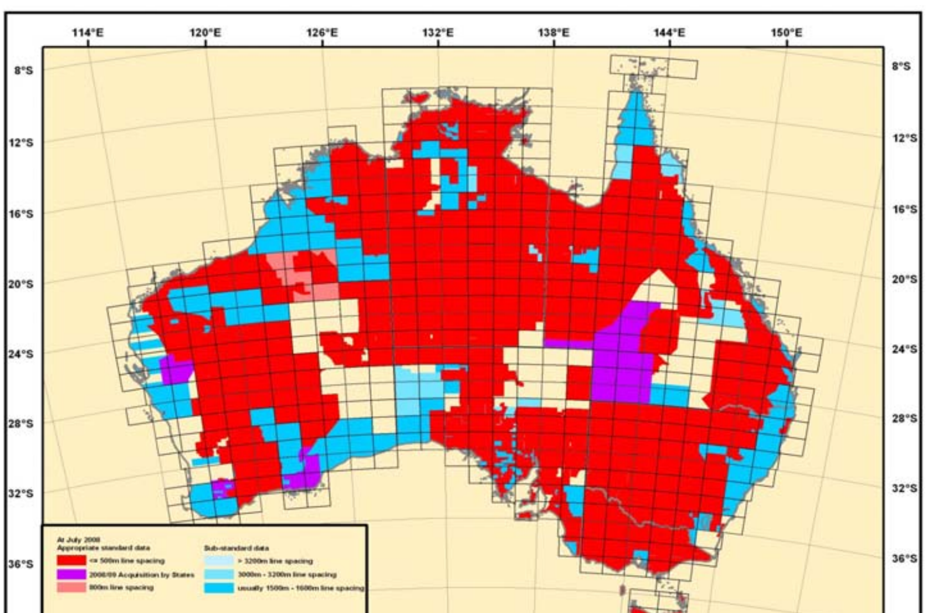

Figure 3. National coverage of airborne gamma-ray data acquired by Geoscience Australia and the State and the Northern Territory geoscience agences as of July 2008.

Geophysical Data Acquisition

Geoscience Australia has recently undertaken an Australia-Wide Airborne Geophysical Survey (AWAGS), funded under the Australian Government's Onshore Energy Security Program, to serve as a radioelement baseline for all current and future airborne gamma-ray spectrometric surveys in Australia. The survey data were acquired in 2007 at a nominal terrain clearance of 80 m above ground level along north-south flight lines spaced 75 km apart and east-west tie lines spaced 400 km apart (Fig. 4). The survey data were acquired and processed according to international standards, and the final estimates of radioelement concentrations along the AWAGS lines are consistent with the International Atomic Energy Agency's (IAEA) radioelement datum.

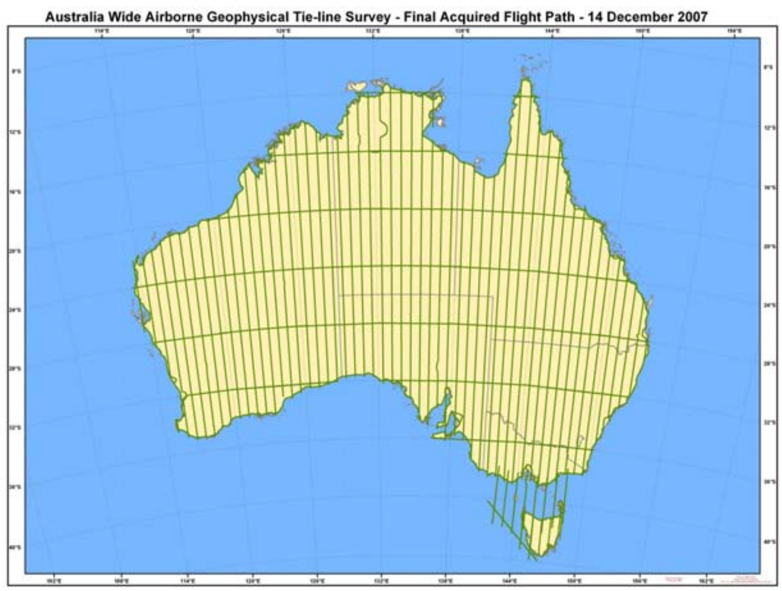

Figure 4. *Nominal flight path pattern for the AWAGS airborne geophysical survey.*

Levelling the Radiometric Database

The AWAGS survey has been used to adjust the hundreds of surveys that comprise the national radioelement database to a common datum. This was achieved by estimating, for each survey in the national database, correction factors that, once applied, minimize both the differences in radioelement estimates between surveys (where these surveys overlap) and the differences between the surveys and the AWAGS traverses. This effectively levels the surveys to the IAEA datum to produce a consistent and coherent national gamma-ray spectrometric coverage of the continent.

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The Radiometric Map of Australia

The levelled database has been used to produce the first "Radiometric Map of Australia" – levelled and merged composite potassium (% K), uranium (ppm eU) and thorium (ppm eTh) grids over Australia at 100 m resolution. A ternary image (K-red, eU-blue, eTh-green) derived from this database is shown in Figure 5. Interpreters can now use the normalised database to reliably relate geochemical

Figure 5. *Ternary image of potassium (red), uranium (blue) and thorium (green) radioelement estimates across Australia after levelling surveys with AWAGS data.*

patterns observed in one area to similar patterns observed elsewhere, and better appreciate the significance of broad-scale variations in radioelement concentrations.
There are several applications that will benefit from the updated database:

- uranium and thorium exploration through the ability to make quantitative comparisons between radiometric signatures in different survey areas;
- heat flow studies and assessment of geothermal energy resources;
- the derivation of a radiation risk map of Australia for natural sources of radiation;
- research in land-use modelling, sustainability, agricultural and forest productivity, radiation risk, mineral exploration, regional geology, regolith and soils; and
- direct comparisons with geochemical data.

Geochemical Mapping

The National Geochemical Survey of Australia (NGSA) project aims to provide pre-competitive data and knowledge to support exploration for energy resources in Australia.
In particular, it will improve the existing knowledge of the concentrations and distributions of energy-related elements such as uranium (U) and thorium (Th) at the national scale. The project is underpinned by a series of pilot geochemical surveys carried out in recent years by Geoscience Australia and the Cooperative Research Centre for Landscape Environments and Mineral Exploration (CRC LEME) to test robust and cost-effective protocols for sample collection, preparation and analysis. Examples of these are the Riverina (Caritat *et al*. 2005; Caritat *et al*. 2007), the Gawler (Caritat *et al*. 2008) and the Thomson (Caritat & Lech 2007; Lech & Caritat 2007) pilot geochemical surveys. Selected results from these pilot projects have been presented by Caritat *et al*. (2008). The current national project, described below, is being conducted in collaboration with the State and the Northern Territory geoscience agencies.

Rationale

The national geochemical survey was initiated because of the realisation that there is no complete geochemical coverage available for Australia and because such a data layer is an important complement to national-scale geological and geophysical datasets.

The current distribution of geochemical data available through the national repository (OZCHEM database) is shown in Figure 6. The map shows that there are vast areas of the country (>60%) that lack any geochemical information. Also, where geochemical data are available,

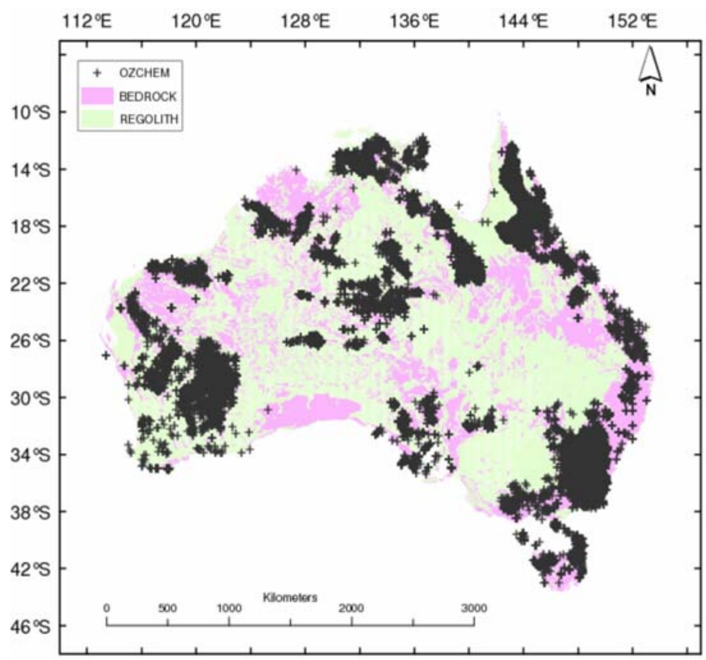

Figure 6. *Distribution of whole rock geochemical data in Australia (plus signs) extracted from the OZCHEM national database as of June 2006, overlain on bedrock pink and regolith (green) coverage.*

they are often not comparable as a result of:

- inconsistent sampling material (e.g. rocks of various types and/or degree of alteration, mineralisation or weathering);
- inconsistent sample preparation methods (e.g. total analyses versus partial digests with weak chemicals);
- large differences in instrumentation used, leading to variable lower limits of detection between datasets (e.g. older versus state-of-the-art instruments);

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- lack of metadata on data quality (e.g. instrument calibration, bias, precision, sample type description, etc.); and
- variable suite of elements analysed (e.g. sometimes very limited suite such as gold (Au) only or gold plus copper (Au + Cu)).

Similarly, the current airborne gamma-ray spectrometric (radiometric) survey coverage available at a resolution deemed appropriate for exploration does not provide a complete national picture of the distribution of radiogenic elements potassium (K), uranium (U) or thorium (Th) (see Fig. 3). This situation is being remedied by the new AWAGS project discussed above, which, together with NGSA, will result in a significantly improved understanding of the distribution of K, U and Th in Australia. Some regional geochemical surveys have been carried out in parts of Australia (e.g., Morris *et al*.1998; Cornelius *et al*. 2008), but no national coverage exists. Since the inception of the concept of regional geochemical surveys in the 1960s, they have proven to be a reliable tool for mineral exploration.

Objectives

The objectives of the NGSA project are to:

- collect transported regolith samples at the outlet of large catchments covering >90% of Australia using an ultra low sampling density approach;
- prepare and analyse the samples to extract the maximum amount of geochemical information (60+ elements) using internally consistent, state-of-the-art techniques;
- populate the national geochemical database with the resulting new data; and
- compile an atlas of geochemical maps for use by the mineral exploration industry to identify areas of interest in terms of energy-related resources and other mineral commodities, which can then be the focus of targeted exploration efforts.

Strategy

A sampling method has been adapted to Australian landscape and climate conditions. It has been field-tested in the Riverina, Gawler and Thomson pilot projects. The cost of a national survey is kept reasonably low by applying an ultra low sampling density approach (1 site/1,000 km^2 to 1 site/10,000 km^2).

The strategy adopted for the national geochemical survey is described below.

<u>Sampling media:</u> Catchment outlet sediments (similar to floodplain sediments in most cases), sampled at two depths (0-10 cm below the surface as well as a 10 cm interval at a depth of between around 60 and 90 cm).

