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# Geological Survey of Canada

## MINERALS COLLOQUIUM

### Program with Abstracts



Ottawa Congress Centre, Ottawa, Ontario  
January 22-24, 1992



Energy, Mines and  
Resources Canada

Énergie, Mines et  
Ressources Canada

Canada

**THE ENERGY OF OUR RESOURCES**

**THE POWER OF OUR IDEAS**



# **Geological Survey of Canada**

## **MINERALS COLLOQUIUM**

**22-24 January, 1992**

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### **Place**

Halls A,E  
Ottawa Congress Centre  
55 Colonel By Drive, Ottawa

### **Scientific Displays**

Some 100 displays will be on view in hall A  
on Wednesday, January 22<sup>nd</sup> from 17h10 to 22h00 and  
on Thursday, January 23<sup>rd</sup> from 14h50 to 19h00.

### **Social Event**

An informal get-together, with cash bar, will be held in Hall A on Wednesday, January 22<sup>nd</sup> between 17h10 and 22h00 and on Thursday, January 23<sup>rd</sup> between 14h50 and 19h00. Also, there will be a "Meet the Speakers" hour on Wednesday evening between 21h00 and 22h00.

# **Minerals Colloquium 1992**

## **Colloquium Organizer and Committee Chairman**

R.F.J. Scoates

## **Program Committee**

W.B. Coker  
W.D. Goodfellow  
D.C. Harris  
C.W. Jefferson  
R.B.K. Shives

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R.M. Laramée  
S. Leslie  
L.C. O'Neill  
S.A. Scully  
C.E. Vodden

The Minerals Colloquium Committee wishes to acknowledge GSC Forum 1992 Committee members for their support and encouragement of this second edition of the Minerals Colloquium.



## FOREWORD

Welcome to the Geological Survey of Canada's second Minerals Colloquium! The Colloquium is intended to highlight the results of the GSC Minerals Program and to promote communication between GSC scientists and their colleagues in the mineral industry, the universities and other government geoscience agencies. The Minerals Colloquium is a regular event, held on a biennial basis.

The GSC is of course only one of many organizations that carry out minerals-related research in Canada, and we are particularly pleased that numerous colleagues from provincial and territorial surveys, academia and the mineral industry have agreed to participate in the colloquium. This is indicative of the spirit of cooperation that will be the hallmark of successful research in the 1990's.

The Minerals Colloquium this year will focus on topics of immediate interest to the mineral industry. There are five oral sessions on the themes Exploration Research, Cordilleran Metallogeny, Resource Assessment, Appalachian Metallogeny and Ocean Drilling Program. In addition, more than 100 poster presentations provide a representative cross section of recent scientific results of GSC's minerals-related research.

A highlight of the Minerals Colloquium will be a keynote address in honour of the late A.H. Lang, one of GSC's foremost economic geologists. The 1992 Lang Lecture will be presented by J.W. Gill and H.R. Stockford, Aur Resources Inc., and is entitled "Integrated exploration strategies plus positive economic criteria equals new mine development".

We are pleased to have John E. Tilton, Coulter Professor and Head of the Department of Mineral Economics, Colorado School of Mines, present an invited lecture "Mineral Resources - a threat to sustainable development?" This thought-provoking lecture will be presented Wednesday evening.

We hope that you will find much of interest among the oral and poster presentations at the Minerals Colloquium. We would be very pleased to receive your comments, not only concerning the format and content of the meeting itself, but also with respect to the direction and emphasis of GSC's minerals-related research.

Elkanah A. (Ken) Babcock  
**Assistant Deputy Minister**



A.H. Lang  
1905-1990

## THE LANG LECTURE

The Geological Survey of Canada (GSC) Minerals Colloquium Committee takes great pleasure in honouring the late Arthur H. Lang, one of the GSC's foremost economic geologists through the presentation of a special invited lecture. The Lang Lecture, is presented by geoscientists who have demonstrated outstanding accomplishments in mineral exploration or research. This year the Lang Lecture is entitled "Integrated exploration strategies plus positive economic criteria equals new mine development" and will be presented by Jim Gill and Howard Stockford of Aur Resources Inc.

### ARTHUR H. LANG

Arthur Hamilton Lang, born in the interior of British Columbia in 1905, was an honours geology graduate of the University of British Columbia. As a child he became interested in minerals and rocks and in several worked-out gold placers and lode prospects in his home region. Local prospectors befriended him and showed him maps and reports of the Geological Survey of Canada (GSC). A topographic map taken from G.M. Dawson's report on the region was on a wall of his father's office. A.H. Lang was employed as a student assistant on GSC parties in British Columbia from 1927 to 1929. He joined GSC in 1930, after completing his Princeton University doctoral thesis "Owen Lake Mining Camp, British Columbia". He was one of the last geologists to be engaged by GSC before the great depression caused a hiring freeze.

His first GSC work was in the Abitibi gold fields (Chibougamau, Waswanipi Lake, Palmarolle and Taschereau map-areas) where he pioneered the field use of air transport and reconnaissance, and use of air-photos in preparing topographic and geological maps. Later, he studied gold deposits of the Noranda-Bell River region of Quebec and the Cariboo District of British Columbia.

Soon after the outbreak of World War II, Lang enlisted in the R.C.A.F. However, GSC insisted on having this cancelled because the Metals Controller was increasingly demanding more projects related to strategic metals and minerals. Lang worked on several of these until petroleum became the main shortage. From 1941 to 1945 he undertook petroleum-related mapping, in the foothills of Alberta.

In 1944 the GSC assigned a few geologists to secret investigations of known uranium deposits and their surroundings. In 1947 the government, on the advice of Atomic Energy Control Board (formed the previous year), decided to permit and encourage private prospecting and mining for uranium. The GSC was made the official agent of the Board in matters related to prospecting and mining. To handle this the Radioactive Resources Division was formed with H.V. Ellsworth, a renowned mineralogist and chemist as Chief. Lang was put in charge of field work and maintaining and verifying an "inventory" of occurrences, which had been begun by Ellsworth during the period of secrecy. Lang succeeded Ellsworth as Chief in 1948. By 1955 uranium production had become well established, and as more attention to other metals was required, the name of the Division was changed to Mineral Deposits Division.

The requirement for reporting radioactive ore discoveries gave Lang unusually good data for preparing and publishing a metallogenic map for uranium. He then encouraged other GSC geologists to prepare such maps for other major, and many minor metals, many of which were published. He compiled two maps combining this information, which were published, with a short explanatory text, in A Preliminary Study of Canadian Metallogenic Provinces.

Soon after the formation of the Geology Division of the Canadian Institute of Mining and Metallogeny, about 1943, a sub-committee was formed to arrange for a special volume "Structural Geology of Canadian Ore Deposits" to mark the Jubilee year of 1948. Lang served as co-editor and contributed two papers. A few years later he undertook special geological research and prepared about half of an early compilation of the Geological Map of Canada at 1:5 000 000, which was refined by R.J.W. Douglas.

The first edition of Canadian Deposits of Uranium and Thorium was the first detailed account of uranium and thorium deposits and occurrences issued by any country. In his recent book Not For Gold Alone Franc Joubin, the founder of uranium mining in the Elliot Lake region of Ontario stated "Now, three years later, my interest in the area was rekindled by a newly published Geological Survey of Canada bulletin by A.H. Lang, entitled Canadian Deposits of Uranium and Thorium. It was a remarkable compilation of data for practically all known radioactive deposits in Canada".

The 3<sup>rd</sup> edition of Prospecting in Canada was reprinted three times within ten years and the 4<sup>th</sup> edition has been reprinted numerous times. It is used for adult education courses, and supplementary reading for university courses. It has been used as a textbook by the International Atomic Energy Institute in Vienna. A paperback containing the chapters on basic geology minerals and rocks and an outline of the geology of Canada was prepared for use by high-schoolers. Lang was author of more than 100 publications on Canadian geology and mining, some of which have been translated and re-published in other countries.

After retirement from the Public Service in 1970, Lang was asked to undertake part-time contractual preparation of geological guidebooks for several national parks, four of which were published.

Throughout his career Lang presented many outstanding lectures and talks based on his original geological research and his study of uranium deposits. He took part in several international conferences on peaceful uses of atomic energy and on geological and metallogenic maps of the world.

He was a fellow of the Royal Society of Canada and the Geological Society of America, and a member of the Fifty-Year Club of the Canadian Institute of Mining and Metallurgy. His field work in British Columbia and Alberta, in areas where travel was largely by pack and saddle horses, gave him great admiration for western horses and for mountains. He skied from age 10 to 80 and golfed in later life when he spent more time in Ottawa.

Immediately following the inaugural Minerals Colloquium in 1990, members of the Colloquium organizing committee and GSC staff presented Arthur Lang with a memento commemorating the first Lang Lecture. He was extremely pleased to be recognized in this fashion. Arthur Lang died in July, 1990; he was in his 86<sup>th</sup> year.

# PROGRAM

**Wednesday, 22 January 1992**

13h30 WELCOME AND OPENING REMARKS

**EXPLORATION RESEARCH I - EXTECH: A MID-TERM REPORT**

13h40 The Exploration Science and Technology Initiative (EXTECH), Snow Lake and Rusty Lake areas, Manitoba

***W.B. Coker***

13h45 Environment of massive sulphide deposition, Snow Lake, Manitoba

***A.G. Galley, A.H. Bailes***

14h00 Geology and geochemistry of the Proterozoic Ruttan Cu-Zn deposit and environment

***D.E. Ames***

14h15 Sedimentological and geochemical effects of liming sulphide tailings on lacustrine systems, Ruttan Mine, Manitoba

***W.W. Shilts, W.B. Coker, G.E.M. Hall, J.D. Adshead***

14h30 Till composition associated with volcanogenic massive sulphide deposits, Snow Lake and Rusty Lake areas, Manitoba: geochemistry, mineralogy and regional trends

***C.A. Kaszycki, G. Gobert, E. Nielsen***

14h45 Gamma ray, magnetic, VLF-EM surveys in the Snow Lake and Rusty Lake areas, Manitoba

***R.B.K. Shives***

15h00 Integrating geological data in a GIS environment for mineral resource potential mapping in Snow Lake, Manitoba

***R.K.T. Reddy, G.F. Bonham-Carter, D.F. Wright***

15h15 COFFEE BREAK

**CORDILLERAN METALLOGENY - GOLDEN TRIANGLE CU-AU AND QUESNEL TROUGH**

15h30 Paleozoic through Tertiary geological framework for mineral deposition in the "Golden Triangle", Iskut and Stikine Rivers area

***R.G. Anderson, M.L. Bevier, M.J. Gunning, B.M. McClelland, G. Nadaradju, P.L. Smith***

15h50 Early Jurassic metallogeny of the Canadian Cordillera

***D.J. Aldrick***

16h10 Lower Jurassic Sulphurets porphyry Cu-Au system, northwest British Columbia

***R.V. Kirkham, S.B. Ballantyne, D.C. Harris, J.R. Henderson, M.N. Henderson, T.O. Wright***

16h30 An integrated approach and model for the discovery of blind Cu-Au porphyry systems in the Quesnel Trough, northern British Columbia

***S.B. Ballantyne, D.C. Harris, R.B.K. Shives, K.L. Ford, P.B. Holman, A. Plouffe, A.S. Judge, J.A. Pilon***

16h50 Porphyry deposits of the Cordillera - Exploration and Research Problems

***J.F.H. Thompson, K.P.E. Dunne, C.I. Godwin, J.R. Lang, A.J. Macdonald, C.R. Stanley***

**17h10-20h00 POSTER SESSION AND CASH BAR**

20h00 Invited Lecture: Mineral resources - a threat to sustainable development?

***J.E. Tilton***

21h00-22h00 MEET THE SPEAKERS,

**POSTER SESSION AND CASH BAR**

**Thursday, 23 January 1992**

**RESOURCE ASSESSMENT: CONTRIBUTING TO SUSTAINABLE DEVELOPMENT**

- 08h30 Evolution of mineral and energy resource assessments at GSC - what we are learning  
**C.W. Jefferson**
- 08h50 Conceptual models as a part of resource evaluation of nuclear energy minerals at the GSC  
**V.R. Ruzicka**
- 09h10 Completing Canada's national parks system: implications for the mining industry  
**P.B. Hale, W.R. Wagner**
- 09h30 Northwest Territories computerized mineral showings database and mineral resources map project - progress report  
**H. Wolf, R.D. Branson, L. Covelio, D.W. Wind, C.W. Jefferson, D. Atkinson, R.M. Laramée, C. Ellis**
- 09h50 The British Columbia experience in mineral resource assessment  
**G.P. McLaren**
- 10h10 Quantitative mineral resource assessment at the USGS  
**D.A. Singer**
- 10h30 **COFFEE BREAK**
- 10h45 **1992 LANG LECTURE - Introduction**
- 10h55 Lang Lecture: Integrated exploration strategies plus positive economic criteria equals new mine development  
**J.W. Gill, H.R. Stockford**
- 12h00 **LUNCH**

**EXPLORATION RESEARCH II**

- 13h30 Glacial history and drift provenance, northeastern Abitibi Belt, Quebec  
**J.J. Veillette**
- 13h50 New insights into the Sudbury structure from reflection seismic profiling  
**B. Milkerelt, A.J. Green, B.O. Dressler, G.G. Morrison, A.J. Naldrett, P. Snajdr (for the LITHOPROBE study group)**

**APPALACHIAN METALLOGENY**

- 14h10 Sediment-hosted barite and sulphide deposits of the Quebec Appalachians  
**S.J. Paradis**
- 14h30 Intra-crustal chromitites in the Bay of Islands Ophiolite: restites from incongruent dissolution into ultramafic intrusions  
**J.H. Bédard**
- 14h50-19h00 **POSTER SESSION & CASH BAR**

**Friday, 24 January 1992**

**OCEAN DRILLING PROGRAM IN MIDDLE VALLEY, LEG 139: PROCESSES AND PRODUCTS OF HYDROTHERMAL FLUID CIRCULATION IN A SEDIMENTED RIFT**

- 08h30 Structural, thermal and hydrologic regime of the Middle Valley sedimented rift  
**E.E. Davis and the Leg 139 scientific party**
- 09h00 Fluid-sediment interactions associated with high temperature fluid flow, Middle Valley.  
**W.D. Goodfellow and the Leg 139 scientific party**
- 09h30 Chemical composition of vent and pore fluids in an active hydrothermal discharge zone, Middle Valley  
**J.W. Lydon, W.D. Goodfellow, D.C. Grégoire**
- 10h00 Formation of massive sulphide deposits in Middle Valley  
**J.M. Franklin and the Leg 139 scientific party.**
- 10h30 **COFFEE BREAK**
- 11h00 Massive sulphides, alteration, and metalliferous sediments at seafloor hydrothermal vents: co-operative international research on seafloor minerals  
**R. Embley, M.D. Hannington, R. Koski, I.R. Jonasson, J.M. Franklin**
- 11h30 Diverse settings for gold-rich massive sulphides on the seafloor  
**M.D. Hannington**
- 12h00 **END OF COLLOQUIUM**



# TALKS

## THE EXPLORATION SCIENCE AND TECHNOLOGY INITIATIVE (EXTECH), SNOW LAKE AND RUSTY LAKE AREAS, MANITOBA

W.B. Coker<sup>1</sup>

The aim of the GSC's initiative in Exploration Science and Technology (EXTECH) is to improve concepts and technologies applicable to exploration for volcanogenic massive base metal sulphide deposits. This will be accomplished through the formulation of integrated regional and deposit-scale models, and the development of geophysical and geochemical methodologies and equipment. The Snow Lake mining camp and the Rusty Lake (Ruttan Mine) area were selected for the first EXTECH program.

The success this integrated project has experienced so far results from the development of a close and cooperative working relationship among the various members of the EXTECH working group as well as with our provincial colleagues and the exploration industry (i.e. Hudson Bay Mining and Smelting, Falconbridge and Minnova).

The end product of this program will be a unified volume in which the base metal environments of the Snow Lake and Rusty Lake regions will be characterized through the geology of the deposits, their relationship to the regional stratigraphy, the mineralogical and chemical compositions and physical properties of the ores, host rocks and alteration, the surficial geochemical dispersion patterns and geophysical signatures.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

## ENVIRONMENT OF MASSIVE SULPHIDE DEPOSITION, SNOW LAKE, MANITOBA

A.G. Galley<sup>1</sup>, A.H. Bailes<sup>2</sup>

Seven past and presently producing base metal massive sulphide deposits occur within two of the five recognized volcanic cycles within the Early Proterozoic Amisk Group at Snow Lake. Three deposits, all copper-rich, occur within a felsic extrusive complex within a thick sequence of first cycle arc tholeiite basalt and basaltic andesite. The remaining deposits, all zinc-rich, occur within felsic sequences at the top of third volcanic cycle; extrusive and intrusive rocks of cycle three display a distinctive fractionated chemistry with elevated concentrations of HFS and light REE elements relative to the other four volcanic cycles.

The synvolcanic Sneath Lake pluton, composed of a series of tonalite stocks, was emplaced during the first volcanic cycle and is considered to have played an important role in generating the copper-rich base metal mineralization in this cycle. Internal complexity and degree of alteration is greatest in the pluton in the vicinity of cycle one base metal deposits; this is consistent with this part of pluton being a centre for magmatic and hydrothermal activity.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

<sup>2</sup> Manitoba Energy and Mines, Winnipeg

## GEOLOGY AND GEOCHEMISTRY OF THE PROTEROZOIC RUTTAN CU-ZN DEPOSIT AND ENVIRONMENT

D.E. Ames<sup>1</sup>

The 52 million tonne Ruttan Cu-Zn VMS deposit occurs within a rhyolite at the top of a differentiated suite of arc tholeiitic volcanic rocks. The deposit lies at a major contact between a thick footwall sequence of basalt and minor andesite, and volcanogenic mafic wacke and breccia in the hangingwall. The extension of the ore horizon was delineated for a strike length of 3100 m, northeast of the deposit and is defined by a discontinuous unit of sulphidic rhyolite tuff. Defining this vital horizon greatly increases the exploration potential of the area.

Protoliths are commonly masked by effects of hydrothermal alteration typified by silicification, Fe-Mg metasomatism and microcline alteration metamorphosed to middle amphibolite grade. Microcline alteration is auriferous and unique to the Ruttan deposit compared to known base metal deposits in Canada although microcline alteration is common in footwall rocks of massive sulphide deposits in the Early Proterozoic Bergslagen district of Sweden.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

## SEDIMENTOLOGICAL AND GEOCHEMICAL EFFECTS OF LIMING SULPHIDE TAILINGS ON LACUSTRINE SYSTEMS, RUTTAN MINE, MANITOBA

W.W. Shilts<sup>1</sup>, W.B. Coker<sup>2</sup>, G.E.M. Hall<sup>2</sup>, J.D. Adshead<sup>3</sup>

Sulphide-rich tailings from Ruttan Mine have formed a substantial delta in Ruttan Lake, causing its water to have a pH of 2.5 and a load of dissolved zinc exceeding 17 ppm. To prevent contamination of nearby Churchill River, a lime solution is injected into the outflow, radically raising the pH and forming a thick precipitate in Brehaut Lake into which Ruttan empties. The precipitate consists of cyclically banded carbonate, sulphate, and several varieties of oxyhydroxide minerals. The zinc content of the precipitate exceeds 2 percent, but the highly alkaline water at the proximal end of Brehaut Lake has less than 3 ppb dissolved zinc. The liming process apparently effectively limits the dispersion of zinc through the drainage system, water and sediment concentrations in the distal end of Brehaut Lake being similar to those in nearby Alto Lake, which is in a different drainage basin and has restricted access. Studies are underway to assess the chemical status of water and sediment samples from Rusty Lake and Churchill River which are directly downstream from Brehaut Lake. Water samples were also collected from ponded drainage beside the Ruttan Lake Road, 20 km east and west of the mine. A dense cover of manganese nodules covers the bottom of Churchill River where the Ruttan/Brehaut/Rusty Lakes drainage enters via Vermillion River. Significant questions that we hope to answer are: (1) what will happen to the Zn-rich carbonate precipitate if liming is discontinued and Brehaut Lake is flooded with 2.5 pH water; (2) what is the cause

\*Speaker is underlined

of the Mn-nodules in the Churchill River and are they in any way related to or affected by the Ruttan outflow; and (3) what is the geochemical effect on regional drainage of constructing the 30 km-long access road using sulphide-bearing mine waste which already shows signs of significant weathering alteration?

<sup>1</sup> Terrain Sciences Division, GSC, Ottawa

<sup>2</sup> Mineral Resources Division, GSC, Ottawa

<sup>3</sup> Sedimentary Processes Research, Manotick

# **TILL COMPOSITION ASSOCIATED WITH VOLCANOGENIC MASSIVE SULPHIDE DEPOSITS, SNOW LAKE AND RUSTY LAKE AREAS, MANITOBA: GEOCHEMISTRY, MINERALOGY, AND REGIONAL TRENDS**

C.A. Kaszycki<sup>1</sup>, G. Gobert<sup>2</sup>, E. Nielsen<sup>3</sup>

A primary objective of the till geochemistry program is to develop new analytical approaches using surficial sediments to identify volcanogenic massive sulphide deposits and associated alteration zones. Till sampling has been carried out at both regional and detailed scales and several samples from various soil horizons (C, B and humus) were collected at each site. Analysis of the geochemistry and mineralogy of several till fractions is in progress. Preliminary interpretation of geochemical data for the <2µm size fraction indicates that B-horizon and C-horizon samples produce similar geochemical trends, related primarily to glacial dispersal. B-horizon samples tend to be depleted in most trace elements relative to C-horizon material, resulting in lower background to anomaly ratios and more poorly defined geochemical trends. The concentration of trace metals in organic samples is lower than that observed in subjacent samples and meaningful trends have not been identified. Sequential extraction techniques have been used to identify the nature of anomalies observed in B-horizon and organic samples. At present, heavy mineral assemblages have only been identified within a selected number of samples. Preliminary data indicate that the distribution of alteration minerals may serve as a guide to identification of volcanogenic massive sulphide deposits on a regional scale.

<sup>1</sup> Consultant, Thompson

<sup>2</sup> Consultant, Winnipeg

<sup>3</sup> Manitoba Energy and Mines, Winnipeg

# **GAMMA RAY, MAGNETOMETER, VLF-EM SURVEYS IN THE SNOW LAKE AND RUSTY LAKE AREAS, MANITOBA**

R.B.K. Shives<sup>1</sup>

Combined airborne gamma ray spectrometric - Magnetometer - VLF-EM surveys flown over the Snow Lake and Rusty Lake areas, Manitoba, were released April 1991, as GSC Open File 2300.

Follow-up ground spectrometry and sampling were conducted in July 1991, to relate the airborne patterns to known VMS deposits, regional and detailed surficial, and bedrock geological mapping.

Initial field results (lithogeochemistry in progress):

1. Direct association of radioelement patterns with mineralisation at Chisel Lake is not obvious. Potassic (microcline) alteration along the Ruttan mine horizon east of the deposit is apparent on the airborne survey and can be quantitatively mapped using ground spectrometry.

2. Phases of the Sneath Lake subvolcanic tonalitic intrusion, are radiometrically distinct. Extrusive equivalents of these phases may show similar variation, (some rhyolites and dacites are radiometrically distinct) thus assisting detailed mapping within the Chisel Basin.
3. Many contrasts between existing regional geological mapping and airborne geophysical patterns offer assistance to future mapping, especially in gneissic/plutonic terranes.
4. Beach sand deposits and Lake Agassiz clays in many areas have unique, well defined signatures.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

# **INTEGRATING GEOLOGICAL DATA IN A GEOGRAPHICAL INFORMATION SYSTEM ENVIRONMENT FOR MINERAL RESOURCE POTENTIAL MAPPING IN SNOW LAKE, MANITOBA**

R.K.T. Reddy<sup>1</sup>, G.F. Bonham-Carter<sup>1</sup>, D.F. Wright<sup>1</sup>

A digital spatial database was established in a GIS environment (SPANS) for the File Lake map area in the Snow Lake area, Manitoba. These data included bedrock geology, lake sediment geochemistry, airborne magnetics, airborne gravity, Landsat TM, and mineral deposits.

These data were incorporated into GIS-based predictive models evaluating volcanogenic massive sulphide (VMS) resource potential. These models can be classified as data driven and knowledge driven. The data driven models - Bayesian Weights of Evidence, Decision Tree and Weighted Logistic Regression - require the presence of mineral deposits in the study area but provide an objective evaluation. The knowledge driven model uses an inference net for a VMS deposit model to link it with various types of mapped evidence to produce a hypothesis "favourable for VMS mineralization". The rules for combining evidence are similar to PROSPECTOR, including fuzzy logic and Bayesian updating. All models produce as a final output a map showing variation in VMS potential.

Future work involves incorporating new data collected through the EXTECH program including till geochemistry, lake sediment, geochemistry, airborne radiometrics, airborne VLF and Digital elevation models to enhance existing models.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

# **PALEOZOIC THROUGH TERTIARY GEOLOGICAL FRAMEWORK FOR MINERAL DEPOSITION IN THE "GOLDEN TRIANGLE", ISKUT AND STIKINE RIVERS AREA**

R.G. Anderson<sup>1</sup>, M.L. Bevier<sup>2</sup>, M.J. Gunning<sup>3</sup>,  
B.M. McClelland<sup>4</sup>, G. Nadaradju<sup>5</sup>, P.L. Smith<sup>5</sup>

At least three important mineralizing events within the "Golden Triangle" (i.e., the Premier, Sulphurets, Eskay Creek, and Bronson Creek (Snip, Stonehouse) camps), are an integral part of the Paleozoic through Tertiary evolution of the northwestern Stikinian and northeastern Coast belt hosts.

Four Paleozoic assemblages form the basement for Stikinia: undated quartzite and marble of possible Yukon-Tanana terrane affiliation; Lower Devonian limestone, chert, and intermediate to felsic composition tuff; middle Carboniferous limestone and pillowed lava; and Permian limestone (and volcanic rocks?).



Mesozoic and Tertiary development comprises at least: 4 magmatic episodes; formation of 3 sedimentary basins, and at least 2 deformational periods separated by an important unconformity. Concordant biochronology and U-Pb and K-Ar geochronometry suggest magmatism occurred during Late Triassic (ca. 228-220 Ma), Early Jurassic (ca. 205-187 Ma), Middle Jurassic (ca. 177-172 Ma), and Paleogene (ca. 55-51 Ma). Mesothermal or epithermal base- and precious metal veins at Premier, Sulphurets, Kerr, Inel, Stonehouse and Snip are cospatial with Early Jurassic alkaline intrusions; Eskay Creek deposit is related to Middle Jurassic back-arc basin formation.

<sup>1</sup> Cordilleran Division, GSC, Vancouver

<sup>2</sup> Continental Geoscience Division, GSC, Ottawa

<sup>3</sup> University of Western Ontario, London

<sup>4</sup> University of California, Santa Barbara

<sup>5</sup> University of British Columbia, Vancouver

### EARLY JURASSIC METALLOGENY OF THE CANADIAN CORDILLERA

D.J. Alldrick<sup>1</sup>

The Early Jurassic epoch is preserved as island-arc complex lithologies throughout the Canadian Cordillera. Associated ore deposits represent the entire spectrum of arc-related deposit types. These districts have been the most aggressively explored region in Canada for the past five years, and the geological setting and mineral deposits continue to be the focus of coordinated multi-agency research, including Geological Survey Branch studies in the Stewart, Toodogone, Hedley, and Rossland areas.

The Early Jurassic rocks formed as two parallel island arcs separated by a backarc trough, with ore deposits concentrated in the two volcanic arcs. Rocks of this epoch are richly mineralized, with an abundance of porphyry, skarn, transitional (mesothermal), epithermal, exhalative and fumarolic deposit types. A variety of deposits, or several occurrences of a single deposit type, may be present within one volcanic centre. Examination of many of these deposits in several mining camps has led to improved deposit models for application to ongoing exploration programs focussed on this prolific metallogenic epoch.

<sup>1</sup> British Columbia Geological Survey Branch, Victoria

### LOWER JURASSIC SULPHURETS PORPHYRY CU-AU SYSTEM, NORTHWEST BRITISH COLUMBIA

R.V. Kirkham<sup>1</sup>, S.B. Ballantyne<sup>1</sup>, D.C. Harris<sup>1</sup>, J.R. Henderson<sup>2</sup>, M.N. Henderson<sup>1</sup>, T.O. Wright<sup>3</sup>

Pyritic gossans in the Sulphurets region are part of a large, deformed and metamorphosed Lower Jurassic porphyry copper-gold system. The system was emplaced in deformed Upper Triassic Stuhini Group sedimentary rocks and the basal part of the Lower Jurassic Hazelton Group volcanic sequence and is associated with intrusions coeval with Hazelton Group volcanism.

The area is complexly deformed with pre-Hazelton Group north-trending upright folds in Stuhini Group rocks and southeast-vergent overturned folds and thrusts and steep north-south faults that postdate all stratigraphic units. Deformation was accompanied by greenschist to subgreenschist facies metamorphism obscuring hydrothermal and mineral distribution patterns.

High-grade gold- and silver-bearing vein systems and bulk tonnage Cu-Au, Cu-Au(-Mo) and Au(-Mo) zones have been the main exploration targets. The bulk tonnage zones are thought to be part of a large, complex porphyry system(s), whereas the precious metal veins are thought to be both part of the porphyry system and related to younger syntectonic processes. Lack of good stratigraphic control and a complex post-mineral fault history, make exploration difficult.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

<sup>2</sup> Continental Geoscience Division, GSC, Ottawa

<sup>3</sup> U.S. National Science Foundation

### AN INTEGRATED APPROACH AND MODEL FOR THE DISCOVERY OF BLIND CU-AU PORPHYRY SYSTEMS IN THE QUESNEL TROUGH, NORTHERN BRITISH COLUMBIA

S.B. Ballantyne<sup>1</sup>, D.C. Harris<sup>1</sup>, R.B.K. Shives<sup>1</sup>, K.L. Ford<sup>1</sup>, P.B. Holman<sup>1</sup>, A. Plouffe<sup>2</sup>, A.S. Judge<sup>2</sup>, J.A. Pilon<sup>2</sup>

Weathering profiles developed above Cu-Au porphyry deposits "liberate" certain ore and alteration minerals. Leaching and redistribution of elements create "new" supergene minerals and native metals. If the weathered rock column is removed by erosion and/or glaciation these stable minerals and metals can be widely dispersed. There are direct means of identifying patterns in surficial material which now masks "buried" deposits, e.g. geochemical survey methods, geophysical techniques and Quaternary geology.

A conceptual model has been developed and is being tested for "blind" porphyry systems in British Columbia. Airborne and ground radiometric mapping of K, U and Th will detect quantitatively anomalous patterns in overburden and outcrop. Hydrogeochemical sampling for Au, Cu and S and geochemical sampling of dispersion trains using gold grains and heavy mineral concentrate identification and analysis can outline the presence of mineralization. Detailed Ground Penetrating Radar surveys within the restricted gold heavy mineral anomaly may yield depth to bedrock and third dimension Quaternary stratigraphy to further locate prospective target areas for "blind" drilling.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

<sup>2</sup> Terrain Sciences Division, GSC, Ottawa

### PORPHYRY DEPOSITS OF THE CORDILLERA – EXPLORATION AND RESEARCH PROBLEMS

J.E.H. Thompson<sup>1</sup>, K.P.E. Dunne<sup>1</sup>, C.I. Godwin<sup>1</sup>, J.R. Lang<sup>1</sup>, A.J. Macdonald<sup>1</sup>, C.R. Stanley<sup>1</sup>

Empirical features of porphyry deposits have been described and utilized in exploration since the early 1900s. Although genetic models for porphyry systems are also widely accepted, significant questions remain. The most important are the source of metals and the characteristics of mineralized versus barren systems. The metal budgets (Cu, Mo, Au, Ag) of porphyry deposits correlate generally with tectonic environment and magma type. However, deposits of anomalous composition occur in most provinces, suggesting that other factors influence metal budgets. These may relate to the composition of the magma source region, mantle/crust metasomatism, ascent history, crust and fluid interaction, crystallization/volatile saturation timing, emplacement dynamics, and fluid interaction processes. The Cordillera of western Canada contains most known types of porphyry deposit and, therefore,

represents a natural laboratory for attempting to resolve these questions and refine exploration models. Also, the Cordillera contains the best known examples of deposits related to alkaline magmatism. Research on these deposits will provide constraints on the generation of gold-rich porphyry systems of both alkaline and calc-alkaline affinity.

<sup>1</sup> Mineral Deposit Research Unit, University of British Columbia, Vancouver

## **MINERAL RESOURCES – A THREAT TO SUSTAINABLE DEVELOPMENT?**

J.E. Tilton<sup>1</sup>

Public concern over the availability of mineral resources, though dormant since the mid-1970s, goes back many years and tends to erupt periodically. The growing interest in sustainable economic development raises the prospects for a new era of concern, as the long term sustainability of economic growth, based on the exploitation of nonrenewable resources, is called into question.

Over the last several decades we have learned much from the research on resource availability. Our ability to define appropriate economic measures of resource scarcity and to measure historical trends has improved. Our theories of resource exhaustion are no longer predicting market behaviour at odds with the historical evidence.

Despite this progress, there is still no definite answer to the question: will resource scarcity someday undermine economic development and the high living standards now found in the industrialized world? Though a definite answer to this question is probably unobtainable, a better understanding of the incidence and nature of subeconomic mineral deposits could provide valuable insights into the future threat of resource exhaustion.

<sup>1</sup> Colorado School of Mines, Boulder

## **EVOLUTION OF MINERAL AND ENERGY RESOURCE ASSESSMENTS AT THE GEOLOGICAL SURVEY OF CANADA – WHAT WE ARE LEARNING**

C.W. Jefferson<sup>1</sup>

The Mineral and Energy Resource Assessment (MERA) process is one of many required for new national parks in the Yukon, NWT and offshore. Resource assessments are also needed for international boundary concerns (this started our seafloor minerals program) and for our nuclear energy policy. The GSC provides technical reports to decision-makers and publishes non-sensitive data.

Prior to 1987 MERAs for new northern parks were mainly based on archived data (Phase I). Some Phase I assessments funded by the GSC (East Arm of Great Slave Lake and Banks-Victoria Islands) generated limited new field data. Now, phase II MERAs involve larger field surveys jointly funded by DIAND, EMR and the Canadian Parks Service. We are learning that (1) public consultation is vital, (2) MERA ratings are difficult to evaluate vis à vis qualitative attributes valued for parks, (3) as predicted, assessments are changing because of newly recognized deposit types (e.g. sedimentary exhalative Ni-Zn-PGE), new exploration targets

(e.g. a known stratigraphic unit with newly discovered showings), and the new MERA surveys (e.g. newly mapped supracrustal rocks and geochemical anomalies).

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

## **CONCEPTUAL MODELS AS A PART OF RESOURCE EVALUATION OF NUCLEAR ENERGY MINERALS AT THE GEOLOGICAL SURVEY OF CANADA**

V.R. Ruzicka<sup>1</sup>

Knowledge of nuclear energy mineral resources is an important component in formulation of Canadian nuclear energy policy, as Canada is the world leading producer and exporter of uranium and an important member of international nuclear energy organizations. Uranium resource evaluation consists of appraisals of identified mineable resources in metallogenic domains and of estimation of their potential.

Conceptual genetic models, which are of a regional and of a deposit scale, are demonstrated in the context of the appraisal of deposits associated with the sub-Athabasca unconformity. The deposits are spatially related to Archean high-heat uraniferous granitoid domes, which are flanked by Aphebian metasedimentary suites including layers of euxinic rocks. The metamorphosed basement complexes are unconformably overlain by unmetamorphosed Helikian clastic rocks. The structurally controlled mineralization took place at stationary redox fronts.

The resources are quantified by computer-assisted methods, by extrapolation of identified geological attributes, by crustal abundance methods, by a modified MIMIC method and by subjective probability estimations.

<sup>1</sup> Mineral Resources Division, GSC Ottawa

## **COMPLETING CANADA'S NATIONAL PARKS SYSTEM: IMPLICATIONS FOR THE MINING INDUSTRY**

P.B. Hale<sup>1</sup>, W.R. Wagner<sup>1</sup>

The amount of land that is being incorporated into parks and other protected areas is rapidly increasing. These restrictions preclude, delay or inhibit mineral activities. Energy, Mines and Resources, Canada (EMR), together with the Mineral Industry Land Use Committee, is using the Integrated Resource Management Information System (IRMIS) to study the impact of land access restrictions on mineral development. The objective is to seek ways to minimize the impact on the competitiveness of the Canadian mining industry.

IRMIS is a desktop mapping system developed by the Mineral Policy Sector (MPS), EMR, in partnership with Earth & Ocean Research Limited. IRMIS enables us quickly and effectively to analyze spatial information and to manage conflicts associated with resource development. It can therefore, contribute to the competitiveness of Canada's resource sector and enhance its environmentally-sound contribution to the economy.

Other uses of IRMIS within MPS, such as those related to federal-provincial mineral development agreements, display of the the National Mineral Inventory, and coastal zone management, will be described.

<sup>1</sup> Mineral Policy, EMR, Ottawa

## NORTHWEST TERRITORIES COMPUTERIZED MINERAL SHOWINGS DATABASE AND MINERAL RESOURCES MAP PROJECT - PROGRESS REPORT<sup>1</sup>

H. Wolf<sup>2</sup>, R.D. Branson<sup>3</sup>, L. Covello<sup>4</sup>, D.W. Wind<sup>5</sup>,  
C.W. Jefferson<sup>6</sup>, D. Atkinson<sup>7</sup>, R.M. Laramée<sup>6</sup>, C. Ellis<sup>7</sup>

This collaborative project was begun in August 1991 to remedy the lack of an effective computerized mineral showings database (CMSD) and comprehensive mineral resources map (MRM) for the NWT. We are reviewing minerals database systems that are in use or being developed by industry, academia and government departments. We plan to develop or adapt a user-friendly CMSD which will be manipulated using personal microcomputers and integrated with a geographic information system (GIS). Data will be entered jointly by Canada - NWT Minerals Initiatives geologists and DIAND geologists based in Yellowknife who will use it as a convenient tool for their work and will manage the routine dissemination of non-confidential information from the CMSD to the public. From this database a new MRM of the entire NWT will be developed in a GIS for use in mineral policy and regional planning of scientific programs. Prototype examples of detailed MRMs are now being constructed for the central Slave Structural Province and South Nahanni River area, for use in map production, mineral exploration and resource assessment.

<sup>1</sup> Contribution to the Canada-NWT Mineral Development Agreement 2

<sup>2</sup> Allegra Management Company, Ottawa

<sup>3</sup> A.J. Robinson & Associates Inc., Kanata

<sup>4</sup> Covelle Bryan and Associates Ltd., Yellowknife

<sup>5</sup> D.W. Wind and Associates, Yellowknife

<sup>6</sup> Mineral Resources Division, GSC, Ottawa

<sup>7</sup> Indian and Northern Affairs Canada, Yellowknife

## THE BRITISH COLUMBIA EXPERIENCE IN MINERAL RESOURCE ASSESSMENT

G.P. McLaren<sup>1</sup>

Mineral resource assessments now play an important role in British Columbia's complex land-use debate. Mineral potential maps are standard products of geological mapping projects, however British Columbia's recent initiatives to complete the provincial park system provide a strong focus, supported in legislation, on assessing subsurface resources prior to park creation.

A systematic approach to assessing and communicating mineral potential information was developed during a detailed mineral resource assessment of the Chilko Lake area. This study comprised detailed stream sediment geochemical surveys, geological mapping and extensive prospecting. A mineral potential classification, based on field data satisfying criteria for metallogenic models, communicates mineral potential rankings for land-use planning and for guidance in exploration.

Similar assessments are being undertaken in other candidate parks. Information gained will assist in excluding known mineral values from park status, in early land-use planning and will provide greater assurances in government decision making. Experience demonstrates that resource assessment data must be based on rigorous, geoscientific field work but must be presented in succinct, clear and non-technical terms to have the greatest benefits in land-use planning.

<sup>1</sup> B.C. Ministry of Energy, Mines and Petroleum Resources, Victoria

## QUANTITATIVE MINERAL RESOURCE ASSESSMENT AT THE U.S. GEOLOGICAL SURVEY

D.A. Singer<sup>1</sup>

Because of its ability to respond to diverse issues and to use different methodologies, a three-part quantitative form of assessment has been applied by the U.S. Geological Survey since 1975 to assess approximately  $3.2 \times 10^6$  km<sup>2</sup> at 1:1 000 000;  $0.5 \times 10^6$  km<sup>2</sup> at 1:500 000;  $0.25 \times 10^6$  km<sup>2</sup> at 1:250 000; and  $0.5 \times 10^6$  km<sup>2</sup> at other scales in all or parts of Colombia, Costa Rica, Bolivia, Venezuela, and the United States; altogether representing nearly half the area of the United States. In three-part assessments; (1) areas are delineated according to types of deposits permitted by the geology, (2) deposit characteristics are estimated by means of grade-tonnage models, and (3) the number of undiscovered deposits of each type is estimated.

Three-part assessments are consistent with any type of resource problem, are quantitative and thus useful for analysis, incorporate all available information, explicitly represent uncertainty, can be improved with more information, and are almost independent of economic considerations. Although several deposits have recently been discovered in assessed areas, these assessments have had their greatest effect on land-use decisions in Alaska and wilderness designations.

<sup>1</sup> U.S. Geological Survey, Menlo Park

## INTEGRATED EXPLORATION STRATEGIES PLUS POSITIVE ECONOMIC CRITERIA EQUALS NEW MINE DEVELOPMENT

J.W. Gill<sup>1</sup>, H.R. Stockford<sup>1</sup>

Aur Resources Inc. employs an exploration strategy, which incorporates an integration of geological, geochemical and geophysical criteria, in its efforts to discover new mineable mineral resources. The establishment of threshold economic criteria with respect to both the minimum size and grade of the target deposit factored for proximity to infrastructure, availability of skilled manpower, production history and land availability are an integral part of this strategy and considered critical to a successful overall exploration program.

The Louvicourt copper-zinc-gold deposit, discovered by Aur in 1989, is widely acknowledged to be one of the most important exploration successes in the mining industry in Canada in recent years. This massive, volcanogenic sulphide deposit, owned 55% by Aur and 45% by La Société minière Louvem Inc., was discovered as a result of strategic land acquisition, a sound geological model and careful compilation of past exploration work, followed by systematic deep drilling spaced at intervals selected on the basis of economic criteria (minimum size and grade) and with the knowledge that borehole geophysics (PEM) and lithogeochemical data would enlarge the effective target area.

The Louvicourt deposit contains undiluted geological reserves, at a 2% Cu equivalent cut off grade of 27.9 million tonnes at an average grade of 4.3% Cu, 2.1% Zn, a 27.4 g/tonne Ag and 1.06 g/tonne Au. This deposit is currently being developed for production at a rate of 1 800 000 tonnes per year. In the case of Aur Resources Inc., integrated exploration strategies plus positive economic criteria do equal new mine development.

<sup>1</sup> Aur Resources Inc.