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Sampling sites: 1,390 catchments covering 91% (or about seven million km^2) of Australia across all States and Territories have been targeted for sampling (Fig. 7). Most catchments will be sampled near their outlet, while those exhibiting internal or poorly defined drainage will be sampled at, or as close as possible to, their lowest point. Catchments smaller than 1,000 km^2 (mostly coastal) and small islands are not included in the survey. The resulting distribution of catchment outlet sites targeted for sampling is shown in Figure 8 and translates to an average sampling density of around 1 site/5,500 km^2.

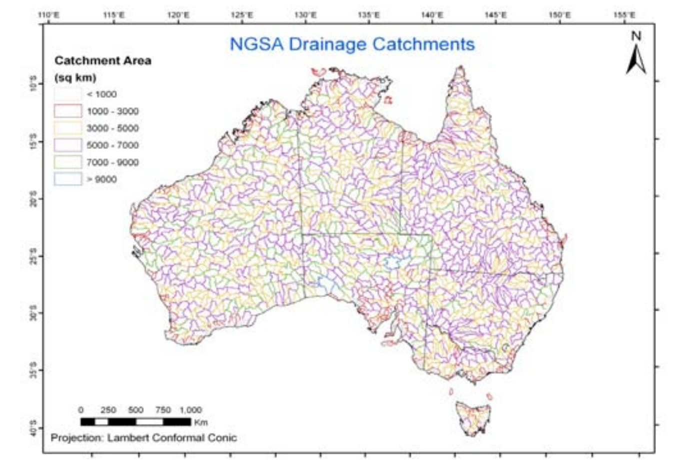

Figure 7. Distribution of catchments for the National Geochemical Survey of Australia.

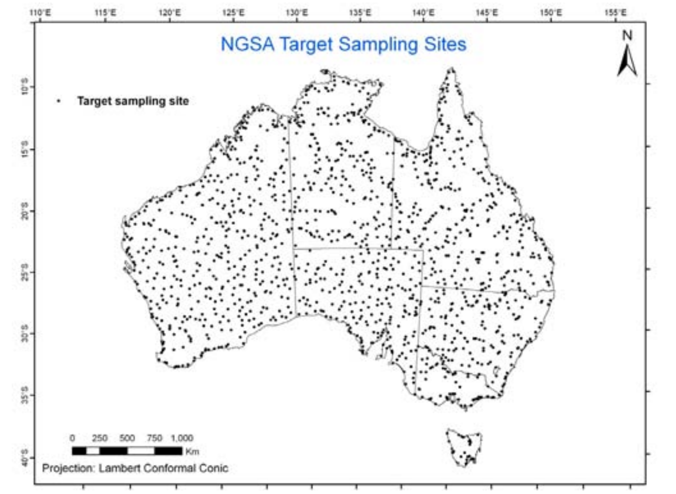

Figure 8. Distribution of target sampling sites for the National Geochemical Survey of Australia.

Sample collection: A detailed Field Manual has been compiled (Lech *et al*. 2007) and all sampling equipment and consumables have been centrally purchased. Sample collection is carried out by the State and the Northern Territory geoscience agencies following a hands-on, in-field training period. At each locality a detailed site description, field pH, and dry and moist soil Munsell® colours are recorded and several digital photographs are taken. All information is recorded digitally to facilitate subsequent uploading into databases.

Sample preparation: Samples are dried, rotary/riffle split and sieved to <2 mm and <75 μm fractions. The <2 mm fraction is mechanically ground for some analyses, while the finer fraction is not. A bulk split of each sample is archived for future investigations.

Sample analysis: Sample analysis has started for 60+ elements using mainly XRF and collision cell ICP-MS at Geoscience Australia. The ICP-MS analyses are carried out on a total digest (HF + HNO_3) of fragments of the XRF beads (Pyke 2000). Other parameters to be recorded routinely at Geoscience Australia are pH 1:5 (soil:water ratio), electrical conductivity 1:5 (soil:water ratio), and laser particle size distribution. Analyses for selected elements not available at Geoscience Australia (e.g. gold (Au), fluorine (F), selenium (Se), and platinum group elements (PGEs)) will take place externally. Additional digests/analyses (e.g. after aqua regia digestion, infrared spectroscopy) are being considered.

Quality assessment/quality control: Sample numbers have been randomised to minimise regional bias, help separate false from true anomalies and obtain meaningful estimates of the variance of duplicates. Field duplicates, analytical duplicates, in-house standards and certified reference materials are introduced at regular intervals in the analytical streams.

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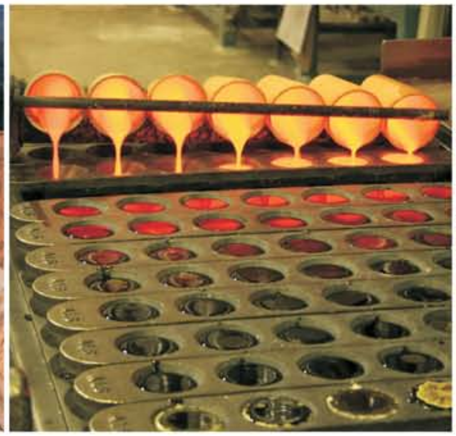


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Data analysis: Graphical and statistical data analysis will be carried out at various scales (regional, States/Northern Territory, and National). Non-parametric univariate and multi-variate analysis along with the production of geochemical maps will be carried out.

Timeline: Following planning in the first half of 2007, fieldwork, including initial training, began in mid-2007 and is expected to continue until early 2009 (allowing for the wet season prohibiting field work in northern Australia for six months each year, and for time to obtain access permission in some area). Figure 9 shows the catchments sampled to 30 June 2008. Sample preparation started in early 2008 and will continue until late 2009. Sample analysis started mid-2008 and will continue until mid-2010. Data analysis and reporting are planned to take place in 2010 and early 2011. The project concludes on 30 June 2011.

Data Delivery

By 2011, the NGSA project will deliver a National Geochemical Atlas of Australia available online. In addition, reports on the geochemistry of all States and the Northern Territory will be released, as will reports on energy related commodities, implications for geothermal resources, comparison with airborne radiometric surveys and for regions which are the focus of OESP projects. The national geochemical database will be populated with the new data.

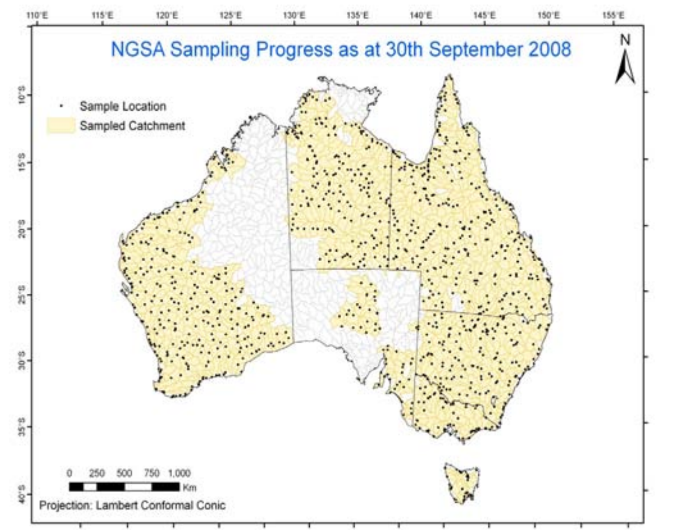

Figure 9. *Distribution of catchments sampled for the National Geochemical Survey of Australia, as of 30 September 2008 (1032 catchments, or 74%, completed).*

The NGSA will lead to increased knowledge of the concentrations and distributions of geochemical elements in the near-surface environment at the national scale. Further, NGSA results should support increased exploration activity for energy related resources in Australia, particularly using national geochemical survey data to select specific areas

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for further exploration investment. Finally, it is hoped that the NGSA will be one of several contributors to success in mineral exploration in Australia. Spin-off benefits in environmental management, land use policy development and geohealth assessment are also expected.

Conclusion

Three new national geoscience initiatives are under way in Australia. A new digital geological map, an airborne geophysical tie line survey to level the radiometric database, and a surficial geochemical survey will provide invaluable pre-competitive data and information to the energy and minerals exploration industry. Within the next few years, as results all come on line, it is hoped that industry, government and academia stakeholders will make use of these three new datasets, individually, but more importantly, also in combination to support their decision-making processes. The potential to reach a new understanding of geological processes active at the continental-scale is now clearly on the horizon in Australia.

Acknowledgments

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The North American Soil Geochemical Landscapes Project — A Canadian Perspective

INTRODUCTION

"Documenting and understanding natural variability is a vexing topic in almost every environmental problem: How do we recognize and understand changes in natural systems if we don't understand the range of baseline levels?"

M.L. Zoback, GSA Today, December 2001

Soil geochemical properties are critical to the health of the environment and to the health of virtually all organisms, including humans, existing near and on the Earth's surface. Chemical elements originating in earth materials move through the biogeochemical cycle and enter the food we eat, the water we drink and the air we breathe. These elements may be essential to our health and well-being, or they may be toxic, even in trace amounts. The nature and elemental content of soils vary both in time and in space across North America. The information obtained by chemically analyzing soils and mapping the abundance and spatial distribution of elements in soils is needed to better assess risk, guide decision-making and foster more integrated regulation by human health and environmental protection agencies.

The natural concentrations of elements differ among soil constituents and vary markedly between geologically distinct terranes. At present there is no common understanding of the amount and origin of variation in soil geochemistry nor is a consistent methodology used for its determination (Jennings & Petersen 2006; Garrett *et al*. 2008a). In addition, outside the earth sciences world there is little awareness of the enormous amount of natural variability and the value of this information for evaluating risk potential and defining the limits above or below which remedial action is necessary. Already there are cases where natural concentrations are consistently higher than the action limits for soils covering large areas.

The requirement for soil geochemical data to assess spatial variability was being met in the United States by a low-density (1 sample per 6,000 km^2) soil geochemical survey conducted during the 1960s and 1970s (Shacklette & Boerngen 1984) but the utility of these data is hampered by detection limits that no longer meet today's standards and a lack of data for some elements of environmental interest. In Canada there have been 99 soil and 274 till sampling surveys undertaken by the Geological Survey of Canada (GSC) and its provincial counterparts but national coverage is incomplete and the methodology is variable (Fig. 1; Spirito *et al.* 2006). There is no national-scale set of soil geochemical data for Mexico. Hence, there is a critical need for data for a wide spectrum of elements and compounds in mineral- and organic-based soils based on up-to-date field and laboratory techniques.

The North American Soil Geochemical Landscapes Project — a tri-national initiative between United States, Canada and Mexico — was established to meet the need

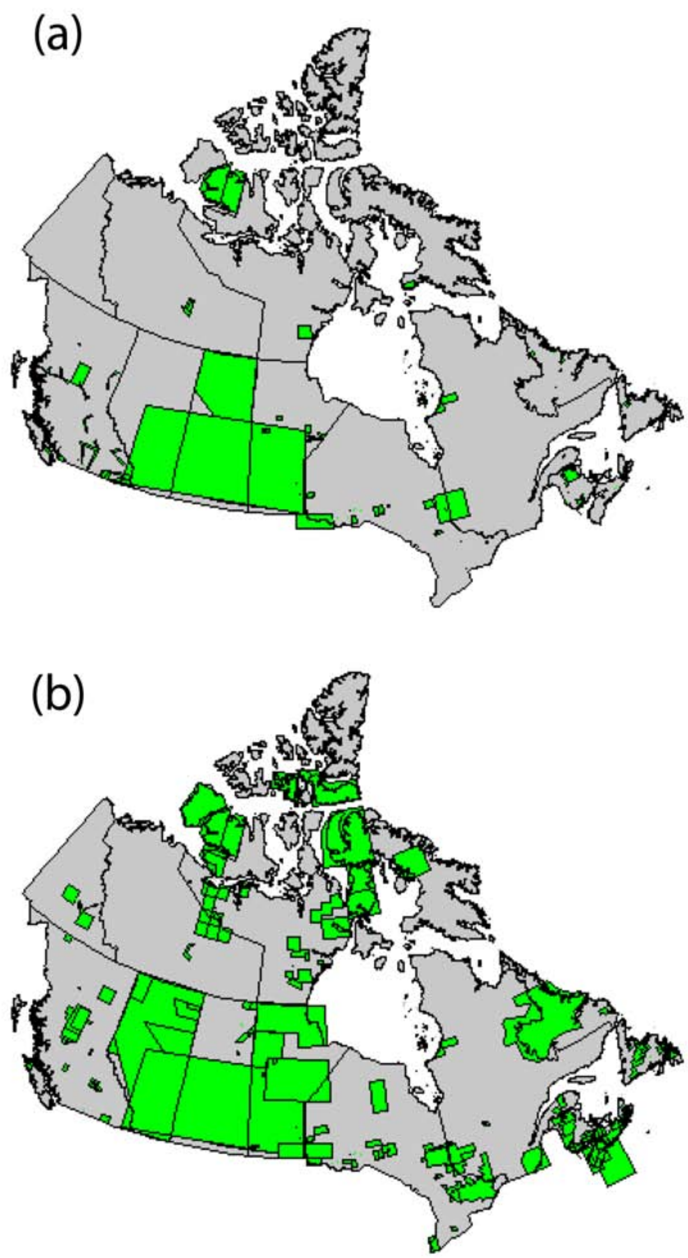

Figure 1. *Map of Canada showing areas (green polygons) covered by a) soil and b) till sampling surveys up to 2007.*

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for soil geochemical data by providing a consistent national- and continental-scale framework and database. For North America, the Tri-national project is the first multi-national multi-agency collaboration of its kind starting with common focus, understanding and protocols. Coordinated continental-scale undertakings have been started elsewhere in the world. The Forum of European Geological Surveys (FOREGS) Geochemical Baseline Programme was set up to provide high quality environmental geochemical baseline data for soils stream water, stream sediment, floodplain sediment, and humus for Europe (Salminen *et al.* 2005; De Vos *et al.* 2006). Sampling of arable and grazing land at a scale of 1 sample/ 2500 km^2 was undertaken in 2008 by 34 geological surveys in Europe (EuroGeoSurveys Geochemistry Working Group 2008).

A Canada-United States pilot study consisting of two sampling transects (E-W and N-S) was carried out in 2004 to test protocols and data applications (Fig. 2). On the basis of the methodology used for the pilot study and its

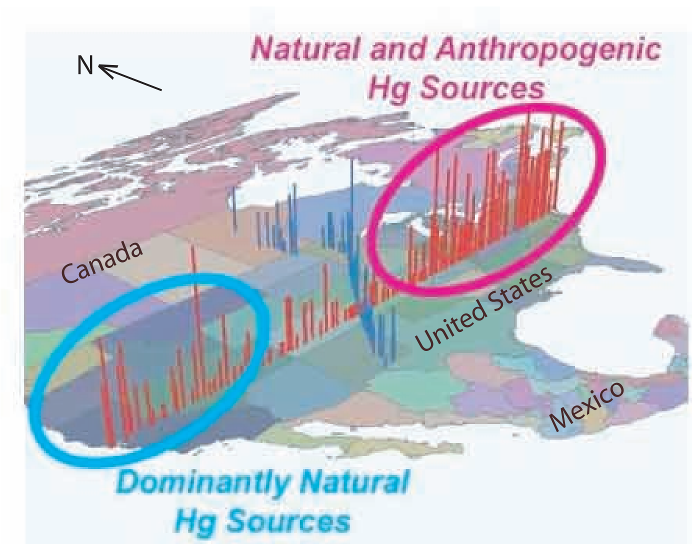

***Figure 2.** Distribution of Hg in the <2 mm fraction of soil samples collected along two transects through United States and Canada. Results of this pilot study showed the following: 1) significant, systematic regional variations in soil geochemistry and microbiology; (2) regional variability that relates to natural soil-forming factors (e.g. geology, rainfall, and temperature); and (3) regional differences that signal anthropogenic sources (Smith & Reimann 2008). Mercury levels in the western United States reflect predominantly natural sources whereas those in eastern United States reflect more strongly inputs from anthropogenic as well as natural sources.*

results, a plan for the Tri-national project was formulated. At the same time consultations were solicited with the user community to ensure that the data produced would be useful. From the project outset care has been taken to develop the necessary mechanisms to have these data recognized and used by government policy makers and regulators dealing with health and environmental protection.

Briefly described, the Project is designed to show the following: (1) systematic regional variations in chemistry at a 40 km sample spacing; (2) regional natural-occurring differences, thereby defining natural regional background levels and controls; (3) regional variation from anthropogenic sources, thereby identifying human impacts on the soil landscape; and (4) a new understanding of the links between soil geochemical factors and environmental and human health. The Project will provide a continental-scale framework for generating soil geochemical and relevant biological and organic compound data, a continent-wide protocols manual for field and analytical methods and user-friendly data that are available and useful for a wide range of applications and disciplines. The Project is *not* designed to provide data for site-specific risk assessments, identify local geochemical hot spots related to natural or human factors, or directly support epidemiological research.

PROJECT DESIGN

Sampling Sites

The Project sampling is based on a spatially balanced array known as a generalized random tessellation stratified (GRTS) sampling design (Garrett 1983; Stevens & Olsen 2004) chosen for its added flexibility. With this design it is possible to locally increase the sampling density in areas of special concerns within the context of the continental sampling framework. A total of 13 212 sites representing an approximate density of 1 site per 1600 km^2 (Fig. 3, *see p.14*) have been selected with 6183 sites in Canada, 5813 in the United States, and 1216 in Mexico.

The total land surface area covered by the Tri-national survey is nearly 40 times the size of France. The collection of soil samples to generate the geochemical database is only possible through the establishment of partnerships. These include federal, provincial and state geological surveys and organizations related to agriculture and forestry. Sampling and data generation will continue for an estimated decade. Use of consistent protocols ensures that the resultant data sets will stitch together to produce a final seamless geochemical database.

Core soil analyses

The Tri-national survey is developing a set of protocols that will be the basis for field sampling and chemical

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Figure 3. Distribution of sample sites (black dots) over North America. Ecozones for North America are shown in colour (after Commission for Environmental Co-operation, 1997). Legend explained on web site listed in reference.

analysis in each of the three countries. Developing a set of protocols to ensure a consistent data set for North America is not without its challenges, some of which are noted as follows: (1) the enormous size of the continent; (2) three international and 95 state and provincial boundaries; (3) the complexity of the operation in that sampling is horizon- and depth-based and involves numerous types of analyses, all requiring field, laboratory, quality assurance, archiving, and data handling protocols; (4) the many types of mineral and organic soils and field situations (e.g. peatland, permafrost, desert, mountain, urban, and agriculture areas) that require diverse equipment and procedures; and (5) the need to anticipate and accommodate possible future requirements. From the outset of the Project, attention has been paid to developing and documenting the protocols necessary to provide a data set that serves as a common national and international standard.

At each site in areas of mineral soils, samples are collected from a depth of 0-5 cm (referred to as the "public health" layer) and from the A- and C- soil horizons (Fig. 4). The <2 mm fraction (an agricultural and environmental standard) is analyzed for a suite of more than 40 major, minor and trace elements, including most elements of environmental concern, following a near-total (4-acid) digestion. A separate sample from the 0-5-cm depth interval from each site will be analyzed for the presence of *Bacillus anthracis* (anthrax). Splits of each soil sample are archived and will be made available for future investigations.

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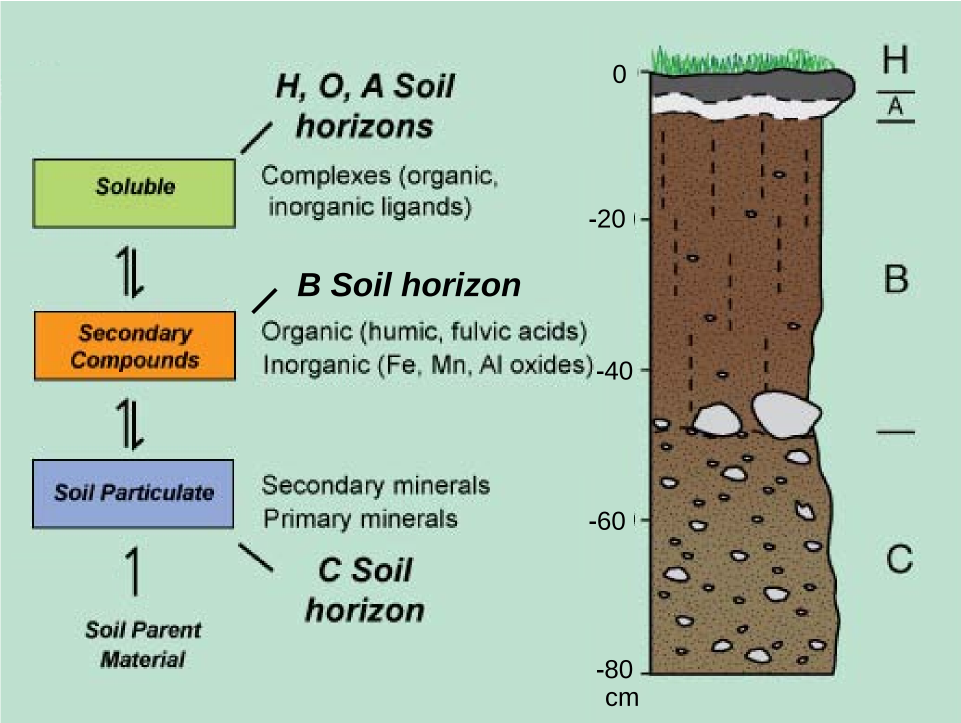

Figure 4. Schematic diagram of a profile showing horizons in a podzolic soil. Samples for the Canadian project are collected from the 0-5 cm (public health) layer, and from the A, B, and C soil horizons. Diagram shows some physical and chemical characteristics of individual soil horizons.