## GLACIAL HISTORY AND DRIFT PROVENANCE, IN NORTHEASTERN ABITIBI, QUEBEC

J.J. Veillette<sup>1</sup>

The now well documented west-southwestward former ice flows in western Abitibi identified both by glacial transport direction and by erosional sequences inscribed on bedrock, are gradually replaced by former ice flows along a northwest-southeast axis in the Matagami area and east of it. If those former ice flows are assumed to be roughly synchronous, the existence of a northeast-southwest ice divide in the Abitibi-Lake Mistassini area during the last glacial maximum, as proposed by some Laurentide ice sheet modellers, best explains the distribution of striations and the distribution, or absence, of Proterozoic indicator clasts from Hudson Bay and Lake Mistassini source areas, recorded to date in central northern Abitibi. The widespread occurrence in northern Abitibi of ice-rafted Proterozoic boulders first brought in from Hudson Bay by the Cochrane readvances and then dispersed by icebergs in Lake Ojibway, precludes the use of surface boulders for long-distance transport studies. Those constraints and new observations may require a close re-examination of results obtained from overburden drilling programs in northeastern Abitibi.

<sup>1</sup> Terrain Sciences Division, GSC, Ottawa

## NEW INSIGHTS INTO THE SUDBURY STRUCTURE FROM REFLECTION SEISMIC PROFILING

B. Milkereit<sup>1</sup>, A.J. Green<sup>1</sup>, B.O. Dressler<sup>2</sup>, G.G. Morrison<sup>3</sup>,  
A.J. Naldrett<sup>4</sup>, P. Snajdr<sup>5</sup> (for the LITHOPROBE working group)

The Sudbury Structure, the site of a possible impact event and associated impact induced igneous activity, is outlined by an elliptical positive magnetic anomaly and is well-known for its nickel-copper deposits. Vibroseis reflection studies were carried out across the Sudbury Structure as part of the Canadian LITHOPROBE project. The main goals of the study were to evaluate the performance of seismic exploration techniques in a complex, mainly intrusive setting and to determine the shape of the Sudbury Structure at depth. Many prominent dipping reflections on the stacked sections can be traced directly to surface and interpretation of the seismic data is constrained by information from boreholes (up to 1.8 km deep) along the transect.

The new seismic data demonstrate that lithological contacts can be mapped beneath the northern half of the structure. These contacts define a relatively simple layered structure. The southern half of the structure is dominated by south-dipping reflections that project into the South Range Shear zone, a ductile deformation zone, indicating significant crustal shortening in a N-S direction. A south-dipping zone of pronounced reflectivity underlies the entire Sudbury Structure to a maximum depth of about 10 km.

<sup>1</sup> Continental Geoscience Division, GSC, Ottawa

<sup>2</sup> Ontario Geological Survey, Toronto

<sup>3</sup> INCO Exploration and Technical Services, Copper Cliff

<sup>4</sup> University of Toronto, Toronto

<sup>5</sup> Falconbridge Ltd., Falconbridge

## \*SEDIMENT-HOSTED BARITE AND SULPHIDE DEPOSITS OF THE QUEBEC APPALACHIANS

S.J. Paradis<sup>1</sup>

Sediment-hosted sulfide and barite deposits occur in Lower to Middle Ordovician clastic and carbonate rocks of foreland and forearc sedimentary basins.

The foreland basin developed at the eastern margin of the Cambro-Ordovician St. Lawrence Platform, comprises allochthonous Lower Ordovician nappes which host stratabound syngenetic and epigenetic Pb-Zn-Cu-Ba deposits. These deposits are hosted by brecciated, massive, locally fossiliferous limestone. The largest deposit, Upton, has reserves in excess of 950,000 tons grading 46.5 % BaSO<sub>4</sub>, 1.9 % Zn, 0.6 % Pb, and 0.15 % Cu. Other significant occurrences include Lord Aylmer, Acton Vale, Wickham, and Durham.

The forearc basin lies southeast of the Green Mountains-Sutton Anticlinorium. It comprises the Middle Ordovician Magog Group which hosts pyritic black shales and volcanoclastites of the Beauceville Formation. The pyritic black shales host gold and massive sulfide deposits. The largest massive sulfide deposit, Champagne, is a sediment-hosted submarine exhalative (SEDEX) deposit which has reserves in excess of 290,000 tons grading 2.7 % Zn, 0.5 % Pb, 0.4 % Cu, 19.7 g/t Ag, and 2.4 g/t Au. Other similar occurrences include Rapides du Diable and Ruisseau Castle.

<sup>1</sup> Québec Geoscience Centre, Sainte-Foy

## INTRA-CRUSTAL CHROMITITES IN THE BAY OF ISLANDS OPHIOLITE: RESTITES FROM INCONGRUENT DISSOLUTION INTO ULTRAMAFIC INTRUSIONS

J.H. Bédard<sup>1</sup>

Appalachian chromitites are divided into three types: 1) Springer's Hill (Lewis Hills, Bay of Islands), 2) North Arm (Bay of Islands), 3) Hall (Thetford). The Springer's Hill type forms massive lenses of high Cr# = [Cr/(Cr+Al)] chromitite, surrounded by dunitic selvages, and occurs deep within intra-mantle harzburgite. This type may have formed through sedimentation of chromite within sub-vertical basalt-filled channels. The North Arm type occurs below and within the lower ultramafic crust as schlieren or layers spatially associated with pyroxenitic (high Cr#) or gabbroic (low Cr#) rocks. The chromite forms by incongruent dissolution of feldspar or pyroxene into late intrusions. The pseudo-stratigraphy of the chromitite (high Cr# below, low Cr# above) mimics that of economic chromitites from the Philippines and Cuba, suggesting a similar origin. The Hall type occurs in the core of a discordant, intra-crustal dunite pipe. The chromitite replaces, veins and forms a breccia-fill to dunitic clasts. It is associated with mica and platinoid minerals and may represent a higher-temperature equivalent of the hydrothermal metasomatic Bushveld hortonolite

<sup>1</sup> Québec Geoscience Centre, Sainte-Foy



## STRUCTURAL, THERMAL AND HYDROLOGICAL REGIME OF THE MIDDLE VALLEY SEDIMENTED RIFT

E.E. Davis<sup>1</sup> and the Leg 139 Scientific Party

Leg 139 of the Ocean Drilling Program occupied four sites in Middle Valley of the northern Juan de Fuca Ridge, with the overall objective of elucidating the processes and products of hydrothermal circulation at a sedimented spreading centre. Four sites were drilled during this "reconnaissance" program to characterize four distinct elements of the hydrothermal system on a regional scale: an area of possible recharge, a hydrothermal "reservoir", a currently active discharge zone, and a large polymetallic sulfide deposit. In addition to coring, operations during the leg included the successful deployment of a variety of unusual downhole instruments and a particularly complete suite of detailed laboratory analyses of solid and fluid samples. Two holes were instrumented to allow formation conditions at depth to be observed for a period of up to 2 years following drilling. Preliminary analyses highlight an array of localized and regional processes which transport heat and mass in this dynamic setting.

<sup>1</sup> Pacific Geoscience Centre, Sidney, B.C.

## FLUID-SEDIMENT INTERACTIONS ASSOCIATED WITH HIGH TEMPERATURE FLUID FLOW, MIDDLE VALLEY

W.D. Goodfellow<sup>1</sup> and the Leg 139 Scientific Party

Four distinct hydrothermal alteration assemblages that are zoned from the high-temperature core of a fluid discharge conduit to the margins of the vent field have been recognized at active venting Site 858 in Middle Valley. The area of alteration has been intersected in five drill holes and over 30 shallow cores, and is at least 400 m wide. Zone 1 is dominated by chlorite-albite-quartz-pyrite and occupies the inner core of a 258 m-brecciated and fractured fluid upflow zone. Zone 2 consists of a quartz-zeolite-sulfide assemblage and occurs vertically above Zone 1. Zone 3 is composed of anhydrite-pyrite-clay whereas Zone 4 consists of carbonate-pyrite-smectite. In Zones 1 and 2, the sediment is indurated, fractured, veined and locally brecciated. Zones 3 and 4 are developed in moderately to weakly indurated sediment cut by rare veins. The hydrothermal minerals have altered biogenic and detrital minerals, have precipitated in open space, have displaced sediment and have formed concretions. They also occur in veins and fractures cutting altered sediment. Mineralogical changes are accompanied by major changes in the Mg, Ca, Fe, Si, Na, CO<sub>2</sub> and trace metal composition of the sediment. The spatial distribution of alteration minerals is controlled by reaction of sediment with upward flowing high-temperature (280°C) fluid in the core of the conduit, and the lateral migration and mixing of this fluid with pore fluids and downward circulating seawater below a hydrothermal carbonate cap. This model of fluid flow and reaction is supported by hydrothermal textures, mineral assemblages, oxygen isotope fractionation temperatures, C and S isotope compositions, initial <sup>87</sup>Sr/<sup>86</sup>Sr ratios in hydrothermal minerals, and wide dispersion halos for elements concentrated in hydrothermal fluids.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

## CHEMICAL COMPOSITION OF VENT AND PORE FLUIDS IN AN ACTIVE HYDROTHERMAL DISCHARGE ZONE, MIDDLE VALLEY

J.W. Lydon<sup>1</sup>, W.D. Goodfellow<sup>1</sup>, D.C. Grégoire<sup>1</sup>

Eleven vents sampled by ALVIN over the 600 m x 400 m AAV vent field show consistent discharge temperatures of 265°C±5 and Mg-free end-member compositions of: (in mmol) Ca 81, Na 430, K 18, B 1.75, Cl 600; (in %mol) Mn 60, Ba 9, Rb 25, Sr 225, Al 20, Ni 5, Co 0.1. A vent near the Bent Hill sulphide mound has different cation ratios and shows a time-dependent compositional variability explainable by dilution by fresh water, possibly thermally-released clay interlayer water. Pore fluid compositions to 10 metres depth show vertical and lateral subsurface dispersal of hydrothermal fluid that progressively change in composition due to the precipitation of calcite, barite and anhydrite, and mixing with downward convecting seawater around active vents. The results indicate that the AAV vent field is fed by a single hydrothermal reservoir located in the sediment pile which is different from the multiple reservoir system feeding the Bent Hill vent. Furthermore, the current vent fluids are cooler and chemically distinct from those that precipitated sulphides during an earlier hydrothermal stage.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

## FORMATION OF MASSIVE SULPHIDE DEPOSITS IN MIDDLE VALLEY

I.M. Franklin<sup>1</sup> and the Leg 139 Scientific Party

Hydrothermal activity at Middle Valley was initiated by magmatic activity, including the intrusion of sills and extrusion of a basaltic andesite dome into and through at least 200 m of turbiditic sediment. Rapid heat transfer from a major magma chamber provided energy to mobilize metals from an igneous basement, forming a hydrothermal system. Simultaneously, this heat loss induced extensive igneous fractionation, forming incompatible element-rich volcanic rocks. Metalliferous hydrothermal fluid was expelled through reactivated faults, forming large massive sulphide deposits at the seafloor.

A major massive sulphide deposit forms a 200 m (dia.) x 35 m (height) mound, that was cored to a depth of 96 m. It contains 2-5% Zn, 0.5-1 % Cu, and very low Pb. Flow of heated, moderate pH, CO<sub>2</sub>-rich fluids through the sulphide mound has converted primary pyrrhotite to pyrite plus magnetite, redistributed base metals, and provided a carbonate infilling.

Vigorous hydrothermal activity is now focussed primarily over the buried basaltic andesite dome. These fluids are forming at about 275°C (their present maximum temperature), through reaction with sediments. They are metal-poor, CO<sub>2</sub>-rich and represent the waning stage of the Middle Valley hydrothermal episode. During the collapse of the system, diabase sills became pyritized, epidotized and chloritized.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

**MASSIVE SULPHIDES, ALTERATION,  
AND METALLIFEROUS SEDIMENTS AT  
SEAFLOOR HYDROTHERMAL VENTS:  
CO-OPERATIVE INTERNATIONAL RESEARCH  
ON SEAFLOOR MINERALS**

R.W. Embley<sup>1</sup>, M.D. Hannington<sup>2</sup>, R. Koski<sup>3</sup>,  
I.R. Jonasson<sup>2</sup>, J.M. Franklin<sup>2</sup>

Joint research with universities and government agencies outside Canada is an important part of the Seafloor Minerals Program. Although ridge-crest studies in Canadian waters (Middle Valley, Endeavour Ridge, Explorer Ridge) have been the focus of the Seafloor Program, co-operative research is being conducted elsewhere in the Pacific and Atlantic. These studies include extensive mapping and sampling in the caldera of Axial Seamount and along volcanically active portions of the Central and Southern Juan de Fuca Ridge, investigations of sediment-hosted deposits in the Escanaba Trough, an examination of the petrochemistry of altered lavas associated with the Galapagos Rift massive sulfides, and detailed studies of sulfide deposits and associated metalliferous sediments in the TAG Hydrothermal Field on the Mid-Atlantic Ridge. Work in the N.E. Pacific is being carried out as part of major research efforts by the NOAA Vents Program and the USGS. Preliminary studies of sulfide deposits in the Lau Basin back-arc also have been conducted in co-operation with French and German researchers, and further work in the S.W. Pacific is planned. The characterization of sulfide deposits in these diverse settings has provided a broad-based data set for comparisons with ancient massive sulfides on land.

<sup>1</sup> NOAA/MRRD, Hatfield Marine Science Center, Newport, Oregon

<sup>2</sup> Mineral Resources Division, GSC, Ottawa

<sup>3</sup> United States Geological Survey, Menlo Park, Ca.

**DIVERSE SETTINGS FOR GOLD-RICH MASSIVE  
SULFIDES ON THE SEAFLOOR**

M.D. Hannington<sup>1</sup>

Gold-rich sulfide deposits occur on both fast- and slow-spreading mid-ocean ridges, on axial volcanoes and off-axis seamounts, in sedimented rifts adjacent to continental margins, in subduction-related back-arc rifts, and at depths from 3700 m to 1500 m. Although examples of gold-rich sulfides occur in each of these settings, some geologic environments are more productive than others. The distribution of gold in seafloor sulfides is well-constrained, based on chemical analyses of over 500 samples from more than 20 different deposits. Average gold contents of deposits on the mid-ocean ridges range from <0.2 to 2.6 ppm Au, with concentrations of 5 to 15 ppm Au occurring locally in low-temperature ( $\leq 250^{\circ}\text{C}$ ) zinc-rich assemblages (Axial Seamount, TAG Hydrothermal Field). Sulfides from sedimented rifts typically contain <0.2 ppm Au (Middle Valley, Guaymas Basin), although Cu-rich sulfides from one deposit contain up to 10 ppm Au (Escanaba Trough). Sulfides associated with back-arc rifting have average gold contents from 0.8 to 4.8 ppm Au (Mariana Trough, Lau Basin, Okinawa Trough). The evolution of back-arc rifts and the petrogenesis of associated volcanics may influence the composition of hydrothermal fluids and their ability to carry gold.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

## POSTERS

### REVISED STRATIGRAPHY AND MINERAL POTENTIAL IN THE EASTERN OGILVIE MOUNTAINS, YUKON

G. Abbott<sup>1</sup>, C. Roots<sup>2</sup>

Recent 1:50 000 scale bedrock mapping 100 km east of Dawson, near the 520 000 tonne Hart River exhalative Cu-Zn-Ag-Au massive sulphide deposit, has defined four sedimentary successions, separated by angular unconformities, and ranging in age from Middle Proterozoic to Middle Paleozoic. The stratigraphy resembles that previously recognized in the western Ogilvie Mountains. The Wernecke Supergroup (pre 1.2 Ga) includes shale and siltstone (Quartet Group), and dolostone (Gillespie Lake Group). The Hart River deposit is in the Gillespie Lake Group, in a shale interval directly beneath pillowed flows. The Fifteenmile Group (1.2-0.8 Ga) has a clastic-dominated lower division and a carbonate upper division. The Windermere Supergroup contains glacial diamictite, siltstone and volcanic rocks equivalent to the Mount Harper succession in the western Ogilvie Mountains. Lower Paleozoic dolostone (Mackenzie Platform) and overlying graptolitic shale and chert are overthrust by lower and middle Paleozoic shale, chert, limestone and volcanics (Selwyn Basin) with potential for bedded barite and Zn-Pb deposits.

<sup>1</sup> Exploration and Geological Services Division, Indian and Northern Affairs Canada, Whitehorse

<sup>2</sup> Cordilleran Division, GSC, Vancouver

### AN APPLICATION OF REFLECTION SEISMOLOGY TO MINERAL EXPLORATION IN THE MATAGAMI AREA, ABITIBI BELT, QUEBEC

E. Adam<sup>1</sup>, B. Milkereit<sup>2</sup>, A. Barnes<sup>1</sup>, C. Beaudry<sup>3</sup>, R. Pineault<sup>3</sup>

As part of the LITHOPROBE Abitibi-Grenville transect, a high frequency Vibroseis survey was conducted in the Matagami mining camp located on the southern part of the Matagami anticlinorium, a gently dipping crustal structure. Significant density and seismic impedance contrasts can be expected at the contact between the lower, predominantly felsic, Watson Lake Group and the overlying Wabasseé basalts. The attitude of this contact is important since it accommodates all known economic deposits discovered in the camp. The goal of the LITHOPROBE study is to map the attitude of the contact along an 8 km transect, using the seismic reflection method adapted to the crystalline environment. Interpretation of the data, by correlation with existing borehole information, suggests that this contact has been imaged along the entire transect. In addition, multiple faulting and tilted crustal blocks were observed in the vicinity of the Daniel fault zone.

<sup>1</sup> École Polytechnique, Montreal

<sup>2</sup> Continental Geoscience Division, GSC, Ottawa

<sup>3</sup> Noranda Exploration Ltd., Rouyn Noranda

### EARLY JURASSIC METALLOGENY OF THE CANADIAN CORDILLERA

D.J. Alldrick<sup>1</sup>

The Early Jurassic epoch is preserved as island-arc complex lithologies throughout the Canadian Cordillera. Associated ore deposits represent the entire spectrum of arc-related deposit types. These districts have been the most aggressively explored region in Canada for the past five years, and the geological setting and mineral deposits continue to be the focus of coordinated multi-agency research, including Geological Survey Branch studies in the Stewart, Toodoggone, Hedley, and Rossland areas.

The Early Jurassic rocks formed as two parallel island arcs separated by a backarc trough, with ore deposits concentrated in the two volcanic arcs. Rocks of this epoch are richly mineralized, with an abundance of porphyry, skarn, transitional (mesothermal), epithermal, exhalative and fumarolic deposit types. A variety of deposits, or several occurrences of a single deposit type, may be present within one volcanic centre. Examination of many of these deposits in several mining camps has led to improved deposit models for application to ongoing exploration programs focussed on this prolific metallogenic epoch.

<sup>1</sup> British Columbia Geological Survey Branch, Victoria

### GEOLOGY AND GEOCHEMISTRY OF THE PROTEROZOIC RUTTAN CU-ZN DEPOSIT AND ENVIRONMENT

D.E. Ames<sup>1</sup>

The 52 million tonne Ruttan Cu-Zn VMS deposit occurs within a rhyolite at the top of a differentiated suite of arc tholeiitic volcanic rocks. The deposit lies at a major contact between a thick footwall sequence of basalt and minor andesite, and volcanogenic mafic wacke and breccia in the hangingwall. The extension of the ore horizon was delineated for a strike length of 3100 m, northeast of the deposit and is defined by a discontinuous unit of sulphidic rhyolite tuff. Defining this vital horizon greatly increases the exploration potential of the area.

Protoliths are commonly masked by effects of hydrothermal alteration typified by silicification, Fe-Mg metasomatism and microcline alteration metamorphosed to middle amphibolite grade. Microcline alteration is auriferous and unique to the Ruttan deposit compared to known base metal deposits in Canada although microcline alteration is common in footwall rocks of massive sulphide deposits in the Early Proterozoic Bergslagen district of Sweden.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

**MINERALOGY AND GEOCHEMISTRY OF  
MIDDLE VALLEY HYDROTHERMAL CHIMNEYS,  
NORTHERN JUAN DE FUCA RIDGE:  
RESULTS FROM ALVIN DIVE CRUISE**

D.E. Ames<sup>1</sup>, J.M. Franklin<sup>1</sup>

Hydrothermal spires and mounds sampled with the submersible Alvin form at about 2420 metres depth at two areas. Mineralogical and chemical variations between 13 vent sites include active, anhydrite dominant chimneys, extinct barite chimneys, and minor massive sulphide outcrop.

Bulk compositions of active chimneys (<276°C) in the High Heat Flow area are typified by Dead Dog Mound: 6.63% SiO<sub>2</sub>, 0.56% Fe<sub>2</sub>O<sub>3</sub>, 3.87% MgO, 37.5% CaO, 21.4% S, 165 ppm Ba, 1200 ppm Cu, 48 ppm Pb, 1600 ppm Sr, 335 ppm Zn, 2.8 ppm As, 2.5 ppm Se, 8.8 ppm B and 3.7 ppb Au. Inspired mound contains slightly higher amounts of metal. The bulk composition of the extinct chimney is: 8.02% SiO<sub>2</sub>, 0.24% Fe<sub>2</sub>O<sub>3</sub>, 12.1% S, 4.3% C, 38% Ba, 3300 ppm Sr, 0.08ppm Au, and low metal content. This chimney contains hydrocarbon, barite, silica and no sulphides.