Additional soil analyses

Each country will carry out certain other procedures and analyses that are particular to its environmental and/or policy needs. Table 1 outlines the scheme for sampling and analyses for the Canadian project. In Canada, the extra procedures

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Table 1. *Sample collection and analyses for North American Soil Geochemical Landscape Project — Canadian aspect.*

Sample Horizons/Depth for Analysis
0-5 cm "public health" layer and A-, B -, C-horizons

Sample Preparation
- Air drying *
- Splitting and archiving *
- Preparing specific size fractions for analysis *
- Ball-milling
- Storing and archiving sample splits and unused sample materials *

Size Fractions for Analysis
- <2.00 mm fraction for all analyses (Note: <2.00 mm splits used for 4-acid and carbon analyses are ball-milled to <100 µm).
- <0.063 mm for selected analyses (carbon, 4-acid, and US-EPA 3050B (aqua regia variant))

"Core" Determinations On Tri-National Soil Samples
- ICP-MS/ES analysis (42 elements) after US-EPA 3050B (aqua regia variant) digestion (0-5 cm , A, B, C)
- ICP-MS/ES analysis (42 elements) after 4-acid near total digestion (0-5 cm , A, B, C) *
- ICP-MS/ES analysis after water leach (0-5 cm and C)
- Carbon – organic and inorganic content (0-5 cm , A, B, C) *
- Loss-on-ignition (0-5 cm , A, B, C)*
- Moisture content (0-5 cm, A, B, C) *
- Bulk density (0-5 cm , A, B, C) *
- Munsell colour (0-5 cm , A, B, C) *
- Particle size analysis *
- Electrical conductivity (0-5 cm , A, B, C) *
- Cation exchange capacity (A, C)

"Add-on" determinations on splits from core tri-national samples
- Selected minor elements (N, P) (0-5 cm, A, B,C)
- Biomethods for assessing soil toxicity (A and C)
- X-ray diffraction (A, B, C)
- Radiometric tests in laboratory (0-5 cm, A, B,C)
- Gastric leach (A and C)

"Add-on" determinations on additional samples or other data collected at the tri-national sites
- Soil gas radon measurements
- Radiometric tests (including measurements of U, Th, K)
- Anthrax (whole sample size fraction)
- Ecotoxicological studies and analysis for selected organic compounds on 0-30 cm sampling interval
- Collaborative sample and data collection for National Forest Inventory
- Perchlorates (A and C)

"Add-on" determinations on additional samples or other data collected outside the tri-national sites
- Stream waters and sediments analysis — sites selected within the same drainage basin and downstream from the previously sampled tri-national soil sample sites. The drainage basins have an areal extent of <100 km2, (mostly first or small second order streams).

Note: Procedures denoted with * are documented in Geological Survey of Canada Open File 4823 (available as free download at http://geopub.nrcan.gc.ca/moreinfo_e.php?id=216141). Remaining procedures are to be released as North American Soil Geochemical Landscape Project Field and Laboratory Protocols Manual (digital document, in preparation).

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include the following: collection and analysis of B-horizon samples; analyses of the <63 μm fractions of A-, B-, and C-horizon samples using total (4-acid) and partial (USA-EPA 3050B) digestions; and analysis of 0-5 cm and C-horizon samples after a water leach (Hall 2008). Another major addition to the Canadian project is the in-situ measurement of soil gas radon and natural radioactivity that are discussed later in this paper (Fig. 5).

***Figure 5**. Brad Harvey (left) and Ken Ford (right), Geological Survey of Canada, making soil gas radon measurements at a Tri-national project site near Pembroke, Ontario. (Photo: Inez Kettles, GSC)*

Use of the <63 μm (silt-plus clay-sized) fraction and partial leaches allow for a more detailed understanding of bioaccessibility. In addition, this fraction of soil and till samples is commonly analyzed in Canada for mineral exploration and geological mapping purposes and there is a large body of existing geochemical data for this size fraction for comparison. For example, the New Brunswick Ministry of Natural Resources has released geochemical data for the <63 μm fraction of more than 8150 mostly till samples. The GSC has published geochemical data for the <63 μm fraction of more than 16,800 samples (S.W. Adcock, Geological Survey of Canada, pers. comm., 2008, http://gdr.nrcan.gc.ca/geochem/index_e.php).

In United States, samples of each of the three depths/horizons at 10% of the sites are being collected for additional microbial characterization. Physiological-based extraction techniques, such as digestion with simulated human gastric and lung fluids, are conducted on a subset of the 0-5cm soils. In Mexico bioaccessibility of selected potentially toxic elements are being measured in 0-5 cm interval and A-horizon samples, as is the mobility of a broad suite of elements in C-horizon and some B-horizon soil samples.

PROJECT ACTIVITIES

Sample collection

In 2007, sampling in Canada was undertaken in Nova Scotia and New Brunswick by the provincial geological surveys and some sites were accessed in the northern Canada, through shared logistics with a Yukon territorial government program (Fig. 6, 7). In the United States,

***Figure 6**. Collection of Tri-national soil horizon samples in the boreal forest of Nova Scotia by Terry Goodwin, Nova Scotia Department of Natural Resources (Photo: Rita Mroz, Environment Canada).*

sampling covered the New Hampshire, Vermont, Massachusetts, Maine, Rhode Island, and Connecticut, New York, Nebraska, and a transect across Alaska. Samples were collected along two transects in Mexico. One transect extended from central Mexico south to the coast of Guerrero state and the other from central Mexico westward to the coast of the state of Sinaloa and then northward to Ciudad Juarez, Chihuahua. The second transect is the southern continuation of the north-south continental transect from the Project pilot study undertaken in the United States and Canada in 2004 (Fig. 2).

Sampling continued in 2008 along a trans-continental swath in Canada (Fig. 8) and in the United States including the states of Utah, Colorado, Kansas, Nevada, Wyoming, Missouri, Arkansas, Louisiana, Mississippi, West Virginia, Delaware, Maryland, New Jersey, Virginia, Pennsylvania, North Dakota, South Dakota, and Minnesota. In Mexico sampling covered the northernmost part of Sonora, Chihuahua, Coahuila and some areas of Baja California (Fig 9).

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Figure 7. *Scott Smith (Agriculture and Agri-Foods Canada) and Toon Pronk (New Brunswick Department of Natural Resources) digging a soil pit in the tundra of northern Yukon. (Photo: Martin McCurdy, GSC)*

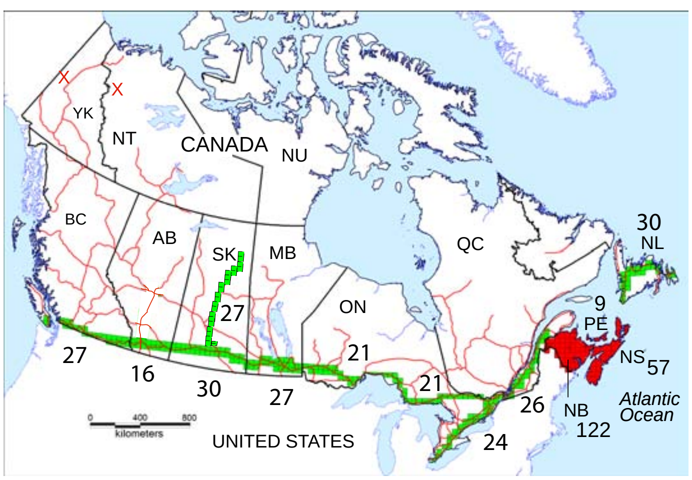

Figure 8. *Trans-Canada soil sampling swath collected in 2008. Sampling was completed in 2007 in eastern Canada (shown in red) and at some sites in the northern Yukon and northwestern Northwest Territories (red X). Numbers indicate the sample count expected to be collected along each segment of the transect in 2008. (Note: BC – British Columbia, AL – Alberta, SK – Saskatchewan, MB – Manitoba, ON - Ontario, QC – Quebec, NB – New Brunswick, NS – Nova Scotia, PE – Prince Edward Island, NL – Newfoundland, NU – Nunavut, NW – Northwest Territories, YK – Yukon).*

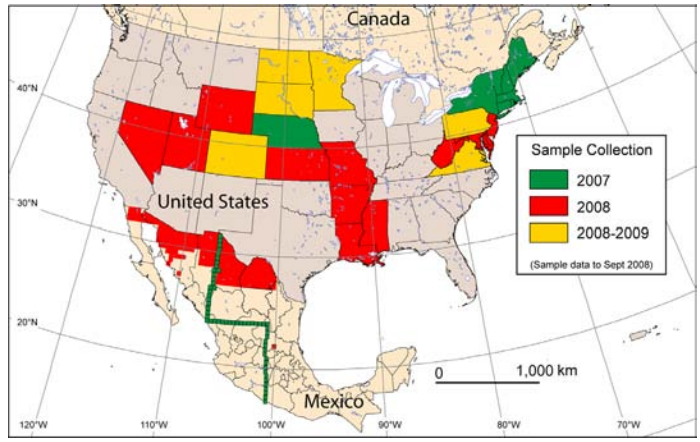

Figure 9. *Map shows completed and ongoing sampling surveys (2007-2009) in United States and Mexico.*

Protocol development

A major part of the Tri-national Project is the development and documentation of protocols for soil sample collection and analysis to ensure consistent geochemical data. The protocol manual being constructed has sufficient background information and detail to provide guidance to individuals from the user community who are seeking advice on procedures. To determine "optimal" methodology for the purpose of establishing a Tri-national protocol it is sometimes necessary to test a variety of analytical methods. One such case was the partial extraction experiment that is described below.

The study of aqua regia and its variants

Soil geochemical data are needed to satisfy the requirements for environmental assessments and regulations pertaining to land use and development and contaminated site remediation. The procedures for analyzing soil samples were decided on by various government departments in different provinces and states, and, as a result, a variety of partial extraction methods are used by environmental agencies in North America to determine element concentrations. In many cases, few details are provided on the requirement for formulation in soil quality guideline documents and websites. Before deciding on a protocol for the Tri-national survey, GSC initiated a research project to test and compare the element concentrations obtained using a variety of partial extraction formulations (Garrett *et al.* 2008b). The following five digestion protocols were tested in soil materials: Aqua regia, Lefort (reverse aqua regia), 1:1 HCl-HNO_3, 1:1:1 HCl-HNO_3-H_2O, and the HNO_3-H_2O_2 variant of US-EPA 3050B. Eight control reference materials classified as certified or recommended were analyzed, with appropriate randomization, in triplicate by the five methods. Two each of the reference materials were collected from soil, till, and stream and lake sediments. Analyses of Variance were undertaken to determine which protocols yielded similar data. The results are described below.

Data applications developed through partnerships

Researchers with the Tri-national Project at GSC

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have established partnerships with groups in other federal agencies to develop or test applications of soil geochemical data to health risk issues, mostly related to toxic metal exposure.

Studies of natural radioactivity linked to the Tri-national project

Radon is a naturally-occurring hazard and the world's second leading cause of lung cancer (World Health Organization 1978). In 2007 Health Canada lowered the threshold limit of exposure in Canadian homes and buildings above which there is a recommended need for remediation. This change has led to research on new approaches to achieve compliance with the guideline.

In 2007 GSC entered into a partnership with Health Canada - Radiation Protection Bureau to make in-situ measurements of soil gas radon radiometric, estimates of soil K, U, and Th concentrations, and, in some areas, to carry out new airborne geophysical surveys (Fig. 5). These new data will be used with Tri-national and other geological data to produce a map of radon prone areas in Canada to guide risk management. The map will be used to delineate those areas where there is increased health risk from radon and, hence, require follow-up testing.

Studies related to soil toxicity

One project at Environment Canada - Biological Methods Division (BMD) involves evaluating the use of boreal forest plant and soil invertebrate species for the development standardized soil toxicity test methods to assess soil pollutants. Researchers from BMD are teaming up with GSC scientists to select reference sites across Canada that reflect the scope of natural variability in geologic terranes. A second collaboration involves Environment Canada-Atlantic (EC-A) scientists who are developing a background soil chemistry/toxicology database for the Atlantic region. At Tri-national sites additional samples from the 0-30 cm depth interval are collected according to the EC-A protocol in order to compare and evaluate the resultant data.

Consultations with scientists from the Contaminated Sites Division (CSD) of Health Canada and Natural Resources Canada- National Forest Inventory (NFI) are also part of the project. The CSD plays a key role in both the development of soil quality guidelines and as expert support on issues related to contaminated sites on federal land. Soil data from the Tri-national Project will provide information on natural background concentrations of soil elements.

RESULTS

Soil geochemistry in eastern Canada

Surveys in Canada started in 2007 and to date only partial results are available for eastern Canada. The distribution of As and Cr in the <63 μm fraction (silt plus clay-sized material) of the C-horizon soil samples are shown in Figures 10 and 11. Arsenic levels range from a low of 2 ppm to a

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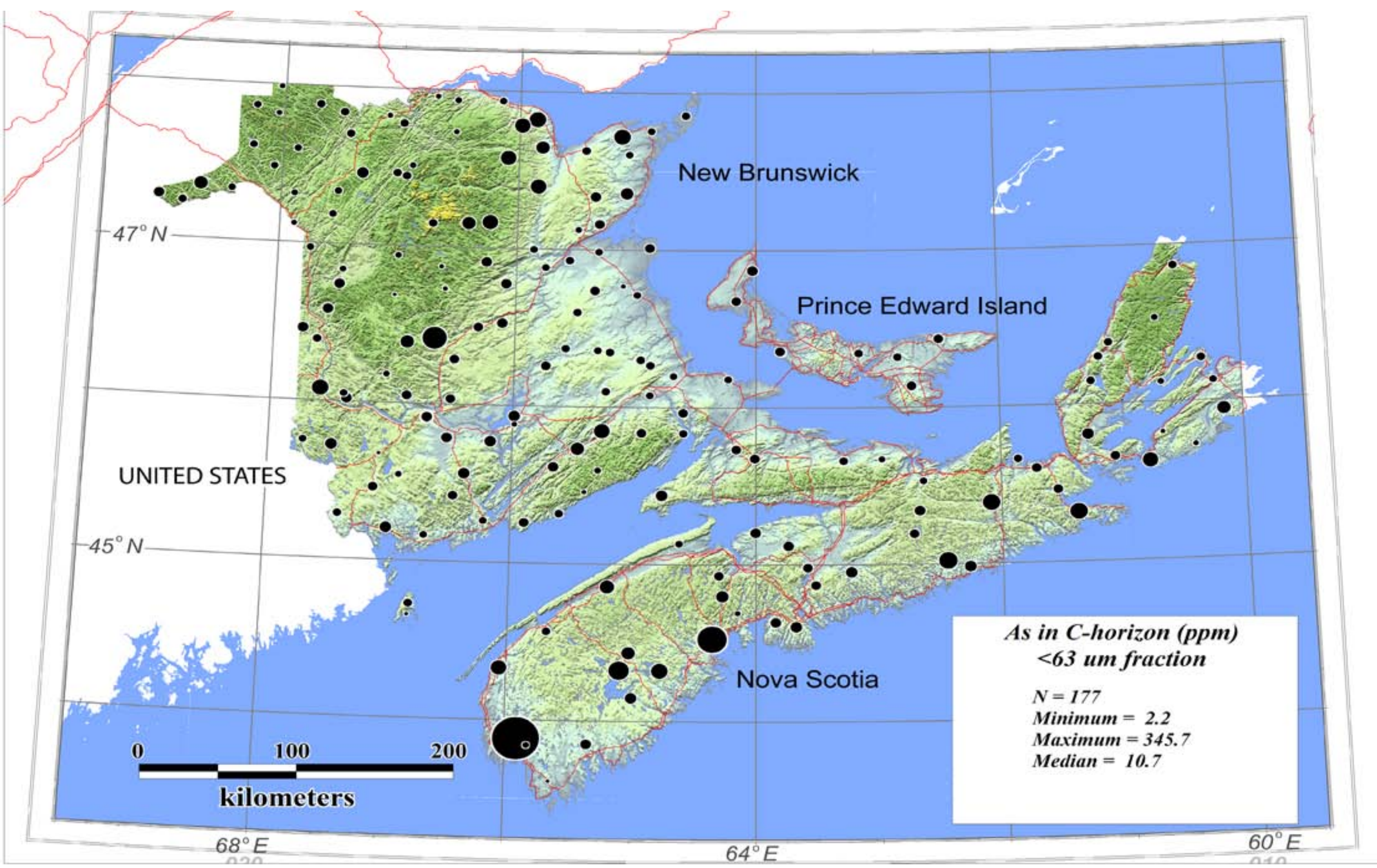

Figure 10. Distribution of As in the <63 μm fraction of C-horizon soil samples in eastern Canada. Samples were analyzed using ICP-MS after a near total (4-acid) digestion.

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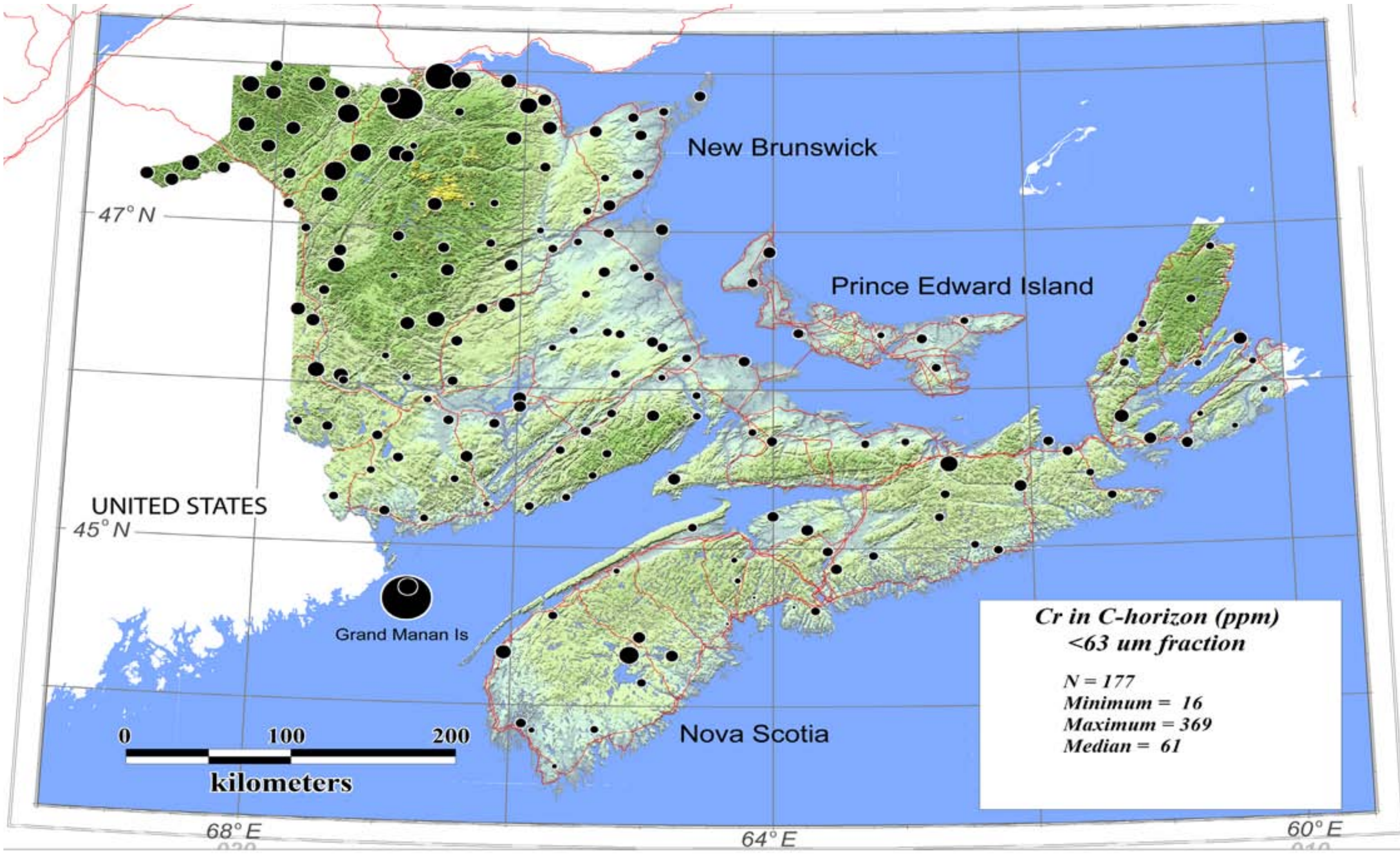

Figure 11. Distribution of Cr in the <63 µm fraction of C-horizon soil samples in eastern Canada. Samples were analyzed using ICP-MS after a near total (4-acid) digestion.

high of 346 ppm (median 10.7 ppm) and Cr concentrations from a low of 16 to a high of 369 ppm (median 41 ppm). Box and whisker plots and a table showing summary statistics indicate the range of concentrations of these 2 elements as well as others of environmental interest in the <63 µm fraction of the C-horizon samples (Fig. 12, Table 2). Box and whisker plots, also known as Tukey box plots, will be used routinely because they effectively display the range of concentrations levels plus the median level for individual elements (Grunsky & Garrett 2008).

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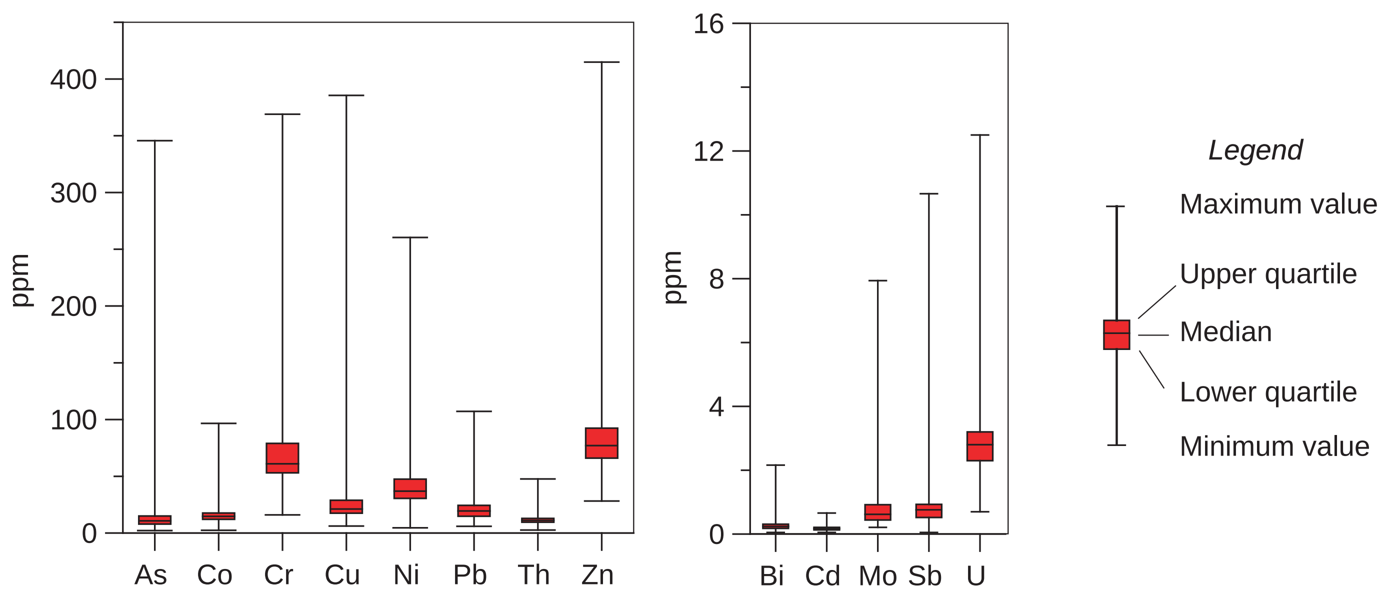

Figure 12. Box and whisker plots show the range of concentrations of selected elements in the <63 µm fraction of the C-horizon samples from New Brunswick, Nova Scotia, and Prince Edward Island.