Active chimneys are unzoned, have complex vent structures and contain anhydrite, gypsum and bassanite with a smectite - talc lining with pyrrhotite, pyrite, marcasite, isocubanite, chalcopyrite, sphalerite and galena. Sulphide samples south of Bent Hill have an outer rim of goethite, barite, marcasite, silica and Pb-As-Sb sulphosalts and a porous core of pyrite, marcasite, sphalerite, chalcopyrite, covellite and galena.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

**PALEOZOIC THROUGH TERTIARY GEOLOGICAL  
FRAMEWORK FOR MINERAL DEPOSITS  
IN THE "GOLDEN TRIANGLE", ISKUT AND  
STIKINE RIVERS AREA**

R.G. Anderson<sup>1</sup>, M.L. Bevier<sup>2</sup>, M.J. Gunning<sup>3</sup>,  
B.M. McClelland<sup>4</sup>, G. Nadaradju<sup>5</sup>, P.L. Smith<sup>5</sup>

At least three important mineralizing events within the "Golden Triangle" (i.e., the Premier, Sulphurets, Eskay Creek, and Bronson Creek (Snip, Stonehouse) camps), are an integral part of the Paleozoic through Tertiary evolution of the northwestern Stikinian and northeastern Coast belt hosts.

Four Paleozoic assemblages form the basement for Stikinia: undated quartzite and marble of possible Yukon-Tanana terrane affiliation; Lower Devonian limestone, chert, and intermediate to felsic composition tuff; middle Carboniferous limestone and pillowed lava; and Permian limestone (and volcanic rocks?).

Mesozoic and Tertiary development comprises at least: 4 magmatic episodes; formation of 3 sedimentary basins, and at least 2 deformational periods separated by an important unconformity. Concordant biochronology and U-Pb and K-Ar geochronometry suggest magmatism occurred during Late Triassic (ca. 228-220 Ma), Early Jurassic (ca. 205-187 Ma), Middle Jurassic (ca. 177-172 Ma), and Paleogene (ca. 55-51 Ma). Mesothermal or epithermal base- and

precious metal veins at Premier, Sulphurets, Kerr, Inel, Stonehouse and Snip are cospatial with Early Jurassic alkaline intrusions; Eskay Creek deposit is related to Middle Jurassic back-arc basin formation.

<sup>1</sup> Cordilleran Division, GSC, Vancouver

<sup>2</sup> Continental Geoscience Division, GSC, Ottawa

<sup>3</sup> University of Western Ontario, London

<sup>4</sup> University of California, Santa Barbara

<sup>5</sup> University of British Columbia, Vancouver

**STRATIGRAPHY, SEDIMENTOLOGY AND STRUCTURE  
OF THE HENIK, MONTGOMERY LAKE AND HURWITZ  
GROUPS IN THE BRAY-MONTGOMERY-AMETO  
LAKES AREA, SOUTHERN DISTRICT OF KEEWATIN:  
IMPLICATIONS FOR GOLD EXPLORATION**

L.B. Aspler<sup>1</sup>, T.L. Bursey<sup>2</sup>, A.N. LeCheminant<sup>3</sup>

The Henik Group (Archean) consists of (ascending order): felsic volcanoclastic and siliciclastic rocks (iron formation-bearing); magnetite-chert BIF; a mafic volcanic/gabbro sill-dyke complex; and turbidites. Montgomery Group siliciclastic rocks mantle pre-tilted Henik Group, recording a westward-draining fluvial plain. An angular unconformity separates the Montgomery and Hurwitz groups (Montgomery type area); rocks historically considered "Montgomery Group" (southernmost Padlei belt) constitute basal Hurwitz Group. The Hurwitz Group was deposited in an intracratonic basin unrelated to Trans-Hudson orogen. The Padlei and Kinga formations reflect a terrestrial to marine transition; onlap of increasingly mature rocks signifies basin broadening. Abrupt appearance of immature siliciclastic debris (Ameto Formation) represents drowning of the Kinga shelf concurrent with uplift along a NE-trending arch between Bates and Griffin lakes. The basin narrowed and deepened in an offlap sequence prograding away from the arch (Ameto to Tavani formations). Proterozoic N- and NW-vergent thrusts and NW-trending oblique-slip faults cut Archean structures (Henik Group) and structures of uncertain age (Montgomery Group). All units are potential gold targets; particularly Henik Group mafic rocks and BIF (in quartz veins).

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

<sup>2</sup> Carleton University, Ottawa

<sup>3</sup> Continental Geoscience Division, GSC, Ottawa

**DEPOSITIONAL ENVIRONMENT FOR  
VOLCANIC-HOSTED MASSIVE SULPHIDE DEPOSITS,  
SNOW LAKE, MANITOBA**

A.H. Bailes<sup>1</sup>, A.G. Galley<sup>2</sup>

Early Proterozoic base metal massive sulphide deposits in the Snow Lake area are spatially associated with two large synvolcanic tonalite intrusions, the Sneath Lake pluton accompanying cycle one volcanism and the Richard Lake tonalite accompanying cycle three. The Sneath Lake pluton displays the greatest internal complexity and highest level of alteration in proximity to the base metal deposits in phase one, suggesting an association between centres of magmatic activity, hydrothermal alteration and base metal deposition. The Richard Lake tonalite does not display increased complexity or increased alteration associated with base metal deposits. However, the Richard Lake pluton does have a related and extensively altered synvolcanic dyke complex in the stratigraphic footwall to cycle three base metal deposits.



The recognition of synvolcanic intrusive complexes is considered to be a useful first order exploration tool as it can focus base metal exploration into areas with sustained high regional heat flow that may be important for the formation of volcanic hosted massive sulphide deposits. Recognition of increased levels of alteration or increased complexity in the intrusions themselves could also prove useful in further focusing exploration over magmatic-hydrothermal centres in the synvolcanic intrusions.

<sup>1</sup> Manitoba Energy and Mines, Winnipeg

<sup>2</sup> Mineral Resources Division, GSC, Ottawa

### **PLATINUM- AND GOLD-BEARING ALLUVIUM, FLORENCE CREEK, YUKON WITH EXAMPLES OF IN SITU GOLD PRECIPITATION**

S.B. Ballantyne<sup>1</sup>, D.C. Harris<sup>1</sup>

A suite of heavy mineral concentrates from an alluvial placer from Florence Creek, Yukon, is being investigated using a scanning electron microscope, energy dispersive X-ray spectrometer and an electron microprobe. Some Pt-Fe alloy isoferroplatinum grains are larger than 500 micrometres and contain rare inclusions of Cu-sulphides, PGE-sulphides, native osmium and gangue minerals. Palladium and rhodium enrichment is dominantly associated with bornite and digenite. PGM grains are of primary origin yet the source of mineralization is unknown. Placer gold grains also contain mineral gangue and have varied compositions of gold and silver. Another source of gold is less than 5 micrometres blebs found on the surfaces of zircon, monazite, ilmenite, scheelite, apatite, feldspar and iron oxides. This "new" gold has been chemically precipitated on the smooth crystal faces, on crystal edges and in cavities of irregular textured grains. A local gold hydrogeochemical survey is being conducted to determine if active gold transport and deposition is continuing.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

### **AN INTEGRATED APPROACH AND MODEL FOR THE DISCOVERY OF BLIND CU-AU PORPHYRY SYSTEMS IN THE QUESNEL TROUGH, NORTHERN BRITISH COLUMBIA**

S.B. Ballantyne<sup>1</sup>, D.C. Harris<sup>1</sup>, R.B.K. Shives<sup>1</sup>, K.L. Ford<sup>1</sup>,  
P.B. Holman<sup>1</sup>, A. Plouffe<sup>2</sup>, A.S. Judge<sup>2</sup>, J.A. Pilon<sup>2</sup>

Weathering profiles developed above Cu-Au porphyry deposits "liberate" certain ore and alteration minerals. Leaching and redistribution of elements create "new" supergene minerals and native metals. If the weathered rock column is removed by erosion and/or glaciation these stable minerals and metals can be widely dispersed. There are direct means of identifying patterns in surficial material which now masks "buried" deposits, e.g. geochemical survey methods, geophysical techniques and Quaternary geology.

A conceptual model has been developed and is being tested for "blind" porphyry systems in British Columbia. Airborne and ground radiometric mapping of K, U and Th will detect quantitatively anomalous patterns in overburden and outcrop. Hydrogeochemical sampling for Au, Cu and S and geochemical sampling of dispersion trains using gold grains and heavy mineral concentrate identification and analysis can outline the presence of mineralization. Detailed Ground Penetrating Radar surveys within the restricted gold heavy

mineral anomaly may yield depth to bedrock and third dimension Quaternary stratigraphy to further locate prospective target areas for "blind" drilling.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

<sup>2</sup> Terrain Sciences Division, GSC, Ottawa

### **A DESCRIPTIVE MODEL FOR AG-PB-ZN VEIN DEPOSITS**

G. Beaudoin<sup>1</sup>, D.F. Sangster<sup>2</sup>

Geological features from six classical districts, Kokanee Range, Keno Hill, Coeur d'Alène, Freiberg, Harz, and Pibram demonstrate that silver-lead-zinc veins form a distinct deposit-type. They have characteristic metal ratios, are comprised of galena and sphalerite in a gangue of siderite, quartz or calcite, and enclosed by spatially restricted phyllic alteration. Silver-lead-zinc districts occur in various tectonic settings, hosted by monotonous sequences of clastic rocks intruded by gabbroic to granitic plutons. The veins are late features in the tectonic evolution of an orogen and are commonly near a crustal-scale fault.

Precipitation occurred near 250-300°C from dilute to saline fluids at an approximate depth of 6 km, following district-scale mixing of up to three distinct fluids, and localised boiling. These fluids include a deep-seated hydrothermal fluid, an upper crust-equilibrated fluid of ultimate meteoric origin, and a late stage meteoric-dominated fluid. Sulphur was derived from local country rocks, carbon from organic and/or deep-seated sources and lead mainly from local upper crustal rocks.

<sup>1</sup> Ottawa-Carleton Geoscience Centre, Ottawa

<sup>2</sup> Mineral Resources Division, GSC, Ottawa

### **LATE PROTEROZOIC AUSTRALIAN-NORTH AMERICAN CONNECTION: UPDATE AND SIGNIFICANCE**

R.T. Bell<sup>1</sup>, C.W. Jefferson<sup>1</sup>

Based on stratigraphy and metallogeny we have proposed that mid-Proterozoic to earliest Cambrian strata of Australia (Adelaide Geosyncline) and northwestern Canada (Cordilleran Miogeosyncline) represent deposition and mineralization within the same long-lived intracratonic trough within the megacontinent "Hudsonia". Three successive, widespread igneous events (Mackenzie, Franklin and Antrim) affected both regions. Reasonably precise geochronology and paleomagnetism on the 0.76 Ga Franklin event in both regions permit the hypothesis. The geometry of fit was uncertain because similar stratigraphic and metallogenic comparisons could be made with Central Africa, the Tarim and North China blocks. Recent recognition of Grenville-like rocks in Antarctica and their proposed linkage to North America have modified the geometry and strengthened our proposed fit. During the earliest Cambrian, Australia-Antarctica was separating from North America, being located on the then "eastern" trailing edge of Gondwana. The then "western" side of Gondwana was growing by accretion during the Pan-African event. We suggest that "Pangean" type megacontinents form every 500-600 million years with roughly half of that time being spent in assembly and break-up respectively.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

## REGIONAL GEOLOGICAL SETTING FOR OLYMPIC DAM-TYPE DEPOSITS

R.T. Bell<sup>1</sup>, S.S. Gandhi<sup>1</sup>

Basement in South Australia is made up of belts of Archean and Early Proterozoic rocks brought together to form the Gawler Craton during an orogeny about 2.0 - 1.9 Ga ago. These have been intruded by syn- and post-tectonic granitoids. After 1.9 Ga and during craton stabilization, several suites of bimodal volcanics and associated sediments were emplaced, of which the latest significant phase (Gawler Ranges Volcanics) is a 1.6 Ga suite of dominantly felsic volcanics and A-type granitic intrusions which host the giant Olympic Dam Fe-Cu-U-Au-Ag-REE deposit. In turn, this was overlain unconformably by mid-Proterozoic continental sandstone (Pandurra Formation) which is cut by a major diabase dyke swarm at about 1.3 Ga.

In varying degrees this sequence of events occurs in many other shield areas (e.g. Canadian, central-eastern African, Baltic, Ukrainian and Guiana). Together these events define an important metallogenic period for iron, copper, uranium and gold deposits.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

## APPLICATION OF BOREHOLE GEOPHYSICS TO TIN EXPLORATION IN NOVA SCOTIA

G. Bernius<sup>1</sup>, B.E. Elliott<sup>1</sup>, P.G. Killeen<sup>1</sup>

Borehole geophysical measurements have been made in holes drilled for exploration and for mine development at several locations in southern Nova Scotia. Using the GSC R&D logging system, thirteen parameters were recorded from five runs in each hole. The logs have been correlated with the geological logs and assays to determine which parameters could provide information useful in future exploration and development.

The parameters logged include: magnetic susceptibility, natural gamma ray spectrometry, IP, resistivity, self potential, temperature and T gradient, and spectral gamma-gamma which relates to heavy element content. Examples of logs are presented illustrating their utility and the information which can be extracted relative to the geology of tin.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

## UTEM PROFILING ALONG REFLECTION SEISMIC LINES IN THE SUDBURY STRUCTURE

D. Boerner<sup>1</sup>, R. Kellett<sup>2</sup>, M. Mareschal<sup>2</sup>

A controlled source electromagnetic (called UTEM) technique was used to acquire 15 km of data across the southern edge of the Sudbury Basin and parallel to the high resolution seismic reflection line. The EM data were used to image the distribution of electrical properties of the rocks in the south range of Sudbury Structure to depths of 5 km.

EM techniques are excellent for determining the bulk properties of geological units but are poor in terms of structural resolution and are thus complementary to the seismic methods.

The data acquired are complicated by several strong responses from near surface conductors and the presence of three major power lines crossing the profile line. However, preliminary results indicate that the Onaping formation is more conductive than the Sudbury Igneous Complex. Also, the extent of the south range shear zone is clearly indicated in the interpreted EM data.

<sup>1</sup> Continental Geoscience Division, GSC, Ottawa

<sup>2</sup> École Polytechnique, Montreal

## GEOLOGICAL SETTING OF THE CHAMPAGNE POLYMETALLIC MASSIVE SULPHIDE DEPOSIT, QUEBEC

J. Bossé<sup>1</sup>, S.J. Paradis<sup>2</sup>, M. Gauthier<sup>1</sup>

The Champagne polymetallic sulphide cluster area includes three of the four formations, constituting the Magog Group, the Frontière, Etchemin and Beauceville. The Beauceville Formation black argillites are the Champagne deposit host rocks.

The Magog Group evolution, from the Etchemin red, then green mudslates to the Beauceville black argillites, denotes the growing reduction tendency of the deposition sedimentary environment. The presence of a coarse polygenetic breccia evolving laterally into a fine tuff facies suggests a significant volcanic activity during deposition of the Beauceville lithologies. On the other hand, the first occurrences of hydrothermal activity appears during the Etchemin Formation. In effect, massive sulphide fragments are found incorporated in a volcanoclastite unit. This hydrothermal activity resumes and culminates with the Beauceville lithologies deposition and the Champagne sulphide cluster genesis.

<sup>1</sup> Université Laval, Sainte-Foy

<sup>2</sup> Québec Geoscience Centre, Sainte-Foy

## PRECIOUS METAL GOSSAN DEPOSITS OF THE BATHURST CAMP, NEW BRUNSWICK

D.R. Boyle<sup>1</sup>

Many of the massive sulphide deposits of the Bathurst Camp have associated overlying gossan deposits. Two of these deposits have been mined and the largest (Murray Brook) is presently being exploited. On a mass and volumetrically balanced basis, Au has been enriched in these gossan deposits by a factor of approximately four. The dominant factors controlling enrichment of Au are: 1) a long period of downward ground water movement under a probably humid temperate climate, 2) the finely divided nature of primary gold distribution, making it more susceptible to dissolution than granular forms of the metal, 3) multiphase hosting of primary Au (pyrite, arsenopyrite and galena), 4) a polysulphide deposit showing very weak (sphalerite), moderate (galena, arsenopyrite, chalcopyrite) and very strong (pyrite, quartz) resistance to oxidation, 5) production of very acidic pore solutions rich in ligands capable of complexing gold, and 6) precipitation of amorphous silica and Fe<sub>2</sub>O<sub>3</sub>-Fe(OH)<sub>3</sub> colloids near the oxidation reduction front of the gossan body followed by destabilization of gold-bearing solutions and precipitation of 'colloidal' gold in gossan voids.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

**DIGITAL STORAGE AND ANALYSIS OF  
GEOSCIENTIFIC DATA: AN AID TO NATMAP  
GEOLOGICAL PROJECTS (FLIN FLON-SNOW LAKE  
BELT, SLAVE PROVINCE)**

J. Broome<sup>1</sup>, B. Brodaric<sup>1</sup>, D. Baril<sup>1</sup>, D. Viljoen<sup>1</sup>,  
S.B. Lucas<sup>1</sup>, J.E. King<sup>1</sup>

The National Geoscience Mapping Program (NATMAP) concept involves cooperation of federal, provincial, industry, and university geoscientists to enhance the quality and quantity of geological mapping in Canada. Geological, geophysical, remote sensing, mineral inventory, geochronological, rock property, topographical and other types of data will be used in each project. Digital storage of these data in a central database will facilitate GIS analysis, allow generation of current, high-quality hard copy products, and permit distribution in standard data interchange formats. Construction of geoscience databases is under way for the Shield Margin (Flin Flon-Snow Lake Belt, Saskatchewan and Manitoba) and Slave Province (Northwest Territories) NATMAP projects. The databases will reside on a Sun Sparcstation running a GIS linked to Oracle database management software. Detailed bedrock geological data from 1991 field work in the Shield Margin area have been collected digitally and will be merged with a digitized regional compilation. The sub-Paleozoic geology in the Shield Margin project area will be interpreted using the data analysis capabilities of several GIS platforms.

<sup>1</sup> Continental Geoscience Division, GSC, Ottawa

**GRAVITY AND MAGNETIC INTERPRETATION  
ALONG THE LITHOPROBE TRANSECT ACROSS  
THE SUDBURY STRUCTURE**

J. Broome<sup>1</sup>, R. Hearst<sup>2</sup>, P.H. McGrath<sup>1</sup>, W.A. Morris<sup>2</sup>,  
M.D. Thomas<sup>1</sup>, E.I. Tanczyk<sup>1</sup>, R.J. Beach<sup>3</sup>, D.W. Halliday<sup>3</sup>

Prominent gravity and aeromagnetic anomalies associated with the Sudbury Structure provide an independent means for assessing crustal models based primarily on seismic reflection images along the LITHOPROBE transect. The resolution of these anomalies was improved by making gravity and ground magnetic observations along the transect at intervals of 1 km and 25 m, respectively. A total of 123 gravity measurements and thousands of magnetic measurements were obtained. Gravity modelling, constrained by a seismic model, indicates that a slab of Levack Gneiss dipping southward beneath the Sudbury Structure can account for much of the large positive anomaly which dominates the gravity field in the region. This interpretation contrasts with an earlier one, which is incompatible with the seismic data and links the anomaly to a hidden subhorizontal mafic-ultramafic slab below the Sudbury Structure. Modelling of strong, linear positive magnetic anomalies over the South Range norite and straddling the boundary between the Onaping and Onwatin formations provides constraints for the seismic model.

<sup>1</sup> Continental Geoscience Division, GSC, Ottawa

<sup>2</sup> McMaster University, Hamilton, Ontario

<sup>3</sup> Geophysics Division, GSC, Ottawa

**THE MONTGOMERY LAKE GROUP, SOUTHERN  
DISTRICT OF KEEWATIN: CONTACT  
RELATIONSHIPS, INTERNAL STRATIGRAPHY,  
STRUCTURE AND ECONOMIC GEOLOGY**

T.L. Bursery<sup>1</sup>, L.B. Aspler<sup>2</sup>

The Montgomery Group (age uncertain) forms erosional outliers truncating Archean Henik Group stratigraphy at an angular unconformity. Discontinuous basal polymictic conglomerate and breccia (clast compositions reflect subjacent basement) and medium- to coarse-grained subarkose (with lenses of interbedded subarkose, siltstone and mudstone) suggest a low-relief sub-Montgomery paleotopography (with paleohills mantled by talus) buried by a westward-draining, locally ponded, fluvial system. Montgomery Group-Hurwitz Group contacts have been controversial. In the type area, we infer an angular unconformity: breccia in basal Hurwitz Group (90% Montgomery Group clasts) truncates subjacent Montgomery Group structure; Montgomery Group outliers are truncated by the Hurwitz Group. In southernmost Padlei belt we suggest that rocks previously mapped as "Montgomery Group" (historical gold-uranium targets) constitute the lower part (Maguse Member) of a conformable Hurwitz Group section. At Montgomery Lake, early folds lack an associated cleavage and are NW-trending, concordant with Archean structure. These folds are transected by a NE-trending cleavage (axial planar to local folds) coincident with cleavage in the Hurwitz Group. Basal Montgomery conglomerates locally contain pebbles-cobbles of pyrite-quartz; disseminated pyrite is ubiquitous.

<sup>1</sup> Carleton University, Ottawa

<sup>2</sup> Mineral Resources Division, GSC, Ottawa

**AEROMAGNETIC MAPS - PAST AND PRESENT**

I. Butt<sup>1</sup>, J. Janveau<sup>1</sup>, L. Lawley<sup>1</sup>, W. Miles<sup>1</sup>, J. Tod<sup>1</sup>,  
P.J. Hood<sup>2</sup>, D.J. Teskey<sup>1</sup>

The Geological Survey of Canada's regional aeromagnetic survey program, begun in 1947 with the objective of providing geologists with a new mapping tool, has seen a progressive increase in the coverage of Canada, plus a dramatic evolution in the manner of data presentation. Targeted initially at the mineral deposits of the Canadian Shield, the program has expanded to include a broader range of geological environments favourable to mineral exploration, as well as sedimentary structures in the search for hydrocarbons.

The current thrust of the program is to complete coverage for all of Canada and its offshore areas. To-date, 80% of the landmass and 20% of the offshore areas have been surveyed regionally at a line spacing of 0.8 km.

Aeromagnetic data are available in a variety of formats, reflecting technological changes that have taken place since 1947 in acquisition and display techniques. Originally analog, records were manually transcribed and contoured onto geographic base maps. Now, aeromagnetic data for the entire data set are available digitally or in the form of enhanced colour plots.

<sup>1</sup> Geophysics Division, GSC, Ottawa

<sup>2</sup> Mineral Resources Division, GSC, Ottawa

# **UNRAVELLING THERMAL HISTORY AND RELATIVE TIMING OF MACKENZIE PLATFORM MISSISSIPPI VALLEY-TYPE Pb-ZN DEPOSITS USING MICROTHERMOMETRY AND CATHODOLUMINESCENCE**

J.J. Carrière<sup>1</sup>, D.F. Sangster<sup>1</sup>

Several dozen Pb-Zn deposits and occurrences of Mississippi Valley-type (MVT) are located in carbonate rocks on the western border of Mackenzie Platform. Recent research on MVT deposits elsewhere in North America reveals that ore-forming fluids are driven into carbonate foreland platforms by gravity-driven flow induced by tectonic uplift.

To evaluate this process in the Mackenzie Platform district, approximately two dozen deposits have been selected for microthermometric and cathodoluminescence study. To date, fluid inclusion determinations on sphalerite have resulted in the following: Robb Lake - Th range = 87-154°C, av. = 119°C; salinity 16 to >23 eq. wt. % NaCl; Gayna River - Th range = 156-231°C, av. = 186°C; salinity = 16 to >23 eq. wt. % NaCl.

Cathodoluminescent studies of sparry white hydrothermal dolomite in six deposits have revealed matching zoning patterns in the Lower Cambrian-hosted Tic and Helihean-hosted Gayna deposits. This is tentatively interpreted to indicate coeval mineralization in these deposits which are separated by approximately 60 km.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

## **GIS PILOT STUDY ON MINERAL RESOURCES OF THE BOW VALLEY CORRIDOR**

D. Chao<sup>1</sup>, W. Hamilton<sup>1</sup>, J. Lutz<sup>1</sup>, M. Price<sup>1</sup>

The Bow Valley Corridor is a region in Alberta richly developed in industrial minerals, for which an abundance of resource data exists. This region was selected as a pilot area for developing Geoscience Information System (GSIS) methodologies for online and graphic display of mineral deposits data, using ArcInfo GIS software.

This pilot effort has two principal products: (1) a hard-copy mineral deposits map at 1:50,000 scale, presenting the deposits in combination with various layers of geologic and geographic information; and (2) an online query/display package that displays the map on a screen with capabilities to (a) zoom in on an area, (b) retrieve and display all data related to any selected deposit, and (c) allow selection by various criteria (e.g. geologic age, formation, township-range, etc). The procedures developed from this pilot study are being applied on a province-wide basis to produce an operational GSIS package and Minerals Map for Alberta.

<sup>1</sup> Alberta Geological Survey, Alberta Research Council, Calgary

## **APPLICATION OF GAMMA SPECTROMETRY TO GOLD EXPLORATION**

B.W. Charbonneau<sup>1</sup>, R.B.K. Shives<sup>1</sup>, M. Legault<sup>2</sup>

Despite relatively few published examples of the application of gamma ray spectrometric methods to gold exploration in Canada there is ample geochemical evidence that the method could be an important adjunct to other geochemical, geophysical and geological data in precious metal exploration programs.

Potassium haloes are well known around many gold deposits. Some gold mineralization is marked by an increase in uranium. There is little evidence for thorium increase accompanying gold mineralization, however several authors have referred to thorium depletion with potassium increase.

The ability to quantitatively measure radioelement concentrations in bedrock or surficial cover, either within boreholes, directly on the ground or remotely via airborne systems, provides explorationists with a practical, inexpensive and potentially powerful tool, especially when combined with other geochemical/geophysical data.

The multiparameter airborne data (gamma-ray, magnetic and VLF-EM) collected by the Geological Survey of Canada contains surveys at various line spacings over many gold areas of Canada. Presented are examples of airborne and ground radiometric signatures relating to gold deposits in New Brunswick, Ontario, Saskatchewan, British Columbia and Northwest Territories.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

<sup>2</sup> University of Ottawa, Ottawa

## **PRELIMINARY GEOMATHEMATICAL ANALYSIS OF LITHOGEOCHEMICAL DATA, MITCHELL-SULPHURETS MINERAL DISTRICT, BRITISH COLUMBIA**

Qiuming Cheng<sup>1</sup>, F.P. Agterberg<sup>2</sup>, S.B. Ballantyne<sup>2</sup>

Lithogeochemical data (major oxides and trace elements) from 1066 surface bedrock samples from an area of approximately 120 km<sup>2</sup> in the Mitchell-Sulphurets mineral district provide the basis for geomathematical studies. A range of alteration types have affected different parts of the study area. Data files with field described rock types and digitized sample locations were created for 6 different mineralized areas. One goal of the geomathematical studies is to develop a method to determine possible original rock types prior to the intense potassic and sulphur enrichment now locally displayed by all rock types.

General statistics were obtained for each element. Multivariate analysis is in progress. Positive and negative results of these applications will be given. Due to active and recent alpine glaciation, exposures in outcrop reach vertical extents of 1500 metres. A special challenge to this investigation is to incorporate these differences in elevation and to generalize commonly used map-based techniques to three-dimensional situations.

<sup>1</sup> Ottawa-Carleton Geoscience Centre, Ottawa

<sup>2</sup> Mineral Resources Division, GSC, Ottawa

## **CANADA'S FUTURE AS A PRODUCER OF METALS**

D.A. Cranstone<sup>1</sup>

Canada has mined for over 140 years. The value of Canada's non-petroleum mineral production in recent years remains at near-record levels after adjusting for inflation. However, Canadian ore reserves of base metals have declined significantly over the past decade, due partly to low metal prices that produced smaller profits, reduced the motivation to explore for those metals, raised the economic threshold for new discoveries to become mines and made the writeoff of lower-grade portions of orebodies necessary. For most metals, Canada does not appear to be finding the economically mineable mineral deposits required to maintain ore reserves.



The immediate hope for maintaining Canada's current output of base metals lies in the development of new mines from deposits discovered in recent decades. In the longer term, improvements in Canadian production technology may help to cut production costs and to maintain production by increasing ore reserves. However, to replenish ore reserves, an increase in the number of orebodies discovered is needed. With the limited exploration funds that are available, Canadian costs of ore discovery must be reduced to achieve this.

<sup>1</sup> Mineral Policy, EMR Canada, Ottawa

### **INTEGRATED RESOURCE MANAGEMENT INFORMATION SYSTEM (IRMIS)**

A. Czich<sup>1</sup>, P.B. Hale<sup>1</sup>

IRMIS is a desktop mapping system developed by EMR's Mineral Policy Sector (MPS) in partnership with Earth & Ocean Research Limited. IRMIS combines a mapping package (QUICKMap) with a database manager (FoxPro) as an effective tool for organizing and querying data. IRMIS provides the ability to display digital geographic information along with dBASE III+ compatible files. This action enables us to quickly and effectively analyze spatial information and to manage conflicts associated with resource development. The system can, therefore, contribute to the competitiveness of Canada's resource sector and enhance its environmentally-sound contribution to the economy.

<sup>1</sup> Mineral Policy, EMR Canada, Ottawa

### **COMPUTERIZED MAPPING ALONG THE PRECAMBRIAN CANADIAN SHIELD MARGIN IN EASTERN SASKATCHEWAN: FLIN FLON- EAST AMISK LAKE AREA**

B.M. Czornobay<sup>1</sup>, W.L. Slimmon<sup>1</sup>

Recent advances in computer technology have made powerful portable computers and software programs available to field geologists. Various software, permitting data analysis and graphics display, aids in the production of geological maps and helps minimize errors associated with conventional map production.

Saskatchewan Geological Survey geologists are currently using FIELDLOG, a program developed by the Ontario Geological Survey linking computer aided drafting with a relational database, for the production of geological maps. This program will be used in conjunction with the NATMAP Shield Margin Project, which has been designated for computerized map production. The purpose of this Federal/Provincial geoscientific study is to extrapolate the mapping and interpretation of the Precambrian rocks underlying the Paleozoic cover south of the Shield margin in the Flin Flon-Hanson Lake region.

Digital data for this area include: bedrock and surficial geology, geophysical/ geochemical/ geochronological datasets, as well as economic mineral occurrence/deposit information. These digital datasets will be updated annually and integrated within a Geographical Information System (GIS). Products of the project will include a variety of geological maps and a comprehensive geoscientific GIS digital database.

<sup>1</sup> Saskatchewan Geological Survey, Regina

### **USSR-USA-CANADA NORTH PACIFIC METALLOGENIC-TECTONIC MAP PROJECT**

K.M. Dawson<sup>1</sup>, J.W.H. Monger<sup>2</sup>, S.P. Gordey<sup>2</sup>, T.D. Feeney<sup>2</sup>

Representatives of the Geological Survey of Canada, United States Geological Survey and Alaska Division of Geological and Geophysical Surveys spent four weeks in July-August of 1991 in productive working visits to three Institutes of the Far East Branch of the U.S.S.R. Academy of Sciences, as part of a joint tectonic-metallogenic map project encompassing the northern circum-Pacific regions of the three countries. Productive discussions in Magadan and Vladivostok emphasized the tectonic environments of terranes, comparisons of specific terranes and mineral deposit models, and relationships between metallogeny and terrane tectonics. Preparation of manuscript maps, terrane sections and descriptions and mineral deposit tables is well advanced. Four field excursions were taken in the Magadan and Primor'ye regions. A workshop planned for the summer of 1992 in Anchorage will allow finalization of publications.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

<sup>2</sup> Cordilleran Division, GSC, Vancouver

### **DRIFT PROSPECTING IN THE MIRA-FRAMBOISE AREA, CAPE BRETON ISLAND, NOVA SCOTIA<sup>1</sup>**

R.N.W. DiLabio<sup>2</sup>, M.B. McClenaghan<sup>2</sup>, C. West<sup>3</sup>

Reconnaissance and detailed till sampling were completed in the Mira (NTS 11F/16) and Framboise (11F/9) areas during the 1991 field season to complement the limited till sampling program carried out in 1990. In 1991, approximately 600 till samples were collected from across the area and geochemical analysis of the <0.063 mm fraction is under way, followed by analysis of the heavy mineral and pebble fractions from selected samples. One half of the till samples was collected from surface pits (3 to 5 km apart) that correspond to regional biogeochemical sample sites, also sampled in 1991. These till samples were collected to establish regional geochemical background values for drift prospecting for base metals and gold and to identify anomalous areas that may indicate mineralized bedrock nearby.

In 1991, about 170 surface till samples were collected from detailed sampling grids around: the Mindamar mine (Zn-Pb-Cu) at Stirling; the Deep Cove occurrence (Mo-Ag-Bi-Cu); and the Blue Mountain occurrence (Pb-Zn). This work will document the nature of glacial dispersal from the mineralized sources, i.e., the directions and distance that superimposed ice flow events have dispersed material and the geochemical signature reflected in tills. Approximately 130 fresh till samples were collected from coastal sections around Gabarus Bay and at several locations as far south as St. Esprit Beach. These samples were collected to document shifts in till provenance and ice flow patterns.

<sup>1</sup> Canada-Nova Scotia Co-operation Agreement on Mineral Development 1990-92

<sup>2</sup> Terrain Sciences Division, GSC, Ottawa

<sup>3</sup> Carleton University, Ottawa

### **DRIFT PROSPECTING IN NORTH-CENTRAL NEW BRUNSWICK**

A. Doiron<sup>1</sup>

Since 1990, a project aimed at mapping surface formations and providing detailed information on till geochemical composition and origin is continuing in the Big Bald Mountain

and Serpentine Lake areas in New Brunswick. This project is a contribution to the Canada-New Brunswick Cooperation Mineral Development Agreement 1990-1995. The area studied is known for its base metal potential as it includes the Chester deposit and lies south of the Heath Steele and Stratmat deposits. Mapping work suggests a Quaternary regional paleogeographical evolution model including local and regional successive glacial flow patterns and resulting glacial transport. In a regional mineral exploration program framework, this basic work provides a better understanding of till geochemical and petrographical composition variations and a more detailed delineation of the potential source of the geochemical anomalies identified in the analyzed tills.

<sup>1</sup> Quebec Geoscience Centre, Sainte-Foy

### THE CAPE RAY GOLD BELT, SOUTHWESTERN NEWFOUNDLAND: TECTONIC SETTING AND STRUCTURAL CONTROL

B. Dubé<sup>1</sup>, K. Lauzière<sup>1</sup>, A. Tremblay<sup>2</sup>

The Cape Ray fault is an Acadian crustal scale fault. Studies indicate that the post-Late Devonian movement is compatible with a transpressive dextral regime. Two increments of ductile strain have been recorded, the first is characterized by reverse-oblique shearing with amphibolite deeper crustal rocks of the Port-aux-Basques gneiss retrograded and thrust upon greenschist supracrustal rocks of the volcano-sedimentary Windsor Point Group (WPG). The second is characterized by strike-slip movement observed in the Isle-aux-Morts River and in the E-W flexure of the fault further to the NE. The ductile deformation was followed by late brittle faulting.

The Cape Ray fault zone is one of the most significant gold bearing fault zone in the Appalachians. Analysis of structures hosting the mesothermal gold quartz veins suggests that mineralization is syn-to late-ductile shearing and is genetically related to the Acadian movement. The mineralization is either located in brittle units and in oblique subsidiary structures or at the contact between the Cape Ray tonalite and the WPG as a result of layer anisotropy.

<sup>1</sup> Quebec Geoscience Centre, Sainte-Foy

<sup>2</sup> INRS Géoressources, Sainte-Foy

### RENDELL-JACKMAN: A FOLD-CONTROLLED MESOTHERMAL VEIN-TYPE GOLD DEPOSIT IN NORTHWESTERN NEWFOUNDLAND

B. Dubé<sup>1</sup>, K. Lauzière<sup>1</sup>, D. Gaboury<sup>1</sup>

The Rendell Jackman gold deposit is one of the most significant mesothermal vein-type gold mineralizations in the Canadian Appalachians. The deposit is located within a metavolcanic sequence with intercalations of sediments and felsic porphyry dykes. All but the porphyry dykes have undergone three episodes of deformation.

The first episode of deformation is evidenced in the metavolcanics by an S<sub>1</sub> foliation containing a down dip stretching lineation. The second episode produced steeply plunging, E-W parasitic folds, an associated axial planar S<sub>2</sub> foliation and discrete E-W high strain zones of brittle-ductile deformation, affecting the metavolcanic sequence and the porphyry dykes. These brittle-ductile high strain zones are particularly developed in the flexure of the

parasitic folds. Gold-bearing veins are shear vein-type and are hosted within and sub-parallel to the S<sub>2</sub> high strain zones. The development and localization of auriferous quartz veins is also strongly controlled by the strong anisotropy induced by the competent felsic dykes compared to the foliated and anisotropic metavolcanics.

The last ductile deformation episode produced F<sub>3</sub> sub-horizontal chevron folds. Northeast and ENE faults were produced during a late brittle event.

<sup>1</sup> Quebec Geoscience Centre, Sainte-Foy

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### GOLD METALLOGENY, EASTERN DUNNAGE ZONE, CENTRAL NEWFOUNDLAND

D.T.W. Evans<sup>1</sup>

Since the mid-1980s the focus of mineral exploration within the eastern Dunnage Zone has been on gold. Known occurrences have gone from a single showing prior to 1980 to greater than 30 showings and prospects.

The gold mineralization, which is epigenetic and largely structurally controlled, appears to be related to post-accretionary transpressive regimes active in the Late Silurian to early Devonian. Such regimes would provide a deep network of structures (fluid pathways) and high concentrations of H<sub>2</sub>O and CO<sub>2</sub>-rich fluids capable of transporting gold.

Two broad classes or styles of gold mineralization are developed within the area: 1) shear-zone related, quartz vein and disseminated gold mineralization; and 2) epithermal, low grade gold mineralization associated with intense hydrothermal brecciation and argillic alteration. Host rocks vary significantly in type and age, but are similar in that they act as either brittle or chemically favourable gold traps localized along regionally extensive structures.

<sup>1</sup> Newfoundland Department of Mines and Energy, St. John's

### THE JOHNSON SHEAR ZONE - A REGIONAL METALLOGENETIC FEATURE IN THE LYNN LAKE AREA

M.A.F. Fedikow<sup>1</sup>, K.J. Ferreira<sup>1</sup>, D.A. Baldwin<sup>1</sup>

The Johnson shear zone is a 44 km long zone of structural disruption that is developed within volcanic, sedimentary and intrusive rocks. Within this poorly understood zone is a large number of disseminated and vein type gold deposits and occurrences, including the Burnt Timber Zone that contains 1.126 million tonnes of 4.5 g/t gold, the T1A Zone that contains 0.907 million tonnes grading 3.1 g/t gold and the Bonanza deposit that contains 655 000 tonnes grading 2.40 g/t gold. In areas of detailed study, such as the Gemmell Lake area, the structural characteristics of the Johnson shear zone are dominated by a major zone of strongly foliated rocks produced as a result of ductility contrast between brittle intrusive rocks and the more ductile mafic volcanic and sedimentary rocks. Gold and sulphide mineralization are postulated to have been derived from mafic volcanic wall rocks as leachates; some minor gold may have been introduced along with silica during regional D<sub>1</sub> deformation.

<sup>1</sup> Manitoba Energy and Mines, Winnipeg

# **CATCHMENT BASIN GEOCHEMISTRY: A COMPARISON OF OVERBANK SEDIMENT AND WATER WITH CONVENTIONAL STREAM AND LAKE SEDIMENT**

C. Finch<sup>1</sup>, G.E.M. Hall<sup>2</sup>, J.W. McConnell<sup>1</sup>

Lake and stream waters were collected in 1991 in two areas of Newfoundland from sites that had previously been sampled for overbank sediment, active stream sediment and lake sediment as appropriate. The sediment has been analysed by neutron activation analysis, ICP-emission spectroscopy, and atomic absorption spectroscopy for more than 40 elements including Au, As, Sb, base metals, and several of the rare earths. The waters have been analysed for more than 50 elements by 3 laboratories using both conventional and newly developed analytical methods.

For the Baie Verte/Springdale area, which contains widespread gold and base-metal mineralization, the geochemical similarities and contrasts of overbank sediment and active stream sediment in reflecting catchment basin geology and mineralization are discussed. A further comparison is made between stream water and stream sediment from several sites where both sediment types and water were collected.

In the Bay d'Espoir/Fortune Bay areas, the two principal sample media being compared are lake water and lake sediment. Samples were collected from areas known to have high geochemical backgrounds in As, Sb and rare earth elements.

<sup>1</sup> Geological Survey Branch, St. John's

<sup>2</sup> Mineral Resources Division, GSC, Ottawa

## **RADIOACTIVITY MAPS OF THE CENTRAL METASEDIMENTARY BELT OF EASTERN ONTARIO AND WESTERN QUEBEC**

K.L. Ford<sup>1</sup>, P.B. Holman<sup>1</sup>, J.A. Grant<sup>1</sup>, J.M. Carson<sup>1</sup>, R. Hétu<sup>1</sup>

Airborne gamma ray spectrometric surveys covering some 31 000 km<sup>2</sup> of the Central Metasedimentary Belt of eastern Ontario and part of western Quebec were flown between 1979 and 1991 with a line spacing of 1 km. Survey results are presented as a series of eight, 1:250 000 scale colour maps which present a comprehensive overview of the regional radioelement distribution patterns and illustrate that this data can be a valuable aid in bedrock mapping and mineral exploration.

A prominent feature of these maps is the apparent regional, structural control on the distribution of most radioactive anomalies which coincide for the most part with radioactive pegmatites. In the case of anomalous uranium concentrations, there appears to be three well defined belts or domains in the Bancroft-Anstruther, Sharbot Lake-Kaladar, and Renfrew areas. Variations in relative radioelement abundances between these three areas are also apparent.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

## **FORMATION OF MASSIVE SULPHIDE DEPOSITS IN MIDDLE VALLEY**

J.M. Franklin<sup>1</sup> and the Leg 139 Scientific Party

Hydrothermal activity at Middle Valley was initiated by magmatic activity, including the intrusion of sills and extrusion of a basaltic andesite dome into and through at least 200 m of turbiditic

sediment. Rapid heat transfer from a major magma chamber provided energy to mobilize metals from an igneous basement, forming a hydrothermal system. Simultaneously, this heat loss induced extensive igneous fractionation, forming incompatible-element-rich volcanic rocks. Metalliferous hydrothermal fluid was expelled through reactivated faults, forming large massive sulfide deposits at the seafloor.

A major massive sulfide deposit forms a 200 m across and 35 m high mound, that was cored to a depth of 96 metres. It contains 2-5% Zn, 0.5-1 % Cu, and very low Pb. Flow of heated, moderate pH, CO<sub>2</sub>-rich fluids through the sulfide mound has converted primary pyrrhotite to pyrite plus magnetite, redistributed base metals, and provided a carbonate infilling.