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		As	Bi	Co	Cr	Cd	Cu	Mo	Ni	Pb	Sb	Th	U	Zn
N	Valid	177	177	177	177	177	177	177	177	177	177	177	177	177
	Missing	0	0	0	0	0	0	0	0	0	0	0	0	0
Unit		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Mean		14.9	0.29	15.3	70	0.18	27	0.86	40.8	21.67	0.86	12.0	3.0	84.1
Median		10.7	0.24	14.7	61	0.17	21	0.62	36.9	19.46	0.76	11.1	2.8	77.0
Mode		10.0	0.24	14.1	58	0.16	14	0.41	33.7	10.50	0.81	11.5	2.7	66.2
Std. Deviation		26.7	0.24	7.8	35	0.09	30	0.92	23.3	12.11	0.98	5.1	1.4	37.5
Variance		713.9	0.06	60.9	1198	0.01	917	0.85	544.8	146.77	0.95	25.5	1.9	1406.3
Minimum		2.2	0.05	2.4	16	0.05	6	0.21	4.6	5.96	0.05	2.6	0.7	28.2
Maximum		345.7	2.16	96.6	369	0.66	386	7.94	260.4	107.20	10.66	47.6	12.5	414.9
Percentiles	5th	3.6	0.12	7.4	37	0.07	13	0.27	15.6	10.50	0.25	7.3	1.9	46.9
	10th	5.5	0.14	9.6	45	0.09	15	0.34	22.7	12.11	0.36	8.3	2.0	52.8
	25th	7.9	0.18	12.1	53	0.13	17	0.44	30.4	14.70	0.52	9.5	2.3	66.0
	50th	10.7	0.24	14.7	61	0.17	21	0.62	36.9	19.46	0.76	11.1	2.8	77.0
	75th	15.0	0.31	17.6	79	0.21	29	0.92	46.7	24.36	0.93	12.9	3.2	92.1
	90th	26.2	0.44	20.1	103	0.29	39	1.38	61.7	31.57	1.14	16.3	4.1	116.3
	95th	30.4	0.57	23.5	116	0.37	54	2.70	72.1	41.90	1.64	20.8	5.2	139.9
	98th	49.6	1.09	30.6	157	0.49	85	4.33	97.5	58.40	2.56	33.3	8.5	190.5

Table 2. *Summary statistics for selected elements in the <63 µm fraction of C-horizon samples from eastern Canada (n=177). Element data were obtained using ICP-MS after a 4-acid digestion.*

The proportional symbol maps and box and whisker plots (Figs 10-12) for soils show the wide range of concentrations for several elements in C-horizon samples from eastern Canada. The majority of sites with high levels of As in Nova Scotia overlie Cambro-Ordovician Meguma Terrane, a thick succession of siliciclastics (T. Goodwin, Nova Scotia Department of Natural Resources, pers. comm., 2008; Keppie 2000). Enrichment of Au and As characterize the gold deposits of the Meguma Terrane (Kontak & Smith 1993) and these elements are commonly geochemically enriched in soils and till down-ice from known gold mineralization (Coker *et al.* 1988).

In northeastern New Brunswick, sample sites with highest As concentrations are located in areas that host base metal occurrences containing arsenopyrite (M. Parkhill, New Brunswick Department of Natural Resources, pers. comm. 2008; New Brunswick Department of Natural Resources 2000). In northwestern New Brunswick, there are high levels of Cr where Ni and other base metal enrichment have been detected in lake sediments, till and bedrock (Parkhill 2005). North-central New Brunswick soils contain elevated Cr where they overlie mafic volcanic rocks that host known occurrences of base metals (New Brunswick Department of Natural Resources Mineral Occurrence Database, 2008). The highest Cr concentration measured in soils in New Brunswick is on Grand Manan Island and reflects the underlying mafic volcanic bedrock where base metal occurrences are known (A. Seaman, New Brunswick Department of Natural Resources, pers. comm. 2008).

Test Research on partial extractions (aqua regia variants)

Results showed that HNO_3-H_2O_2 variant of US-EPA 3050B generally extracts significantly less metals and metalloids, with the exception of Hf, Nb, Th and Zr, than aqua regia and similar digestions (Garrett *et al*. 2008b). For the remaining protocols, aqua regia and three HCl-HNO_3 variants, the results are similar.

At present there are large amounts of aqua regia and US-EPA aqua regia-variant digestion data for soils published in North America and internationally. Also, the aqua regia digestion yields very consistent results for most elements. As a result of testing, the Tri-national project will use the US-EPA 3050B aqua regia-variant digestion. This procedure used a 4:1 HCl-HNO_3 mix rather than the 3:1 of "classical" aqua regia. The GSC has prepared a protocol defining the

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procedures to be used for Tri-national analyses that can be obtained upon request from the authors.

SUMMARY

The Tri-national project will provide a database of geochemical data that serves as a common national and international standard applicable at all levels of government. By early 2009 data will be available for a transcontinental swath in Canada and many states in United States and Mexico that covers diverse geologic and ecoclimatic terranes. The development and detailed documentation of field, laboratory and data handling protocols are a major part of the Tri-national project. Research is also ongoing on key analytical protocols to determine "optimal" methodology for generating soil geochemical data that are useful for health risk assessment. The protocols and data generated from these research efforts may be used in risk assessments, for developing or improving soil guidelines, and for assessing bioavailability.

Since the initiation of the Project, care has been taken to learn about the environmental research or regulatory activities ongoing in other Canadian provincial and federal government departments that require or have the potential to benefit from soil geochemical data. Partnerships have been formed with other agencies to carry out sampling or to develop new applications for these data through additional value-added projects. Several field meetings and demonstrations have taken place and Project information and data have been released through annual workshops, regular newsletters, and presentations at conference and meetings. These activities and also new sample collection will be continued by Geological Survey of Canada and provincial survey scientists over the next 5 to 10 years. In future, results will be released digitally through web postings by the federal and provincial geological surveys, journal articles, and other government reports.

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Canada: http://ess.nrcan.gc.ca/eh-esh/trinat/index_e.php
United States: http://minerals.cr.usgs.gov/projects/geochemical_landscapes/t1subtask1.html

Project participants

Agriculture and Agri-Food Canada; Alberta Geological Survey; British Columbia Geological Survey; Canadian Forest Service, National Forest Inventory; Environment Canada, National Guidelines and Standards Office; Environment Canada - Biological Methods Division; Natural Resources Canada - Geological Survey of Canada; Health Canada - Radiation Protection Bureau; Health Canada - Contaminated Sites Division; Manitoba Geological Survey; New Brunswick Department of Natural Resources; Northwest Territories Geoscience Office; Nova Scotia Department of Natural Resources; Ontario Geological Survey; Saskatchewan Energy and Resources - Northern Geological Survey

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I.M. Kettles, A.N. Rencz, P.B.F. Friske
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A guide for mineral exploration through the regolith in the Cobar Region, Lachlan Orogen, New South Wales,

written by K. G. McQueen. Published by CRC LEME, 2008. ISBN 1 921039 85 X.

To write an "Explorers' Guide" is a difficult task. It is all too easy to make assumptions about how much the reader knows of such matters as regolith, geology, geochemistry, analytical chemistry, etc. On the other hand, such a field-orientated guide cannot be a text book, let alone a series of text books. It must strike a balance between "teaching Grandma to suck eggs" and leaving too many important issues un-addressed. Dr McQueen has made a creditable effort to meet this impossible challenge. A newcomer to exploration in the Cobar Region of the Lachlan Orogen will find the Introduction and Regolith sections valuable in setting the scene. The seasoned explorer may find parts of the exploration strategies section moving into the reals of preaching to the converted, but where does one draw the line?

The use of colour photographs of type locations is very helpful: indeed there could have been more. It is however, unfortunate that no coordinates are provided for the localities photographed. Personally I find it very helpful to be able to stand at the same spot described by an author and to be able to see for myself exactly what is described in the text. Given the valuable inclusion of a mini CD, it would have been easy to load a file of GPS coordinates for all illustrations. The inclusion of two field excursions in the digital appendices goes some way towards overcoming this deficiency. Additionally, the inclusion in the appendix of discovery case histories will also be invaluable to explorers in the region.

I found the Guide Summary and Key (pages 98 to 109) a well constructed summary and think that if used in the field as a guide in the way anticipated by CRC LEME, this Summary would prove to be very helpful.

It is all too easy to "nit pick" over a document like this. Sure the section on Mapping the Regolith (section 2.7) is too short to be used effectively by anyone not already experienced in regolith terrain mapping, but then this document is not meant to be a text book on regolith mapping. On balance I would find this a useful addition to my field vehicle glove box if I was undertaking exploration in this part of the world. However, it is worth pointing out that the binding of my copy turned out to be far from robust without being subjected to the rigours of field usage.

Nigel Radford

CALENDAR OF EVENTS

International, national, and regional meetings of interest to colleagues working in exploration, environmental and other areas of applied geochemistry. These events also appear on the AAG web page at: www.appliedgeochemists.org

2008

• December 3-12, 2008. **Modular Course in Exploration Geochemistry**. Sudbury, Ontario, Canada. Email: spiercey@laurentian.ca, Website: http://earthsciences.laurentian.ca.