Vigorous hydrothermal activity is now focussed primarily over the buried basaltic andesite dome. These fluids are forming at about 275°C (their present maximum temperature), through reaction with sediments. They are metal-poor, CO<sub>2</sub>-rich and represent the waning stage of the Middle Valley hydrothermal episode. During the collapse of the system, diabase sills became pyritized, epidotized and chloritized.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

## **STRATABOUND CU, GRANITE-RELATED MO-U, AND FELSIC-VOLCANIC-HOSTED U AT DEVRIES LAKE, SOUTHERN GREAT BEAR MAGMATIC ZONE, N.W.T.**

S.S. Gandhi<sup>1</sup>, N. Prasad<sup>1</sup>

Metasiltstones of the Aphebian Snare Group and a younger felsic volcanic assemblage at DeVries Lake, have been deformed and intruded by granites of the approximately 1850 Ma old Great Bear magmatic zone. The metasiltstones are part of a siliciclastic platform sequence that contains ferruginous cordierite-garnet beds and magnetite lenses, and host chalcopyrite-pyrite-rich beds and associated sulphide-rich veins at the 'Kol' showing. The sulphides contain minor amounts of Au, Co and W. Minor folds here plunge gently to the north.

Granite-related veins occur in folded metasiltstones at the 'Nori' prospect and contain molybdenite, uraninite/pitchblende, biotite, tourmaline and magnetite.

The felsic volcanic assemblage includes a pink porphyritic unit, characterized by abundant magnetite as disseminated grains and streaks as much as 10 cm long. It contains 20 to 100 ppm U, and in addition hosts uraninite/pitchblende veinlets at the UGI and FXO prospects. This uranium-magnetite association reflects a regional metallogenic characteristic of the southern Great Bear magmatic zone.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

## **SUB-DUPEROW FORMATION BRINES IN SOUTHERN SASKATCHEWAN**

M. Gent<sup>1</sup>, K. Kreis<sup>1</sup>

Highly concentrated, potentially commercial formation brines have been found in Middle Devonian and older formations within the Western Canadian Sedimentary Basin of southern Saskatchewan. This display documents the quality and distribution of these subsurface brines, their generalized geology in the region, their economic potential, and the chemical products that might be derived from them.

Investigation of this resource includes an open file report entitled 'Sub-Duperow Formation Brines in Southern Saskatchewan' prepared at Saskatchewan Energy and Mines (SEM). In addition, a digitized data bank of approximately 14,000 borehole formation water analyses has just been completed jointly by the ISPG and SEM. The GSC and SEM are about to begin further investigations into the geology, economics and processing technology of Saskatchewan brines as part of the Mineral Development Agreement.

In the United States and elsewhere, brines provide the raw materials for a multi-billion dollar chemical industry. Saskatchewan brines tested to date compare favourably with or surpass these commercial brines, and may constitute a major mineral resource leading to economic diversification in the region.

<sup>1</sup> Saskatchewan Energy and Mines, Regina

## RECENT GEOLOGICAL MAPPING IN THE GRENVILLE PROVINCE TO THE EAST OF VAL D'OR, QUEBEC

R. Girard<sup>1</sup>, J. Moorhead<sup>1</sup>, T. Birkett<sup>2</sup>, N. Marchildon<sup>3</sup>

Geological mapping at 1:250,000 scale completed in 7 map sheets to the east of Val d'Or, Québec (31N/15, 16; 32B/4, 5; 32C/1, 2, 8) reveals:

1. in the south a supracrustal assemblage of about 50% paragneiss, 25% tonalite, 20% mafic and intermediate gneiss, rare bodies of ultramafic rock and quartz-garnet rock; intruded by some 5% of pink granite, monzodiorite, syenite and younger bodies of coronitic gabbro and later intrusions of lamprophyre.
2. in the north massifs of foliated to gneissose biotite leuco-tonalite in continuity with Archean tonalites of the Faillon region; and kilometric lenses of supracrustal rocks similar to those of the southern portion.

The Grenville Front juxtaposes Archean rocks and their re-metamorphosed equivalents and is offset by late faults oriented northeast-southwest. The older gneissose rocks are the equivalents of Archean rocks of the Abitibi and Pontiac Subprovinces to the west of the Grenville Front. The Kenoran east-west tectonic grain is partially transposed to a Grenvillian northeast-southwest orientation. Regional metamorphic grade in the area ranges from amphibolite to granulite facies.

<sup>1</sup> Ministère de l'Énergie et des Ressources du Québec, Val d'Or

<sup>2</sup> Quebec Geoscience Centre, GSC, Sainte-Foy

<sup>3</sup> Department of Geology, Rensselaer Polytechnic Institute, Troy, New York

## THE DEVELOPMENT AND APPLICATION OF SELECTIVE SEQUENTIAL EXTRACTION PROCEDURES IN EXPLORATION GEOCHEMISTRY

G.E.M. Hall<sup>1</sup>, W.B. Coker<sup>1</sup>, J.E. Vaive<sup>1</sup>, C. Kaszycki<sup>2</sup>

There is renewed interest in the use of selective extraction procedures to identify the partitioning of metals in geochemical samples (tills, soils, sediments), caused in part by the reported success of such methods widely applied in the Soviet Union. Of particular interest is the identification and quantification of metals bound in the amorphous and crystalline Fe-oxide fractions in soils

and in the soluble organic phase of humus. The precision and accuracy obtained by wet chemical procedures to extract metals held in these phases and others are reported in an application study to surficial material from Snow Lake, Manitoba. The information obtained in these selective extractions are proving valuable in delineating the sources, primary and secondary, of geochemical anomalies; this will be demonstrated in the Manitoba study.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

<sup>2</sup> Consultant, Thompson, Manitoba

## INDUSTRIAL AND METALLIC MINERALS/GSIS

W. Hamilton<sup>1</sup>, M. Price<sup>1</sup>, B. Fildes<sup>1</sup>

More than 30 different kinds of economic minerals are found in Alberta, mostly industrial (nonmetallic) minerals but with some notable metallics, in at least 1,500 known occurrences. Data on geologic setting and resource attributes of these mineral occurrences have been captured systematically by AGS geologists using a computer-based file: the Alberta Mineral Deposits and Occurrences (AMDO) file.

Ready access to the data is provided using automated file searching methods, on both Macintosh and "PC-compatible" computers. HyperCard software is used on Macintosh computers while "user-friendly" elements of HyperCard have been developed on the DOS platform by use of a package called ToolBook, a software construction set for Windows.

Another means of access to Alberta minerals data is under development within the concept of a Geoscience Information System (GSIS), based on ArcInfo GIS software. GSIS allows integration of the data with other resource information and provides online query/display capabilities. Graphic output from the system is being used for production of a mineral deposits map of Alberta.

<sup>1</sup> Alberta Geological Survey, Alberta Research Council, Calgary

## APPLIED MINERALOGY AND GEOCHEMICAL SURVEYS OF AU-CU PORPHYRY SYSTEMS IN THE NORTHERN QUESNEL TROUGH, BRITISH COLUMBIA

D.C. Harris<sup>1</sup> and S.B. Ballantyne<sup>1</sup>

The discovery of the Mount Milligan deposit in 1987 has increased exploration activities in the northern Quensel Trough. However, the area contains little outcrop and is covered with several tens of metres of overburden. Hydrogeochemical sampling for Au, Cu and S and geochemical sampling of dispersion trains using gold grain shapes and fineness, heavy mineral concentrate identification and analysis can be used to outline potential area for mineralization. Mineralogical investigation of known deposits is essential in understanding the minerals found in dispersion trains. Within the Mount Milligan deposit, two populations of gold fineness are present, indicating more than one episode of mineralization. Pyrite, chalcopyrite, magnetite and lesser bornite are the principal ore minerals with a supergene zone containing native copper, goethite, a secondary copper sulfide, malachite and cuprite.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa



# **ORE MINERALOGY AND LITHOGEOCHEMISTRY OF THE MITCHELL-SULPHURETS DISTRICT, POTASSIC, HIGH-SULPHUR PRECIOUS-METAL SYSTEM**

D.C. Harris<sup>1</sup>, S.B. Ballantyne<sup>1</sup>

The district is noted for its intensity of alteration, namely potassic, sulphidization and more locally silicification and its diversity of ore minerals. Vertical extent of alteration and mineralization as exposed is over 1000 metres within the 10 x 15 kilometre district. The eastern portion is dominantly a Ag, Au-Sb-rich belt characterized by silver sulphosalts, tetrahedrite and coarse electrum hosted within silica ± carbonate-barite gangue. The western belt is basically a series of Cu-Au-As porphyry systems dominated by native gold, chalcopyrite and tennantite ore zones. Within the north central area silicified Mo-F ± Au ± Cu ores are present with fluorine contents within the 1000-5000 ppm range. The whole district contains huge volumes of pyrite-sericite rocks with greater than 50 ppb gold and sodium depletion to less than one weight percent. Magma chemistry of the numerous intrusions and the coeval volcanic pile is confusing due to the episodic nature of the mineralization and complex structural history of the district.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

## **APPLIED MINERALOGY AND LITHOCHEMISTRY OF THE KERR-SULPHURETS Cu-Au PORPHYRY SYSTEMS**

D.C. Harris<sup>1</sup>, S.B. Ballantyne<sup>1</sup>

Placer Dome Inc.'s newly discovered Kerr-Sulphurets Cu-Au porphyry deposit is predominantly hosted in a potassic altered pyrite-rich sericite-chlorite schist. Whole rock K<sub>2</sub>O contents with associated sulphur concentrations generally contain over 6 weight percent. Gold concentrations range between 100-500 ppb where principal copper minerals are chalcopyrite and tennantite. A bornite-rich interval demarks enriched Cu-Au-As and Se concentrations since it is also associated with chalcopyrite, tennantite, enargite, chalcocite and rare colusite (Cu,Fe)<sub>26</sub>V<sub>2</sub>(As,Ge)<sub>6</sub>S<sub>13</sub>.

Adjacent to the deposit, relatively unaltered intrusions range from diorite to monzonite. A single chlorite-altered monzonite hosts bornite, chalcopyrite, tetrahedrite, electrum, magnetite-hematite chiefly on fractures. Rare clausthalite (PbSe), merenskyite Pd(Te,Bi)<sub>2</sub>, chalcocite, covellite and malachite are present in ores having up to 150 ppb Pd and 60 ppm Se.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

# **THE CANADA-NORTHWEST TERRITORIES MINERAL INITIATIVES, 1991-1996**

M. Irving<sup>1</sup>, M. Stuble<sup>1</sup>

The new Canada-NWT Economic Development Agreement was signed in February 1991. Under the Agreement, funding has been provided for the Mineral Initiatives. The Mineral Initiatives, similar to the past MDA (Mineral Development Agreement), have a budget of \$8.2 million cost-shared 70% federal and 30% territorial over five years (1991-1996). They have been designed to promote and stimulate the mineral industry in the NWT.

Four Mineral Initiatives have been established: 1) Geoscience (\$7.5 M); 2) Technology (\$0.2 M); 3) Information (\$0.3 M); and 4) Prospector's Assistance (\$0.3 M). The Initiatives will be managed by a Management Committee with representation from DIAND-Geology; Energy, Mines and Petroleum Resources (GNWT); EMR Canada; and Economic, Development and Tourism (GNWT). An equitable distribution of funding between the various NWT regions has been established by the Committee.

Projects under the Geoscience Initiative have been selected after consultation with the mineral industry, DIAND-Geology, the GSC and the Government of NWT. Projects are primarily devoted to regional and more-detailed mapping. They are coordinated with A-base GSC and DIAND projects, (NATMAP) and University research.

<sup>1</sup> Indian and Northern Affairs Canada, Yellowknife

## **GEOLOGICAL SETTING OF SULPHIDE MINERALIZATION IN ARCHEAN ROCKS OF THE NAPAKTULIK LAKE AREA, SLAVE STRUCTURAL PROVINCE**

V.A. Jackson<sup>1</sup>, J. Gebert<sup>2</sup>, H. Falck<sup>3</sup>

The greenschist to amphibolite facies Archean supracrustal belt in the Napaktulik (formerly Takijuk) Lake area defines a NE-trending synform dominated by volcanic and volcanoclastic rocks with minor greywacke and shale. Many primary features were obscured by deformation synchronous with and subsequent to the main fold and fabric forming event. Previous investigations were focussed on volcanogenic massive sulphides, but the current studies indicate that sulphide concentrations include:

STRATIFORM TYPE	SULPHIDES	SETTING	EXAMPLE	DISCORDANT TYPE	SULPHIDES	SETTING	EXAMPLE
Volc. Massive Sulfide	py, po, cpy, sph, ga, (Ag)	Mafic-felsic volc. contact	Hood #10, Hood #41	Quartz Veins	py, asp, cpy	Mafic volcs. Sediments, early granite intrusions	Blue Lake
Massive Sulfide Zone	py, po, cpy, sph, ga	Felsic-mafic volc. contact & volc. sed. contact + carbonate	Hawk Lake, Blue Lake	Silica - Flooded	py, asp, (Au)	Fold closures & limbs	Blue Lake
Iron Formation	gt, amp, py, po	Volc.-sed. contact & mafic-felsic volc. contact + carbonate	Blue Lake, Hood River	Shear Zones	py, po	Belt parallel, predating last folding event in volcs.	Throughout Belt

Current investigations are aimed at further characterization of the sulfide concentration types and expanding their usefulness as a guide to exploration.

<sup>1</sup> Indian and Northern Affairs Canada, Yellowknife

<sup>2</sup> Government of the Northwest Territories, Yellowknife

<sup>3</sup> Consultant, Yellowknife

## **EVOLUTION OF MINERAL AND ENERGY RESOURCE ASSESSMENTS AT THE GEOLOGICAL SURVEY OF CANADA – WHAT ARE WE LEARNING**

C.W. Jefferson<sup>1</sup>

The Mineral and Energy Resource Assessment (MERA) process is one of many required for new national parks in the Yukon, NWT and offshore. Resource assessments are also needed for international boundary concerns (this started our seafloor minerals program) and for our nuclear energy policy. The GSC provides technical reports to decision-makers and publishes non-sensitive data.

Prior to 1987 MERAs for new northern parks were mainly based on archived data (Phase I). Some Phase I assessments funded by the GSC (East Arm of Great Slave Lake and Banks-Victoria Islands) generated limited new field data. Now, phase II MERAs involve larger field surveys jointly funded by DIAND, EMR and the Canadian Parks Service. We are learning that (1) public consultation is vital, (2) MERA ratings are difficult to evaluate vis à vis qualitative attributes valued for parks, (3) as predicted, assessments are changing because of newly recognized deposit types (e.g. sedimentary exhalative Ni-Zn-PGE), new exploration targets (e.g. a known stratigraphic unit with newly discovered showings), and the new MERA surveys (e.g. newly mapped supracrustal rocks and geochemical anomalies).

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

## **TILL COMPOSITION ASSOCIATED WITH VOLCANOGENIC MASSIVE SULPHIDE DEPOSITS, SNOW LAKE AND RUSTY LAKE AREAS, MANITOBA: GEOCHEMISTRY, MINERALOGY, AND REGIONAL TRENDS**

C.A. Kaszycki<sup>1</sup>, G. Gobert<sup>2</sup>, E. Nielsen<sup>3</sup>

A primary objective of the till geochemistry program is to develop new analytical approaches using surficial sediments to identify volcanogenic massive sulphide deposits and associated alteration zones. Till sampling has been carried out at both regional and detailed scales and several samples from various soil horizons (C, B and humus) were collected at each site. Analysis of the geochemistry and mineralogy of several till fractions is in progress. Preliminary interpretation of geochemical data for the <2 µm size fraction indicates that B-horizon and C-horizon samples produce similar geochemical trends, related primarily to glacial dispersal. B-horizon samples tend to be depleted in most trace elements relative to C-horizon material, resulting in lower background to anomaly ratios and more poorly defined geochemical trends. The concentration of trace metals in organic samples is lower than that observed in subjacent samples and meaningful trends have not been identified. Sequential extraction techniques have been used to identify the nature of anomalies observed in B-horizon and organic samples. At present, heavy mineral assemblages have only been identified within a selected number of samples. Preliminary data

indicate that the distribution of alteration minerals may serve as a guide to identification of volcanogenic massive sulphide deposits on a regional scale.

<sup>1</sup> Consultant, Thompson

<sup>2</sup> Consultant, Winnipeg

<sup>3</sup> Manitoba Energy and Mines, Winnipeg

## **INTEGRATED GEOSCIENTIFIC STUDIES IN THE CHIBOUGAMAU MINING CAMP, NORTHWESTERN QUEBEC**

P.B. Keating<sup>1</sup>, D.-J. Dion<sup>2</sup>, M. Beaumier<sup>2</sup>, R. Morin<sup>2</sup>

The Chibougamau region contains many polymetallic orebodies and has been extensively studied during the last forty years. It is located about 500 km north of Montreal. Recent work has shown that information available in this area can be compared with the various models proposed for similar volcano-sedimentary belts. This study area is part of the Chibougamau-Matagami greenstone belt. It is covered by diverse geophysical and geochemical surveys: a combined electromagnetic and magnetic survey and a high resolution gravity survey as well as a low density geochemical soil survey. From the interpretation of these various data sets, we conclude that the Chibougamau syncline has a depth extension of about 5 km. However, the Doré Lake Complex extends no deeper than 2 km. The Opemisca pluton appears to extend to a depth of about 6 km, while the Chibougamau pluton is thin, about 1 km, in most places, but thickens to the south-east. Our interpretation shows that in the study area the greenstone belt thickness ranges from 2 to 6 km. These results are compared with various geological models and they agree with the model proposed by Daigneault and Allard (1990).

<sup>1</sup> Geophysics Division, GSC, Ottawa

<sup>2</sup> Ministère de l'Énergie et des Ressources du Québec, Charlesbourg

## **PREDICTING GRADE IN IRON ORE BLAST HOLES USING BOREHOLE GEOPHYSICS: A GSC/CANMET/IRON ORE COMPANY OF CANADA JOINT PROJECT**

P.G. Killeen<sup>1</sup>, C.J. Mwenifumbo<sup>1</sup>, W. Petruk<sup>2</sup>

A series of borehole geophysical measurements was made at the Iron Ore Company of Canada mine near Labrador City to assess the possibility of using borehole geophysics to obtain information on mineral grain size and liberation characteristics, iron ore grade, manganese content and magnetite/hematite ratios.

Using the GSC R&D logging system, magnetic susceptibility (MS), natural gamma-ray spectral (NGRS) and spectral gamma-gamma (SGG) logs were recorded in eight blast holes at four open pits. The large diameter, air-filled 15m deep blast holes presented some new problems, but experimental logs were run using a special device to center and sidewall the probes.

The MS log responds to the magnetite content, the NGRS log reflects the lithology, and the SGG log relates to the iron content. Some examples of these logs will be presented with a description of the experimental setup.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

<sup>2</sup> CANMET, Ottawa

## KITSAULT LAKE VOLCANIC EXHALATIVE SR (-ZN) OCCURRENCE, NORTHWEST BRITISH COLUMBIA

R.V. Kirkham<sup>1</sup>, D.C. Harris<sup>1</sup>, I.R. Jonasson<sup>1</sup>, J.K. Mortensen<sup>2</sup>

An unusual volcanic exhalative Sr(-Zn) occurrence is present in the upper part of the Lower Jurassic Hazelton Group in the Kitsault Lake area of northwest British Columbia. Celestite, sphalerite, pyrite with minor amounts of barite, strontianite, galena, arsenopyrite, greenockite and trace amounts of orpiment occur in association with dark carbonaceous, pebbly mudstone (diamictite) interbedded with andesitic tuff-breccia. The sulphate minerals are bedded with sulphides disseminated both in the sulphate and diamictite units. Pyrite also occurs in deformed colloform layers, framboids, wispy veins and clasts in the diamictite.

A felsic lapilli tuff unit, about 100 to 200m(?) stratigraphically below the exhalative Sr(-Zn) occurrence, has yielded a U-Pb zircon age of  $193.5 \pm 0.4$  Ma. The stratigraphic setting is analogous to that of the important Eskay Creek deposit about 120 km to the northwest.

Most celestite deposits occur in evaporite-redbed environments. The authors are unaware of any other documented occurrence of volcanic exhalative celestite. This bedded sulphate unit could be a distal volcanic exhalative product in a basin adjacent to a paleotopographically higher exhalative hydrothermal centre.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

<sup>2</sup> Continental Geoscience Division, GSC, Ottawa

## STRATIGRAPHIC AND STRUCTURAL SETTING OF THE SULPHURETS PORPHYRY CU-AU SYSTEM, NORTHWEST BRITISH COLUMBIA

R.V. Kirkham<sup>1</sup>, J.R. Henderson<sup>2</sup>, M.N. Henderson<sup>1</sup>, T.O. Wright<sup>3</sup>

The Sulphurets porphyry Cu-Au system was emplaced in Upper Triassic Stuhini Group and basal Lower Jurassic Hazelton Group rocks. The Stuhini Group marine sedimentary and volcanic rocks were deformed into north-trending upright folds and uplifted and eroded prior to deposition of the fossiliferous Lower Jurassic sedimentary Jack Formation (new name) and overlying volcanic succession of the Hazelton Group. The Jack Formation has not been recognized yet in the vicinity of the mineral deposits at Sulphurets. A major unconformity to disconformity with considerable erosion has also been recognized under the felsic volcanic Mount Dilworth Formation at the top of the Hazelton Group. In some areas under the unconformity the Hazelton Group and Jack Formation are missing and the Mount Dilworth Formation sits directly on the Stuhini Group.