• December 15-19, 2008. **American Geophysical Union Fall Meeting**. San Francisco, USA. Website: www.agu.org/meetings/fm08/

2009

• January 26-29, 2009 **Mineral Exploration Roundup 2009.** Vancouver, B.C. Canada. Website: http://www.amebc.ca/roundupoverview.htm

• February 14-28, 2009. **Hydrothermal Ore Deposits Short Course**, University of Ottawa, Ottawa, Canada, Website: http://earth.uottawa.ca/short_course.html

• March, 2009. **Ore Deposits of South America.** ARC Centre of Excellence in Ore Deposits (CODES), Hobart, Tasmania. Website: http://fcms.its.utas.edu.au/scieng/codes/cpage.asp?lCpageID=55

• March 1-4, 2009. **Prospectors and Developers Association of Canada Annual Convention,** Toronto, Canada. Website: http://www.pdac.ca

• May 9-13, 2009. **U2009 - Global Uranium Symposium** Keystone, Colorado, USA. Website: www.U2009.org/

• May 21-23, 2009. **3rd International Symposium on Trace Elements in the Food Chain – Deficiency or Excess of Trace Elements in the Environment as a Risk of Health (TEFC2009)**, Budapest, Hungary Website: http://www.medicalgeology.org/

• May 24-27, 2009. **AGU/Geological Association of Canada/Mineralogical Association of Canada Joint Meeting** Toronto, Canada. Website: http://www.gac.ca/activities/index.php

• June, 2009. **Ore Deposit Geochemistry, Hydrology and Geochronology.** ARC Centre of Excellence in Ore Deposits (CODES), Hobart, Tasmania. Website: http://fcms.its.utas.edu.au/scieng/codes/cpage.asp?lCpageID=55

• June 1-4, 2009. **24th International Applied Geochemistry Symposium,** Fredericton, New Brunswick, Canada Website: http://www.unb.ca/conferences/IAGS2009

• June 22-26, 2009. **Goldschmidt 2009.** Davos, Switzerland. Website: http://www.goldschmidt2009.org/

• August 17-20, 2009. **Society for Geology Applied to Mineral Deposits 10th Biennial Meeting**, Townsville, Australia. Website: www.sga2009.jcu.edu.au

• June 23-26, 2009. **8th International Conference on Acid Rock Drainage**, Skelleftea, Sweden. Website: www.securing.skelleftea.se

• September 7-11, 2009. **Geoanalysis 2009**. Drakensberg Region, South Africa. Website: http://geoanalysis2009.org.za

• September 21-26, 2009. **Association of Environmental and Engineering Geologists** 52nd ANNUAL MEETING, Lake Tahoe, USA. Website: http://www.aegweb.org/i4a/pages/Index.cfm?pageID=3696

• October 18 to 23, 2009. **VIII INTERNATIONAL SYMPOSIUM ON ENVIRONMENTAL GEOCHEMISTRY, Ouro Preto/MG, Brasil**. Website: http://www.12cbgq.ufop.br/12cbgq/principaleng.htm

• October 18-21, 2009. **Geological Society of America Annual Meeting**. Portland, Oregon, USA. Website: www.geosociety.org/meetings/index.htm

• December 7-11, 2009. **AGU Fall Meeting**, San Francisco, USA. Web site: www.agu.org/meetings

2010

• April, 2010. **27th Society for Environmental Geochemistry and Health, European Conference**, Galway, Ireland. Website: http://www.nuigalway.ie/segh2010/

• May, 2010. **Geological Association of Canada/Mineralogical Association of Canada Annual Meeting** Calgary, Canada. Website: http://www.gac.ca/activities/index.php

• June 21-24, 2010. **11th International Platinum Symposium** Sudbury, Canada. Website: http://11ips.laurentian.ca

• July 14-18, 2010. **Goldschmidt 2010.** Knoxville, USA. Website: www.geochemsoc.org/news/conferencelinks/

• October 31-November 3, 2010. **Geological Society of America Annual Meeting**. Denver, Colorado, USA. Website: www.geosociety.org/meetings/index.htm

2011

• May 25-27, 2011. **Geological Association of Canada/Mineralogical Association of Canada Annual Meeting** Ottawa, Canada.

2012

• August 5–15, 2012. **34th International Geological Congress**, Brisbane, Australia. Website: http://www.ga.gov.au/igc2012

• 2012. **Geoanalysis 2012**. Brazil

Please let this column know of your events by sending details to:

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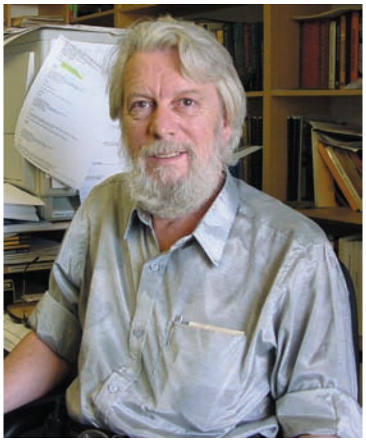
Obituary



David Murray McConchie

It is with great sadness that I report to you the passing of Dr. David McConchie, Professor of Engineering and Geochemistry at Southern Cross University, Australia. It would appear that Dave had a massive heart attack, while on field work in the Forsyathe area of Far North Queensland. He was a friend and colleague of many IAG Members.

Professor McConchie completed a diploma of education (Secondary) in 1974 from Christchurch Teachers College N.Z., a BSc (1975) in Geology and Masters Thesis (1978) from University of Canterbury N.Z., and a PhD (1986) in geology from the University of Western Australia. He was first appointed to the Northern Rivers School of Advanced Education, the precursor to Southern Cross University, Australia in 1987. In 1997, he was awarded a personal chair and became Professor of Engineering and Environmental Geochemistry where he lead the Applied Geochemistry Research Group and co-founded the Centre for Research on Acid Sulfate Soils.

He also established the Environmental Analysis Laboratory (EAL) as a commercial analysis laboratory so that it could provide analytical services back to staff and students of SCU at a reduced cost, and for the community; this now forms the foundation of a major research facility. Prof. McConchie was a Director and Chief Scientist for Virotec Global Solutions Ltd. and a Director of ReMine Gold Pty. Ltd., RISATEC Pty. Ltd. and Mt Aspiring Geochemistry Consultants Pty. Ltd.

He received numerous research grants, published over 100 research papers and 5 books, made over 80 conference presentations, prepared over 300 consultancy reports, and was the author of 7 patents. His books, *Practical Sedimentology* and *Analytical Sedimentology* (Chapman & Hall, N.Y.), were described in a review in the December 1995 issue of *The Australian Geologist* as “contemporary classics in sedimentology.” In recognition of the quality of his research and consultancy work, he was a finalist in the Australian Eureka Prize for environmental research in both 1995 and 1996; he also received a Vice-chancellor’s award for teaching excellence at Southern Cross University in 1995.

He was a member of the Association of Applied Geochemists, the Society for Sedimentary Research, the American Geological Institute, the Geological Society of Australia, the Geological Society of New Zealand, the Clay Minerals Society, and the New York Acadamy of Sciences.

Over the last 20 years, his research and consultancy work was focused on the geochemistry of trace metals in sediment, water and biota; acid sulfate soils and acid rock drainage; early diagenetic mineral transformations; trace element speciation in sediments; the influence of biota on trace element distributions in sediment and water; applications of geochemical engineering and the use of bauxite refinery residues in environmental remediation. He carried out geochemical and sedimentological consultancy work, for many industry and government organisations, in Australia and overseas and specialises in the development of innovative solutions for environmental problems. His recent work on treating bauxite refinery residues and using the modified materials to treat acid rock drainage, tailings dam and pit lake water, acid sulfate soils, sulfidic mine tailings and waste rock, and some industrial effluents is proving to be highly effective and the technology is now being marketed worldwide by Virotec Global Solutions. Dave is survived by his wife Fiona, daughter Keetah, son Jade, and four grand children.

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Mineral Exploration Roundup 2009 Short Course

January 26 to January 29, 2009
Vancouver, British Columbia, CANADA
Website: http://www.amebc.ca/default.htm

Sources and Sinks in Hydrothermal Systems

Presented by AME BC, Dick Tosdal, Stephen Cox, Mike Lesher, Kurt Kyser, Peter Hollings, Wayne Goodfellow
Date: January 24-25, 2009

Overview:

Ore deposits require a source of fluids, ligands, and metals as well as a transport system and sink for precipitation in economic concentration. These involve the interplay between magmatic activity, basin development, and tectonics. Understanding the scale of those systems and recognizing where within a paleohydrothermal system on might be can provide important vectors toward undiscovered resources.

This 2-day course will examine the sources and sinks of hydrothermal deposits. The course is aimed at mineral exploration, government, academic and student geologists, and provides an opportunity to meet and exchange data and views with leading researchers in the field.

RECENT PAPERS

This list comprises titles that have appeared in major publications since the compilation in **EXPLORE** Number 140. 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**.

Alaniz-Alvarez, S.A. and Nieto-Samaniego, A.F. (eds.), 2007. Geology of Mexico: Celebrating the Centenary of the Geological Society of Mexico. GSA Spec. Paper 442. 475 p.

Baumgartner, R., Fontbote, L. and Vennemann, T., 2008. Mineral zoning and geochemistry of epithermal polymetallic Zn-Pb-Ag-Cu-Bi mineralization at Cerro de Pasco, Peru. EG 103(3): 493-537.

Benavides, J., et al., 2008. Exploration guidelines for copper-rich iron oxide-copper-gold deposits in the Mantoverde area, northern Chile: the integration of host-rock molar element ratios and oxygen isotope compositions. Geochemistry: Exploration, Environment, Analysis 8(3/4): 343-367.

Benavides, J., et al., 2008. Application of molar element ratio analysis of lag talus composite samples to the exploration of iron oxide-copper-gold-type mineralization: Mantoverde area, northern Chile. Geochemistry: Exploration, Environment, Analysis 8(3/4): 369-380.

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Church, S.E., von Guerard, P., and Finger, S.E. (eds.), 2007. Integrated Investigations of Environmental Effects of Historical Mining in the Animas River Watershed, San Juan County, Colorado. USG Prof. Paper 1651. 1096 p. (2 vol. and CD-Rom).

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Degraff, J.V. (ed.), 2007. Understanding and Responding to Hazardous Substances at Mine Sites in the Western United States. GSA Rev. Eng. Geol. V. 17. 180 p.

Demetriades, A., 2008. Overbank sediment sampling in Greece: a contribution to the evaluation of methods for the "Global Geochemical Baselines" mapping project. Geochemistry: Exploration, Environment, Analysis 8 (3/4): 229-239.

DeVivo, B., et al., 2008. Environmental geochemical maps of Italy from the FOREGS database. Geochemistry: Exploration, Environment, Analysis 8 (3/4): 267-277.

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Gerst, M.D., 2008. Revisiting the cumulative grade-tonnage relationships for major copper ore types. EG 103 (3): 615-628.

Godel, B. and Barnes, S-J., 2008. Image analysis and composition of platinum-group minerals in the J.M. reef, Stillwater Complex. EG 103(3): 637-651.

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Mungall, J.E., and Naldratt, A.J., 2008. Ore Deposits and the Platinum-Group Elements. Elements 4 (4): 253-258.

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RECENT PAPERS

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Salminen, et al., 2008. Indications of deposits of gold and platinum group elements from a regional geochemical stream sediment survey in NW Tanzania. Geochemistry: Exploration, Environment, Analysis 8 (3/4): 313-322.

Schetselaar, E.M., et al., 2008. Remote Predictive Mapping 1: Remote Predictive mapping (RPM): A Strategy for Geological Mapping Canada's North. Geoscience Can. 34 (3/4): 93-111.

Shand, P., Degens, B., and Rogers, S., 2008. The geochemistry of acid-saline waters and drainage sediments in the Avon Catchment, Western Australia Wheat belt. EXPLORE No. 140: 1-11.

Sillitoe, R.H., 2008. Special Paper: Major gold deposits and belts of the North and South American Cordillera: Distribution, tectonomagmatic settings and metallogenic considerations. EG 103 (4): 663-687.

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Zhang, C., et al., 2008. Use of trans-Gaussian kriging for national soil geochemical mapping in Ireland. Geochemistry: Exploration, Environment, Analysis 8 (3/4): 255-265.

New Members

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The further south you go, the brighter the stars.

Is it something in the air? Is it our isolation in the Southern Ocean? Is it our proximity to Antarctica? Our access to World Heritage temperate wilderness? Or is it our focus on distinctive research that is globally significant in quality and scope? What exactly has made UTAS one of the top 10 research universities in Australia? Certainly, all of these factors have been crucial.