The Hazelton Group is overlain conformably or possibly slightly unconformably by marine clastic sedimentary rocks of the Bowser Lake Group. Pillow lavas and tuffaceous units in the Salmon River Formation occur locally near the base of the Bowser Lake Group. Hazelton and Bowser Lake Group rocks exhibit large-scale overturned folds and thrusts.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

<sup>2</sup> Continental Geoscience Division, GSC, Ottawa

<sup>3</sup> U.S. National Science Foundation

## APPLICATION OF AEROMAGNETIC GRADIOMETER SURVEYS TO DETAILED MAPPING AND MINERAL EXPLORATION IN MANITOBA, SASKATCHEWAN, NOVA SCOTIA AND NEW BRUNSWICK

F. Kiss<sup>1</sup>, P. Stone<sup>1</sup>, J. Tod<sup>1</sup>, D.J. Teskey<sup>1</sup>

Airborne gradiometry has proven to be an effective technique for detailed mapping of faults and contacts between geological units. In 1991 surveys were carried out in the Cape Breton Highlands and the southwestern Miramichi belt in New Brunswick as part of the Canada-Nova Scotia and Canada-New Brunswick Mineral Development Agreements respectively. Surveys were also flown over the northern margin of the Phanerozoic cover in Saskatchewan and Manitoba to assist in the extension of detailed mapping of the greenstone belts to the north, as part of the Saskatchewan-Canada and the Manitoba-Canada Mineral Development Agreements. These latter two surveys also represent a contribution to NATMAP programs in Saskatchewan and Manitoba.

<sup>1</sup> Geophysics Division, GSC, Ottawa

## EXPLORATION METHODS FOR KIMBERLITE- AND LAMPROITE-HOSTED DIAMOND DEPOSITS IN CANADA

B.A. Kjarsgaard<sup>1</sup>

Economic kimberlite-hosted diamond deposits are found in stable cratonic areas older than 2.5 Ga ('on craton'). In contrast, viable lamproite-hosted deposits are found in Proterozoic mobile belts adjacent to Archean cratons. As such, vast tracts of land in Canada are suitable areas in which to find both kimberlites and lamproites. One of the most common exploration methods for locating kimberlite and lamproite is the use of indicator minerals recovered from till and soil samples. However, in Canada, application of this exploration method is problematic due to the widespread regional glacial events which have occurred, complicated by 'local' ice movements oblique to the regional ice flow pattern. Therefore, successful exploration should use a combination of techniques, based on type of country rock, overburden and climate. The poster will review worldwide applications of indicator mineral sampling (heavy mineral separates from stream sediment, soil and till sampling), geophysical surveys (magnetic, gravity, electrical and radiometric) and remote sensing (LANDSAT, aerial photography) to kimberlite and lamproite exploration.

<sup>1</sup> Mineral Resources Division/Continental Geoscience Division, GSC, Ottawa

## QUATERNARY GEOLOGICAL STUDIES, CENTRAL NEWFOUNDLAND<sup>1</sup>

R.A. Klassen<sup>2</sup>, P.J. Henderson<sup>3</sup>

Quaternary geological studies within the Buchans (12A /15) and Badger (12A /16) map areas are designed to establish a geological framework for mineral exploration through integration of Quaternary mapping, stratigraphic studies, and compositional analyses of glacial sediments. In this region drift prospecting has been confounded by thick glacial deposits and complex ice flow history. In the Badger area, the dominant northeastward ice flow was preceded by southward flow in its western part. Within the Red Indian Lake basin, near Buchans, regional ice flow trending northeast-southwest was superseded by flows toward the south and the north and northwest. P-forms indicate

subglacial meltwater flowing both northeast and southwest. Surficial deposits are predominantly till of varying thickness and morphology. The till is commonly sandy, contains evidence of internal sorting, and may be overlain by thin outwash deposits which suggests deposition from an ablating ice sheet. Near Buchans, extensive, sub-till glaciofluvial and glaciolacustrine deposits occur to 320 m a. s. l. They, in turn, overlie mineralized bedrock and their incorporation within overlying till complicates the compositional relationship between bedrock and surficial sediments.

<sup>1</sup> Canada-Newfoundland Mineral Development Agreement 1990-1994

<sup>2</sup> Terrain Sciences Division, GSC, Ottawa

<sup>3</sup> Henderson Geological Services, Ottawa

## GEOSCAN – REFLECTING 150 YEARS OF SCIENCE AT THE GEOLOGICAL SURVEY OF CANADA

A.G. Kopf-Johnson<sup>1</sup>, B. Blair<sup>1</sup>, J. Caron<sup>1</sup>

Since 1842, the Geological Survey of Canada has explored and documented the geology and resources of this vast country, providing leadership in scientific research. From William Logan's first Report of Progress to the latest publications, this collection of geoscientific knowledge represents over 32 000 citations. The GEOSCAN database provides researchers with the capability to readily access and search this wealth of information.

GEOSCAN is Canada's national bibliography for the earth sciences, providing bibliographic and subject access to over 130 000 documents. Coordinated by the Geological Survey of Canada, GEOSCAN is cooperatively produced through the activities of federal and provincial geological surveys, a university library, and one professional society. Public access to GEOSCAN is available through the GSC Library, whereas GSC staff may access GEOSCAN through the GSC Network.

<sup>1</sup> Geoscientific Information Division, GSC, Ottawa

## ANALYSIS OF HIGH RESOLUTION AEROMAGNETIC DATA OVER THE WESTERN LOBE OF THE FOX RIVER SILL, MANITOBA

L.J. Kornik<sup>1</sup>, R.F.J. Scoates<sup>2</sup>

The Proterozoic (1883 Ma, U-Pb zircon age) Fox River Sill in northern Manitoba is one of Canada's largest layered intrusions. It is a stratiform ultramafic-mafic complex which consists of two segments (western and eastern lobes), having a combined strike length of about 270 km and a thickness ranging from 2 to 2.5 km. The Fox River Sill and ultramafic-mafic Lower Differentiated Intrusives intrude into and form an integral part of the Fox River Belt, which also includes sedimentary rocks and ultramafic to mafic volcanic rocks.

Recently, high resolution total field and vertical gradient aeromagnetic data covering the Fox River Sill and Lower Differentiated Intrusives, have been made available through the courtesy of BP Resources Canada Limited. The new magnetic data suggest the presence of faulting in both the main Fox River Sill and the Lower Differentiated Intrusives. The greater detail allows the better definition of some portions of the contact of the

sill and of perturbations in the sill, and reveals the continuity of lithological units within the sill and adjacent rocks of the Fox River Belt.

<sup>1</sup> Continental Geoscience Division, GSC, Ottawa

<sup>2</sup> Mineral Resources Division, GSC, Ottawa

## ELECTROMAGNETIC INVESTIGATIONS ALONG THE LITHOPROBE TRANSECT ACROSS THE ABITIBI BELT AND THE GRENVILLE FRONT

R.D. Kurtz<sup>1</sup>, R. Kellett<sup>2</sup>, M. Mareschal<sup>2</sup>, M. Chouteau<sup>2</sup>, P. Zhang<sup>2</sup>, F. Richard<sup>1</sup>, D.E. Boerner<sup>1</sup>, R.C. Bailey<sup>3</sup>

Magnetotelluric (MT) and Transient Electromagnetic (TEM) soundings were conducted along a 350 km profile on one of the Abitibi/Grenville transects. The survey extends from the Selbaie Mine area in the north across the Abitibi Greenstone Belt, over the Pontiac, and includes the Grenville Front. The Abitibi subprovince is host to a major proportion of Canada's mineral resources. The phase pseudosections indicate a remarkable similarity in the lower crust in each subprovince but there are indications of lower-crustal/upper mantle electrical anisotropy that may be different in each subprovince. Variations in the depth, magnitude and direction of the anisotropy could indicate differences in tectonic development. High resolution AMT soundings to 10 000 Hz were made in the 1991 survey to define upper crustal structure and to allow a better correlation with the seismic reflection results.

<sup>1</sup> Continental Geoscience Division, GSC, Ottawa

<sup>2</sup> École polytechnique, Montréal

<sup>3</sup> University of Toronto, Toronto

## STRATIGRAPHIC SEQUENCES OF THE BACK RIVER VOLCANIC COMPLEX, SLAVE PROVINCE, N.W.T.

M.B. Lambert<sup>1</sup>, D. Paul<sup>1</sup>, C. Beaumont-Smith<sup>1</sup>

Three volcano-sedimentary sequences (Innerring, Thlewycho and Boucher-Regan) represent major episodes of volcanism and construction of an Archean stratovolcano.

Dacitic to andesitic lavas and ash-flow tuffs of the Innerring succession form the upper portions of an ancestral volcano. The Thlewycho succession represents remnant flanks of a large stratovolcano built around the ancestral volcano. Its laterally variable stratigraphy depicts numerous cycles of andesitic to dacitic lava effusions, ash-flow eruptions and epiclastic/pyroclastic sedimentation. The Boucher-Regan sequence comprises subaqueous mafic lavas, late-stage felsic central eruptions and associated clastic debris.

Clastic and chemical sedimentation mark the end of each major eruptive sequence. Banded iron-formations formed (1) on the subaqueous flanks of the ancestral volcano, (2) in association with carbonate and algal muds deposited near felsic domes at the close of Thlewycho volcanism, and (3) within turbidites of the immediately overlying Beechy Lake Group.

<sup>1</sup> Continental Geoscience Division, GSC, Ottawa



## THE CERTIFICATION OF STANDARDS FOR TRACE AND MAJOR ELEMENT ANALYSIS IN GEOCHEMICAL MATERIALS

M.E. Leaver<sup>1</sup>, W.S. Bowman<sup>1</sup>, G.E.M. Hall<sup>2</sup>,  
L. Hulbert<sup>2</sup>, J.J. Lynch<sup>2</sup>

Accurate measurement of elemental concentrations is essential for mineralogical exploration. The Canadian Certified Reference Materials Project (CCRMP) has been certifying compositional reference materials (RMs) for twenty years. CCRMP in cooperation with the Geological Survey of Canada has produced a variety of geochemical reference materials, including various rocks, soils, and lake and stream sediments. In the consensus approach to certification used by CCRMP, each laboratory participating in the measurement program uses a method of its own choosing in the analysis of the candidate reference material. The results are therefore considered an example of the state-of-the-art in analysis. The results of these measurement programs will be described to demonstrate the state-of-the-art in the analysis of geochemical materials for trace and major elements.

<sup>1</sup> CANMET, Ottawa

<sup>2</sup> Mineral Resources Division, GSC, Ottawa

## THE SULLIVAN VENT COMPLEX: PRELIMINARY PETROGRAPHIC AND FLUID INCLUSION STUDIES

C.H.B. Leitch<sup>1</sup>, R.J.W. Turner<sup>1</sup>, T. Höy<sup>2</sup>

In the vent zone, minor quartz is found in abundant pyrrhotite veins or a matrix cement of calcite-pyrrhotite-chlorite-tremolite-dravite-biotite-muscovite-sphene-ilmenites, between variably chlorite, biotite, or tourmaline altered clasts in fragmental rocks ("conglomerate" and "breccia") commonly found at the base of the massive sulphide orebody. Albite-chlorite alteration, cutting earlier biotite hornfelsing or "granophyre", appears related to hydrothermal cells around Moyie gabbro sills/dykes, which are numerous in and below the deposit and likely intruded pre-, syn-, and post mineralization. Fluid inclusions in the quartz are moderate temperature (300°C) and salinity (15-32 wt.%), containing significant CaCl<sub>2</sub> and MgCl<sub>2</sub> and often saturated in NaCl. In finely laminated ore at the southeastern fringe of the overlying bedded orebody, remnant framboidal pyrite is overgrown by coarse euhedral pyrite and poikilitic garnet, magnetite and quartz; pyrrhotite is remobilized into fractures. In this zone, pegmatitic sphalerite and quartz contain inclusions of moderate temperature (165-295°C) and salinity (20-25 wt.%). Similar fluids are found in inclusions from the Sheep Creek Cu-Co deposit in Aldridge equivalent rocks of Montana.

<sup>1</sup> Mineral Resources Division, GSC, Vancouver

<sup>2</sup> B.C. Geological Survey Branch, Victoria

## THE DISTRICT-SCALE SULLIVAN-NORTH STAR ALTERATION ZONE, SULLIVAN MINE AREA, BRITISH COLUMBIA: A PRELIMINARY PETROGRAPHIC STUDY

C.H.B. Leitch<sup>1</sup>, R.J.W. Turner<sup>1</sup>, T. Höy<sup>2</sup>

Lowe Aldridge feldspathic greywacke, siltite and argillite, within a zone extending 6 km south from and stratigraphically lower than the Sullivan orebody, are variably altered to

muscovite-pyrite and tourmalinite assemblages which include variable quartz, muscovite, epidote, tourmaline, pyrite and pyrrhotite, lesser sphalerite and galena, and rare chalcopyrite and arsenopyrite. Similar alteration at the Stewwinder and North Star deposits suggests that they are expressions of the same hydrothermal system that formed the Sullivan deposit. Metamorphic grade in these rocks is middle greenschist, as indicated by the assemblage quartz-muscovite-Mg chlorite-albite-microcline-biotite-epidote-garnet, whereas Fe-chlorite appears to be retrograde. Garnet, probably manganiferous, occurs only within altered rocks and likely reflects hydrothermal Mn enrichment of the original sediment. The presence of garnet provides an indicator of altered rocks, where other macroscopic criteria are lacking. Other more restricted exploration criteria such as abundant sulphides, tourmalinite and massive non-bedded or fragmental rocks can focus exploration within the garnet-bearing zone. Albite-chlorite alteration, superposed on biotite alteration, is developed adjacent to Moyie sills. Epidote-tremolite "granophyric" alteration may also be an expression of proximity to these sills.

<sup>1</sup> Mineral Resources Division, GSC, Vancouver

<sup>2</sup> B.C. Geological Survey Branch, Victoria

## COMPUTER-ASSISTED GEOLOGICAL MAPPING IN MANITOBA - AN EXAMPLE FROM THE SHIELD MARGIN PROJECT

P.G. Lenton<sup>1</sup>, E.C. Syme<sup>1</sup>

The National Mapping Program Shield Margin Project involves compilation of the geology of the Flin Flon - Snow Lake belt using a Geographic Information System as the platform for the compilation. The project is a joint venture involving Saskatchewan Survey, Manitoba Survey and the Geological Survey of Canada with contribution from the University of New Brunswick. The compilation area straddles the Saskatchewan-Manitoba border covering an area approximately bounded by 54°N 103°W and 55°N 99°W. Compilation will be at an optimum scale of 1:100 000 but will include all available information regardless of scale. The first Manitoba component is the Elbow Lake region (NTS 64K/15), a 1:20 000 mapping project. Outcrop descriptions were recorded in the field on a portable computer using an XBase database system. Digitized UTM coordinates were added to the database and the geological contacts digitized using PAMAP GIS software. The digitized map was transferred to the GSC for production of a full colour map using ArcInfo GIS software. The digital map with databases attached will be the first Manitoba contribution to the Shield Margin compilation. Production time from the completion of mapping to printing of a colour map was approximately 3 months.

<sup>1</sup> Manitoba Geological Survey Branch, Winnipeg

## HYDROTHERMAL MICA FROM ALTERED FOOTWALL ROCKS AT THE BRUNSWICK NO. 12 MASSIVE SULPHIDE DEPOSIT, BATHURST, NEW BRUNSWICK

D.R. Lentz<sup>1</sup>, W.D. Goodfellow<sup>2</sup>

The composition of chlorite and phengitic muscovite from the sulphide feeder and peripheral hydrothermal alteration zones indicate that vein and host-rock chlorite and muscovite from the stringer zone have the same composition, but have higher Fe/(Fe+Mg) and Al and lower Mn compared to mica from the peripheral alteration zones. Paragonite also occurs in the sulphide

stringer zone and Ba is locally enriched in muscovite from this zone. The enrichment of Fe and Al in mica from altered footwall felsic volcanic and metasedimentary rocks reflects changes in the bulk composition. Tschermak substitution involving  $\text{Mg:Fe}^{2+} + \text{Si}^{4+} = 2 \text{Al}^{3+}$  exchange favors the coupled substitution of  $\text{Mg}^{2+}$  and  $\text{Si}^{4+}$  which accounts, in part, for the positive correlation between Al and Fe/(Fe+Mg) ratios in chlorite. After correcting the Fe/(Fe+Mg) ratio for tetrahedral Al, there remains a positive correlation between Al and Fe/(Fe+Mg) ratios. The Fe/(Fe+Mg) ratios in chlorite were controlled, in part, by the aFe/aMg ratios of the hydrothermal fluid, which decreased from the core of the discharge conduit now represented by stringer sulfides, to the hydrothermally altered margins of the feeder pipe. This indicates increased mixing between a Mg-depleted ore-forming hydrothermal fluid and seawater away from the center of fluid discharge.

<sup>1</sup> Mineral Resources Division, GSC, Bathurst

<sup>2</sup> Mineral Resources Division, GSC, Ottawa

### **CORRELATION OF SEISMIC REFLECTION DATA WITH GEOLOGY AT THE ANSIL MINE, ABITIBI BELT, QUEBEC**

LITHOPROBE Abitibi-Grenville transect group

As part of the LITHOPROBE Abitibi-Grenville Transect a high frequency reflection seismic experiment was carried out along an east-west profile across the Blake River Group of the Abitibi Subprovince. The main goal of the study was to obtain a 3-D image of an Archean greenstone belt. The seismic profile is located in the Noranda Mine Sequence, east of the Lake Dufault Pluton. It traverses a sequence of volcanic and intrusive rocks, which crosscuts the NNE-trending andesites and rhyolites of the Mine Sequence and the ENE oriented Hunter Creek Fault (HuCF). North of the fault the line runs parallel to WNW-trending rhyolitic and andesitic units. All the volcanic rocks are intruded by diorite and gabbro dykes. Shallow east-dipping units are seen in the Mine Sequence. North of the Hunter Creek Fault, however, the volcanic units are folded in an anticline plunging approximately at 45° to the ESE. The seismic data from the Mine Sequence are of excellent quality. A preliminary interpretation of the data, by correlation with Minnova's diamond-drill sections in the Ansil Mine area, suggests that moderately east-dipping and subhorizontal reflections correspond to volcanic and intrusive contacts.

### **NATMAP SHIELD MARGIN PROJECT: DEVELOPMENT OF AN INTERPRETIVE GEOSCIENCE DATABASE FOR THE FLIN FLON-SNOW LAKE BELT, MANITOBA AND SASKATCHEWAN**

S. Lucas<sup>1</sup>, A. Leclair<sup>1</sup>, R. Stern<sup>1</sup>, P. Lenton<sup>2</sup>, A.H. Bailes<sup>2</sup>, E.C. Syme<sup>2</sup>, D. Thomas<sup>3</sup>, B. Reilly<sup>3</sup>, W. Slimmon<sup>3</sup>

The NATMAP Shield Margin Project is designed to generate new perspectives of the Flin Flon-Snow Lake Belt (Manitoba and Saskatchewan) and its sub-Paleozoic continuation. The project is a cooperative venture involving the Manitoba and Saskatchewan Geological Surveys, the Saskatchewan Research Council, the Geological Survey of Canada (GSC), universities, and the mineral exploration industry. Principal project goals include: (1) construction of a digital geoscience database including compilation of both new and existing data; and (2) development of an interpretive geological map for the sub-Paleozoic

continuation of the belt. Bedrock geological mapping is being undertaken by both provincial surveys with field-based digital data entry. Detailed geochronological, isotopic, structural and metamorphic studies are being led by the GSC and participating universities. A program to systematically examine drillcore of Precambrian rocks south of the shield margin has been established to aid the interpretation of sub-Paleozoic geology. Surficial mapping, till sampling and compilation of existing data have also been initiated; this work will contribute to the geoscience database and be used for both mineral potential and environmental studies.

<sup>1</sup> Continental Geoscience Division, GSC, Ottawa

<sup>2</sup> Manitoba Energy and Mines, Winnipeg

<sup>3</sup> Saskatchewan Geological Survey, Regina

### **CHEMICAL COMPOSITION OF VENT AND PORE FLUIDS IN AN ACTIVE HYDROTHERMAL DISCHARGE ZONE, MIDDLE VALLEY**

J.W. Lydon<sup>1</sup>, W.D. Goodfellow<sup>1</sup>, D.C. Grégoire<sup>1</sup>

Eleven vents sampled by ALVIN over the 600 m x 400 m AAV vent field show consistent discharge temperatures of 265°C±5 and Mg-free end-member compositions of: (in mmol) Ca 81, Na 430, K 18, B 1.75, Cl 600; (in %mol) Mn 60, Ba 9, Rb 25, Sr 225, Al 20, Ni 5, Co 0.1. A vent near the Bent Hill sulphide mound has different cation ratios and shows a time-dependent compositional variability explainable by dilution by fresh water, possibly thermally-released clay interlayer water. Pore fluid compositions to 10 metres depth show vertical and lateral subsurface dispersal of hydrothermal fluid that progressively change in composition due to the precipitation of calcite, barite and anhydrite, and mixing with downward convecting seawater around active vents. The results indicate that the AAV vent field is fed by a single hydrothermal reservoir located in the sediment pile which is different from the multiple reservoir system feeding the Bent Hill vent. Furthermore, the current vent fluids are cooler and chemically distinct from those that precipitated sulphides during an earlier hydrothermal stage.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

### **CHEMICAL STRATIGRAPHY AND CORRELATION IN THE BEDDED ORES OF THE SULLIVAN DEPOSIT**

J.W. Lydon<sup>1</sup>, N.C. Reardon<sup>1</sup>

The bedded ores of the Sullivan deposit, as with many other Sedex deposits, are characterized by beds of laminated sulphides, the origin of which is of importance to genetic models for Sedex deposits in general. Macroscopic correlation using photographic logs of drill core and microscopic correlation using SEM traverses of selected intervals of ore stratigraphy suggests that at least four processes contribute to the formation of laminae. Debris flows and turbidite flows originating on the flanks of an elevated vent complex are more prevalent in the lower part of the mine stratigraphy. Rhythmic precipitation from the water column, either from a buoyant hydrothermal plume or a brine pool, is responsible for laminations of sphalerite. Periodic concentration of carbonate and manganese at specific stratigraphic horizons, is probably related to the early diagenetic upward mobilization of these components to the sediment-water interface. Subsurface intergranular precipitation and replacement of carbonate and sulphides during diagenesis can explain much of the pyrrhotite distribution.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

## TECTONIC CONTEXT FOR MINERALIZATION IN THE CENTRAL CAPE BRETON HIGHLANDS, NOVA SCOTIA

G. Lynch<sup>1</sup>, C. Tremblay<sup>1</sup>

Three distinct styles of mineralization in the central Cape Breton Highlands are directly related to, or have been strongly affected by Acadian deformation:

1. Imbricate thrusting and steep angle reverse faulting characterize the principal phase of Devonian contractional deformation. Mesothermal quartz-carbonate-pyrite gold veins occupy shallow-dipping to flat lying tension gashes developed in the proximity of large reverse faults. The veins have a geometry and orientation which suggest a relationship to the reverse faults.
2. Late Devonian crustal extension features shallow-dipping mylonite zones. Concordant polymetallic base metal Cu-Zn-Pb lenses, contained within Silurian arc assemblages, have been affected by the extensional shear, resulting in extensive recrystallization, metamorphism, and late arsenopyrite enrichment. A primary exhalative origin may be speculated for the deposits, but remains ambiguous due to the effects of deformation.
3. Widespread late Devonian high level felsic plutons were emplaced in the extending crust. These locally display features of hydrothermal brecciation, and intense stockwork veining. Zoned systems display potassic, phyllic, and argillic alterations, and abundant pyrite.