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Closing date – Friday 19 December 2008. To find out more visit www.newstars.utas.edu.au

The University of Tasmania retains the right to invite applications or not to make an appointment.
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UNIVERSITY OF TASMANIA

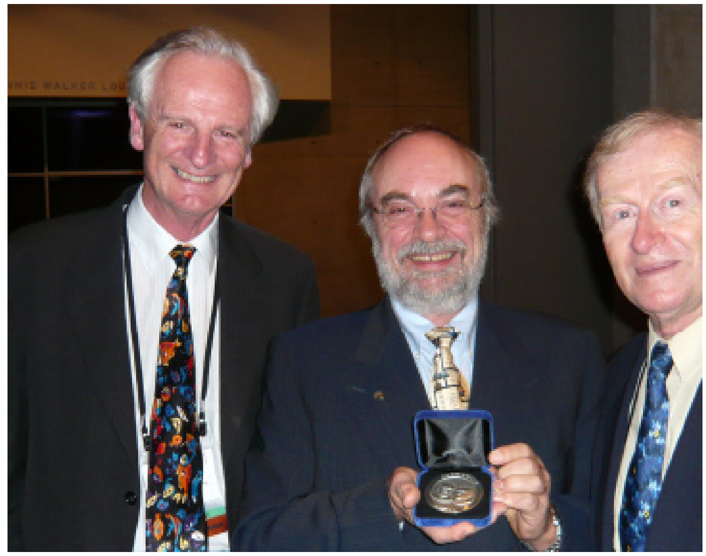
AAG Member Nigel Radford wins Award

The 2008 Butt Smith Medal for Outstanding and Sustained Research Excellence in Geoscience was awarded to Dr. Nigel Radford of Newmont Asia Pacific in a special presentation during the Australian Earth Science Convention in Perth on 23rd July, 2008. The Award was presented by Dr. Steve Rogers, Chief Executive Officer of the CRC for Landscape Environment and Mineral Exploration (CRC LEME) and Dr. Mike McWilliams, Chief of CSIRO Exploration & Mining.

Dr. Radford, a consulting geochemist at Newmont, is widely known throughout the Australian and international exploration geochemistry community through his personal research in application and testing of innovative ideas in regolith geochemistry. He has a world-class reputation in the mineral exploration community and is a committed teacher and mentor of younger staff members. The 2006 Butt Smith Medal winner, CSIRO's Dr. Ravi Anand, says Dr. Radford is a visionary geologist. "In the 1980s he played an important role in the exploration community, convincing them that the regolith had positive exploration aspects, providing a vital interface between scientists and explorers."

"Dr. Radford's work on the Bulk Leach Extractable Gold technique of stream sediment sampling of gold together with Bill Griffin of Newmont has resulted in world leadership in the field," Dr.Anand says. "He has also been a strong advocate of the role of organic processes in the regolith and the formation of geochemical anomalies. This initiative has been confirmed by the discovery that metal signatures are preserved in specific organs of native trees."

The Medal honours eminent geoscientists Dr. Charles Butt and Dr. Ray Smith of the CSIRO Division of Exploration and Mining, who made invaluable contributions to mineral exploration, regolith geochemistry and ore deposit research over the past 37 years. Butt increased awareness of the geochemical processes that operate in deeply weathered, lateritic terrains, while Smith worked on developing methods for locating mineral deposits hidden by deep weathering



(L-R) Dr. Charles Butt with 2008 Butt Smith Medal recipient, Dr. Nigel Radford and Dr. Ray Smith.

profiles or overlain by sediments. The Butt Smith Medal is jointly awarded by CRC LEME and CSIRO Exploration & Mining every two years. CRC LEME Chief Executive Officer Dr. Steve Rogers says it is fitting that Dr. Radford received the Award.

"He has a strong association with CRC LEME and helped develop and present the bid for CRC LEME One and served on the Mineral Advisory Council for both CRC LEME One and Two." CSIRO Exploration & Mining Chief Mike McWilliams says the award adds to an already outstanding career. "Dr. Radford has been an active member of the Association of Applied Geochemists since 1982, serving on council for eight years and as Association President in 2001. He was the co-chairman of the committee that organised the very successful Applied Geochemistry Symposium in Perth in 2005."

CSIRO Media Centre
http://www.csiro.au/news/MediaCentre.html

GEEA Now Available on New Website

The AAG's journal, *Geochemistry: Exploration, Environment, Analysis* (GEEA), is now available online via the Lyell Collection (www.lyellcollection.org) – a fully searchable online collection of most of the Geological Society of London's books and journals. Note that the journal will be removed from the Ingenta site during October 2008. As a member of the Association of Applied Geochemists, you are entitled to access all of the online content for this journal. Before you can access the journal you will need to activate your subscription. To do this, go to the subscription activation page (www.lyellcollection.org/cgi/activate/ibasic) and put in your subscriber ID number - which you should have received from The Geological Society via email. If you have not received your ID number, contact Betty Arseneault at the AAG Business Office.

Gwendy Hall
Editor, Geochemistry: Exploration, Environment, Analysis

24th International Applied Geochemistry Symposium, June 1-4, 2009.
Hosted by the University of New Brunswick in Fredericton, New Brunswick CANADA.
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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.

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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
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Regional Councillor Report for Northern Europe: European Activities in Environmental and Exploration Geochemistry.

Despite the good metal prices up to last week, European research in Applied Geochemistry is mainly related to environmental issues. Several geochemical mapping projects are currently underway as spin-off of the publishing of the FOREGS Geochemical Atlas of Europe of which the data and reports are public domain and remain a source for further study and good teaching material.

The new European Chemicals Regulation REACH (Registration, Evaluation and Authorisation of Chemicals) came into force on the 1st June 2007. (http://ec.europa.eu/environment/chemicals/reach/reach_intro.htm.) REACH, as well as the pending EU Soil Protection Directive, both require additional knowledge about "soil quality" at the European scale. The GEMAS (geochemical mapping of agricultural soils and grazing land of Europe) project aims at providing harmonized geochemical data of arable land and land under permanent grass cover at the continental, European scale. Geological Surveys in 34 European countries, covering an area of 5.6 million km^2, have agreed to sample their territory at a sample density of 1 site each, arable land (0-20 cm) and land under permanent grass cover (0-10 cm), per 2500 km^2. Sampling will take place during 2008, following a jointly agreed field protocol. All samples will be prepared in just one laboratory, a strict quality control procedure has been established and all samples will be jointly analyzed in just one laboratory for any one chemical element/parameter. http://www.ngu.no/no/hm/Publikasjoner/Rapporter/2008/2008-038/

Even though London is large, on a smaller scale than GEMAS, the British Geological Survey has started a major project with a geochemical baseline survey of Greater London and surrounding areas during the summer of 2008 and 2009. Known as 'London Earth', the project will provide information on the chemistry of the surface environment of the most heavily populated area of the UK. Comparison of the soil results from London with those of adjacent rural areas will allow the identification of changes in the chemistry of the environment brought about by human activity.

The results from this survey will be accessible to all. This geochemical urban-sampling survey consists of trained teams working on foot and in pairs collecting 6000 soil samples across the Greater London area. Four samples will be taken in each square kilometer at depths of 0-20 cm and 35-50 cm with a 1 m long hand-held auger. Samples will normally be taken from open ground, such as parks, playing fields, back gardens and roadside verges. http://nds.coi.gov.uk/content/detail.asp?NewsAreaID=2&ReleaseID=373696

Similar to the work on the Wolfson geochemical atlas of England and Wales (Webb et al., 1978) in the 1970s, students will be employed to form the sampling teams. Hopefully these new samples will be better preserved than the samples for the Wolfson Atlas. The idea to re-analyse these more than 30 year old stream sediment samples in order to study what environmental changes had occurred since they were collected, proved impossible as nobody seems to know where the samples were stored.

Major mineral exploration efforts seem to continue tobe concentrated mainly in the Scandinavian countries where there are lots of activities. During the recent 33rd International Geological Congress in Oslo, Norway, for nine days 6,000 scientists from 113 discussed all aspects of geology including geochemical aspects. http://www.33igc.org/coco/LayoutPage.aspx?ContainerID=5002&guid=1

Next year Sweden will organize an international conference "Securing the future mining, Metal & Environment in a sustainable society" and 8th ICARD international conference on acid rock drainage in Skelleftea, Sweden 33-26 June 2009, details see www.securing.skelleftea.se

The Finish Geological Survey GTK is ever active. AAG fellow Dr. Pertti Sarala reported: "Due to increased international interest to the exploration of base and precious metals, gold and PGE in Finland, GTK's large databases including geochemical datasets are now highly valuable. Demand on them is high, and both foreign and Finnish exploration and mining companies are actively asking them. Also, the large exploration databases

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EXPLORE

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March newsletter: January 15
June newsletter: April 15
September newsletter: July 15
December newsletter: October 15

Manuscripts should be double-spaced and submitted in digital format using WORD. Photos and figures (colour or black and white) should be submitted as separate digital files and as high resolution jpeg or PDF files. Tables should be submitted as separate digital files in EXCEL format. All scientific/technical articles will be reviewed. All contributions may be edited for clarity or brevity.

Formats for headings, abbreviations, scientific notations, references and figures must follow the Guide to Authors for *Geochemistry: Exploration, Environment, Analysis* (GEEA) that are posted on the GEEA website at: http://www.geolsoc.org.uk/template.cfm?name=geea_instructions_for_authors

Submissions should be sent to:
Beth McClenaghan, Geological Survey of Canada, 601 Booth Street, Ottawa, ON, CANADA K1A 0E8 Email: bmcclena@nrcan.gc.ca

LIST OF ADVERTISERS

Regional Councillor Report...

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of Outokumpu Ltd. that were moved to GTK are largely asked nowadays. GTK has its own developing activities relating to MMI and other weak leach methods, on-line XRF measurements and heavy mineral studies together with "traditional" aqua regia till geochemistry in exploration for gold, PGE and base metals. These testes are valuable because the focus is moving from the targeting scale to regional mineral potentiality mapping. For this purpose easy, fast and effective methods are needed for sampling and producing analyzes from large areas. Also, there is need for developing GIS-based mineral potential mapping that uses spatial modeling. GTK's large, nation-wide geochemical databases are proven to be usable." http://en.gtk.fi/ExplorationFinland/

There is ongoing research in a number of European institutes and universities on aqueous transport of inorganic contaminants in various environments. Geochemistry in relation to exploration remains unpopular but the increasing popularity of forensic science in television series has led to an increased interest with students in applied geochemistry. At East Anglia University in the UK students can opt for a four year course leading to a master degree in Chemistry in Forensic and Investigative Chemistry.

In the Netherlands, a group in Utrecht has been working on spatial geochemistry partly sponsored by government which wants to modernize soil quality ranking criteria and possibly even regional defined criteria. Finally it sinks in that even in a 200x300 km country regional background variation can be significant! At the European level, the Netherlands are involved in upcoming Soil System Modeling project, strongly influenced by the American Critical Zone concept, and a project on Forensic Soil Science. In my own institute, ITC (International Institute for Geo-Information Science and Earth Observation), we try to develop applications for mineral exploration and pollution studies in arid areas through linking IR bands in RS-data in high resolution imagery to chemistry hard facts on the ground. Specific features in the near- but specially the thermal IR spectra of minerals are used which are measured with an external integrating sphere attached to a FTIR instrument for larger samples.

I thank Bjorn Bolviken, Olle Selenus , Peter Simpson, Sergey Grigorian, Rosa Cidu, Dee Flight, Bernadette Azzie, Pertti Sarala, and Gerben Mol (not an AAG member) for responding to my e-mail request for information on European activities.

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