<sup>1</sup> Quebec Geoscience Centre, Sainte-Foy

## LANDSAT THEMATIC MAPPING WITH GROUND TRUTH ELEMENT DISTRIBUTION: AN EXAMPLE FROM BRITISH COLUMBIA'S GOLDEN TRIANGLE DISTRICT

J. Ma<sup>1</sup>, S.B. Ballantyne<sup>1</sup>

Landsat TM data have been processed to map limonitic and altered rock exposures in arid and semi-arid regions. Our study has successfully mapped similar rocks, specific lithologic units and structural features in the rugged and ice-field covered Sulphurets-Brucejack Lake project area. Precious metal and gold enriched porphyry deposit exploration has recently focused on quartz-pyrite-sericite zones found within lithogeochemical anomalies of silica, sulphur and potassium.

Ice and snow, alpine and valley vegetation and shadows occupy 32%, 35% and 7% of the scene respectively. Separate theme images for each were created and then excluded by masking so that striking results for exposed bedrock were achieved. In the 3 band colour composite image using PC 5, 4, 3 (red, green, blue), limonitic and altered zones appear as bright yellow pixels, syenite and granodiorite appear as blue and purple and unaltered rock units are light brown.

The high pass filtering of TM band 5 and TM band 5, 4, 3 colour composite images delineate lineaments and a 20 kilometre diameter circular feature. An eleven theme image-map was developed using supervised classification methods.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

## THE BRITISH COLUMBIA EXPERIENCE IN MINERAL RESOURCE ASSESSMENT

G.P. McLaren<sup>1</sup>

Mineral resource assessments now play an important role in British Columbia's complex land-use debate. Mineral potential maps are standard products of geological mapping projects, however British Columbia's recent initiatives to complete the provincial park system provide a strong focus, supported in legislation, on assessing subsurface resources prior to park creation.

A systematic approach to assessing and communicating mineral potential information was developed during a detailed mineral resource assessment of the Chilko Lake area. This study comprised detailed stream sediment geochemical surveys, geological mapping and extensive prospecting. A mineral potential classification, based on field data satisfying criteria for metallogenic models, communicates mineral potential rankings for land-use planning and for guidance in exploration.

Similar assessments are being undertaken in other candidate parks. Information gained will assist in excluding known mineral values from park status, in early land-use planning and will provide greater assurances in government decision making. Experience demonstrates that resource assessment data must be based on rigorous, geoscientific field work but must be presented in succinct, clear and non-technical terms to have the greatest benefits in land-use planning.

<sup>1</sup> B.C. Ministry of Energy, Mines and Petroleum Resources, Victoria

## REFLECTION SEISMIC STUDIES AT SELBAIE MINES, QUEBEC: PRELIMINARY RESULTS

B. Milkereit<sup>1</sup>, L. Reed<sup>2</sup>, C. Spencer<sup>1</sup>, A. Barnes<sup>3</sup>  
(for LITHOPROBE study group)

Selbaie Mines is located in the Harricana-Turgeon belt in northern Quebec and is well-known for its Cu-Zn-Au-Ag-deposits. As part of the LITHOPROBE Abitibi-Grenville transect two high frequency Vibroseis seismic reflection surveys were conducted around the active (and noisy) mine site. Reflection seismic profiling for shallow crustal structures requires special acquisition and processing parameters. Short shot-receiver offsets, high seismic frequencies (up to 140 Hz), and high stacking fold (up to 120) are necessary to overcome poor signal-to-noise ratios in a crystalline environment. Accurate refraction static corrections and DMO-processing are necessary to preserve the high frequency content of the data, to improve stacking velocity estimates, and to image steeply dipping structures. A first interpretation of the data, by correlation with detailed surface geological information, suggests that an important east-dipping structure has been imaged at depth; other prominent reflections may be associated with diabase dykes.

<sup>1</sup> Continental Geoscience Division, GSC, Ottawa

<sup>2</sup> BP Resources, Toronto

<sup>3</sup> École Polytechnique, Montreal

## GEOLOGICAL MAPS OF CANADA: THEIR HISTORY AND EVOLUTION

W.C. Morgan<sup>1</sup>, B. Chen<sup>1</sup>, O.E. Inglis<sup>1</sup>, and P. Corrigan<sup>1</sup>

As part of its 150<sup>th</sup> Anniversary, the Geological Survey of Canada is preparing an exhibit to illustrate some aspects of the history and evolution of geological maps of Canada. The maps are being chosen to illustrate the spread of geographical and geological exploration across what is now Canada. Advances in geoscientific knowledge as well as the dramatic changes in cartographic techniques from early hand-colouring to modern computer-generated digital colour are depicted. The present poster provides a selection of maps from that exhibit showing 1) The World, North America, and Canada; 2) Newfoundland; and 3) The Canadian Shield, Labrador.

The GSC is initiating a reprint series of selected early geological maps of Canada suitable for framing.

<sup>1</sup> Geoscience Information Division

## MISE-À-LA-MASSÉ STRUCTURAL MAPPING OF THE VICTORIA GRAPHITE DEPOSIT, ONTARIO

C.J. Mwenifumbo<sup>1</sup>

A number of mine development holes were drilled in 1989 at the Victoria Graphite deposit, Smiths Falls, Ontario, to obtain information for planning a small scale open pit operation. The geological and resistivity logs indicated several highly conductive, high grade graphite ore lenses within a broad graphitic horizon. Some of these ore lenses could also be mapped on the surface in trenches. Hole-to-hole and surface-to-hole correlations of these graphite ore lenses were not obvious and were sometimes ambiguous. In some situations multiple graphite lenses were intersected in one hole while an adjacent hole had only one intersection. By successively electrically energizing the different graphite lenses, drillhole mise-à-la-masse measurements were made in several holes to determine the interrelationship of the different graphite ore lenses. This established the geometry and structural setting of the deposit. Information from mise-à-la-masse measurements made a significant contribution in planning the mine development.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

## APPLICATION OF BOREHOLE GEOPHYSICS TO MASSIVE SULPHIDE EXPLORATION: SEWELL BROOK, NEW BRUNSWICK

C.J. Mwenifumbo<sup>1</sup>, A. Cinq-Mars<sup>1</sup>, P.G. Killeen<sup>1</sup>

Borehole geophysical measurements were made in five holes at the NovaGold Sewell Brook lead-zinc-copper massive sulphide discovery. The parameters logged included resistivity, induced polarization (IP), self potential (SP), magnetic susceptibility (MS), natural gamma ray spectrometry (NGRS), spectral gamma gamma (SGG), and temperature. Preliminary interpretation of the data indicates that economic sulphides can be accurately located in drillholes by SGG measurements. Resistivity, IP and SP logs locate sulphide mineralization as well but do not correlate well with sulphide concentration. The conductivity of the sulphides is low because of the high content of sphalerite which is a poor electrical conductor. The NGRS data

accurately map changes in lithology and alteration. Alteration comprises mainly chloritization, silicification and pyritization. NGRS data promise to be important for mapping these alterations and hence for mapping favourable horizons of sulphide mineralization. Because of the high thermal conductivity of the sulphides, especially sphalerite, the temperature and temperature gradients at this deposit are highly anomalous and could be useful as an exploration tool.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

## AN OVERVIEW OF REGIONAL GEOLOGICAL, METALLOGENIC AND GEOCHEMICAL SURVEYS IN THE PROVINCE OF NOVA SCOTIA WITH IMPLICATIONS FOR MINERAL RESOURCE POTENTIAL

Nova Scotia Department of Natural Resources

Work conducted by the staff of the Nova Scotia Department of Natural Resources has been directed at providing an up-to-date data base for the evaluation of the mineral resource potential of the province, including both metallic and industrial minerals. This work includes: (1) field-based studies of all aspects of the provincial geology, (2) mineral inventory compilation, (3) public awareness and education and (4) policy making and implementation. Consequently, the projects both completed and ongoing, reflect these long-term goals and include: (1) regional-scale mapping (bedrock and pleistocene) on the mainland (e.g., South Mountain Batholith, Carboniferous basins) and Cape Breton (e.g., Cape Breton highlands); (2) regional- (e.g., stream, lake) and deposit- (e.g., Yava Pb-Zn, Dominique Sn-Cu-Zn) scale surficial geochemical studies; (3) mineral deposit studies (e.g., Meguma gold, East Kemptville Sn, redbed Cu, Gays River Pb-Zn); (4) industrial mineral evaluation (e.g., gypsum, limestone, aggregate); (5) core-storage facilities for collecting and storing diamond drill core from exploration projects; and (6) establishment of a geological reference database (i.e., GEOSCAN). A summary of the work completed over the past several years will be presented along with highlights of some of the products which illustrate the wide spectrum of resources within the province and the potential for sustaining our mineral wealth.

## GLACIAL DISPERSAL OF GOLD IN THE EASTMAIN RIVER AREA, QUEBEC

M. Parent<sup>1</sup>

The Aupapiskach and Natel lakes area (33 B/4) is underlain by a segment of the Eastmain River greenstone belt. The study area includes several gold showings, which occur mainly within amphibolite bedrock. A single ice-flow direction, towards WSW, has been recognized in the region. Detailed sampling (60 samples/km) was carried out downglacier from a narrow mineralized zone. The gold content of the silt + clay fraction of till was measured by neutron activation techniques. Preliminary results indicate that the measured concentrations are reproducible, at least in the analyzed grain size fraction, and that the gold anomalies can be traced over a downglacier distance of several hundred metres. However, this clastic dispersal undergoes very rapid dilution.

<sup>1</sup> Québec Geoscience Centre, Sainte-Foy



## VIZIEN GREENSTONE BELT: WELL-PRESERVED SUPRACRUSTAL ROCKS WITHIN PLUTONIC TERRANES OF THE MINTO BLOCK, NORTHEASTERN SUPERIOR PROVINCE

J.A. Percival<sup>1</sup>, K.D. Card<sup>1</sup>

Although mainly composed of plutonic and high-grade metamorphic rocks, the Minto block also contains lower-grade rocks in the Goudalie domain, which consists dominantly of tonalitic gneisses enclosing the Vizion greenstone belt. The WNW-striking belt, about 40 x <10 km, consists of volcanic (mafic, intermediate, felsic), sedimentary (pelite, quartzite, conglomerate), and intrusive (peridotite, gabbro, tonalitic porphyry) units forming four discrete, fault-bound, steeply NE-dipping lithotectonic panels. From the structural base, these include: 1) a mafic to felsic volcanic sequence, capped by sedimentary rocks; 2) a panel of ultramafic- to mafic intrusions and schists, cut by tonalitic porphyry; 3) a NW-plunging antiform of interlayered felsic and mafic volcanic rocks; and 4) a panel of schistose, mainly mafic rocks of mixed volcanic and intrusive origin. Mineral assemblages in volcanic rocks of panels 1 and 2, including cordierite-anthophyllite and garnet-muscovite-sillimanite, define mid-amphibolite metamorphic conditions and suggest syngenetic alteration, possibly in a massive sulphide-forming environment. Tourmaline in mafic rocks and quartz veins could indicate gold potential.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

## PARTITIONING OF AS, NI AND U IN WALLROCK SAMPLES FROM OPEN PIT MINES, ATHABASCA BASIN, NORTHERN SASKATCHEWAN

J.B. Percival<sup>1</sup>

Environmental concerns related to the decommissioning of mine sites have focused on potential problems arising from the in situ leaching of heavy metals from waste rock piles and tailings. However, surficial alteration of wallrock in abandoned open pit mines may also contribute heavy metals directly to the groundwater.

A suite of wallrock samples from two abandoned open pits in the Athabasca basin was subjected to a series of partial extractions to leach metals associated with (1) exchangeable sites, (2) carbonates and easily-acid soluble sites, (3) uraninite, sulphides and organics, (4) amorphous Fe-oxides, (5) crystalline Fe-oxides and (6) residual minerals. The preliminary results indicate that under weathering conditions (i.e., pH 5.5-7) exchangeable, carbonate-bound and easily-acid soluble As and U may be released into the environment. Nickel appears to be more strongly bound owing to its association with Fe-oxides and residual minerals. The total contribution to pit waters and the fate of these metals requires assessment as part of the decommissioning strategy of the mines.

<sup>1</sup> Continental Geoscience Division, GSC, Ottawa

## CLAY MINERAL CHARACTERIZATION OF ACTIVE HYDROTHERMAL DEPOSITS, MIDDLE VALLEY

J.B. Percival<sup>1</sup>, D.E. Ames<sup>1</sup>

Actively venting chimneys (<276°C) at the High Heat Flow and Bent Hill areas have a clay-rich core typically 2 mm wide with finely disseminated sulphide and an outer zone (>10 cm) dominated by anhydrite.

In the High Heat Flow area, samples from the Dead Dog chimney (261°C) are characterized by smectite and anhydrite whereas in the Heineken Hollow (180°C) poorly crystalline smectite occurs. Heineken Hollow is a depressed area, 3-5 m diameter, with diffuse hydrothermal fluid flow with a central small chimney. At the Central site (257°C) a milky white gel-like clay occurs in the mound adjacent to an active chimney. This gel-like clay is composed of smectite (saponite?) and a serpentine (lizardite-like) mineral. The serpentine was identified by x-ray diffraction after a 550°C heat treatment of the oriented clay slide. Anhydrite, talc (observed in thin section) and a regularly interstratified illite/smectite mixed layer mineral occur in samples from the Inspired Mounds (254°C). In the Bent Hill area, anhydrite and gypsum dominate the sample; no clay minerals were observed.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

## GEOCHEMISTRY AND STABLE ISOTOPE COMPOSITION OF THE WINDY CRAGGY CU-CO MASSIVE SULPHIDE DEPOSIT, NORTHWESTERN BRITISH COLUMBIA

J.M. Peter<sup>1</sup>, S.D. Scott<sup>2</sup>

The Windy Craggy Cu-Co massive sulphide deposit is located in northwestern British Columbia within intercalated argillite and tholeiitic volcanic flows and sills of Upper Triassic age. There are at least two discrete sulphide lenses. Feeder pipe/stockwork mineralization is associated with each lens and consists of a complex network of sulphide-quartz-chlorite veins. Two types of alteration occur within the feeder system: 1) chloritization, which is isovolumetric and 2) silicification, which is characterized by significant volume increase. Fluid inclusion microthermometry of primary, two-phase, aqueous inclusions in quartz-sulphide veinlets from the stockwork gives homogenization temperatures ranging from about 140 to 370°C, and salinities between 6 and 17 eq. wt% NaCl. Values of  $\Sigma^{34}\text{S}_{\text{CDT}}$  for most sulphides range between -1.5‰ and +3.0‰ and indicate that sulfur was leached from the underlying basalts. Carbon and oxygen isotope composition of calcite and siderite within massive mineralization gives  $\Sigma^{13}\text{C}_{\text{PDB}}$  values between -5.0‰ and +6.0‰ and  $\Sigma^{18}\text{O}_{\text{SMOW}}$  values between +7.6‰ and +23.2‰. These values indicate a marine carbon source or a mixed magmatic and marine source. The fluid inclusion salinities and calculated positive  $\Sigma^{18}\text{O}$  values for the hydrothermal fluid are best explained by the interaction of seawater with subsurface sedimentary rocks, although evaporitic processes within a basin cannot presently be ruled out.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

<sup>2</sup> University of Toronto, Toronto

## GROUND PENETRATING RADAR SURVEYS FOR QUATERNARY GEOLOGY STUDIES AND MINERAL EXPLORATION IN CENTRAL BRITISH COLUMBIA

J.A. Pilon<sup>1</sup>, A. Plouffe<sup>1</sup>, A.S. Judge<sup>1</sup>, S.B. Ballantyne<sup>2</sup>

In September 1991, a series of experimental ground penetrating radar (GPR) surveys were conducted in central British Columbia to assess the capability of the instrument to define detailed Quaternary deposit characteristics and to image the upper part of the subjacent mineral deposits. These surveys were conducted at 50 and 100 MHz. Two claimed properties were surveyed: Mount Milligan (Placer Dome)

where subsurface characteristics are well known from drilling, and AOK prospect (Takla Star Resources Ltd.) currently defined only as an aeromagnetic anomaly. Ground penetrating radar seems to be useful to determine character and thickness of overburden in those areas. Preliminary study of the profiles obtained with the ground penetrating radar indicates that the following features could be detected by the instrument: (1) stratigraphy within the unconsolidated surficial sediments, (2) contact between the bedrock and the surficial sediments, and (3) shallow structures such as faults and fractured zones within the bedrock. Typical depths of penetration were in excess of 20 m at Mount Milligan and 30 m at the AOK prospect.

<sup>1</sup> Terrain Sciences Division, GSC, Ottawa

<sup>2</sup> Mineral Resources Division, GSC, Ottawa

### QUATERNARY STRATIGRAPHY AND HISTORY, CENTRAL BRITISH COLUMBIA

A. Plouffe<sup>1</sup>

This poster documents some of the Quaternary stratigraphy along Klawli and Nation rivers in central British Columbia. The oldest sediments exposed are glaciotectionized glaciolacustrine deposits which are overlain by a pre-Fraser till. Distal outwash or deltaic sand separates this lower till from the upper till attributed to the Fraser Glaciation. Retreat of Fraser Glaciation ice was marked by the impounding of a glacial lake in Nation River valley, which is indicated by the thick accumulation of glaciolacustrine rhythmites (varves?). A smaller local glacial lake also formed in Klawli River valley. Work under progress includes study of till geochemistry and petrography as an aid in interpreting direction and distance of glacial transport. Such data will form a basis for applied geochemical exploration using surficial materials.

<sup>1</sup> Terrain Sciences Division, GSC, Ottawa

### STRATIGRAPHY OF THE UPPER GLENELG FORMATION AND ITS RELATIONSHIP TO SEDIMENT-HOSTED COPPER MINERALIZATION IN THE MINTO INLIER, VICTORIA ISLAND

R.H. Rainbird<sup>1</sup>, W. Darch<sup>2</sup>, C.W. Jefferson<sup>3</sup>, R. Lustwerk<sup>2</sup>,  
M. Reese<sup>2</sup>, K. Telmer<sup>4</sup>, T. Jones<sup>5</sup>

Disseminated Cu-Co-Fe sulphides are stratabound in the upper clastic member of the late Proterozoic Glenelg Formation near Hadley Bay, Victoria Island. Here we report preliminary results of regional mapping, paleocurrent, isopach and petrographic studies which will attempt to relate mineralization to basin development and architecture. Preliminary work in 1991 confirms the three-fold subdivision of the Glenelg Formation proposed by G. M. Young. The lower clastic member consists of poorly exposed deep-water mudstones with rare turbiditic sandstone intercalations. It is overlain by shallow water carbonates of the cherty dolostone member (~400 m). A sporadic karstic topography developed on the carbonates is correlated with a similar surface within the Rae Group near Coppermine 450 km southeast, but is absent in the Brock Inlier 300 km farther west. This surface has been infilled by the upper clastic member (200-300 m), a coarsening upward succession of siliciclastic rocks interpreted as a northwesterly prograding

fluvio-deltaic complex. Marine inundation reworked the uppermost quartzarenites and deposited a distinctive, regionally extensive stromatolite biostrome which caps the formation.

<sup>1</sup> Continental Geoscience Division, GSC, Ottawa

<sup>2</sup> Noranda Exploration Co. Ltd., Winnipeg

<sup>3</sup> Mineral Resources Division, GSC, Ottawa

<sup>4</sup> University of Ottawa, Ottawa

<sup>5</sup> Cambrian College, Sudbury

### INTEGRATING GEOLOGICAL DATA IN A GEOLOGICAL INFORMATION SYSTEM ENVIRONMENT FOR MINERAL RESOURCE POTENTIAL MAPPING IN SNOW LAKE, MANITOBA

R.K.T. Reddy<sup>1</sup>, G.F. Bonham-Carter<sup>1</sup>, D.F. Wright<sup>1</sup>

A digital spatial database was established in a GIS environment (SPANS) for the File Lake map area in the Snow Lake area, Manitoba. These data included bedrock geology, lake sediment geochemistry, airborne magnetics, airborne gravity, Landsat TM, and mineral deposits.

These data were incorporated into GIS-based predictive models evaluating volcanogenic massive sulphide (VMS) resource potential. These models can be classified as data driven and knowledge driven. The data driven models—Bayesian Weights of Evidence, Decision Tree and Weighted Logistic Regression—require the presence of mineral deposits in the study area but provide an objective evaluation. The knowledge driven model uses an inference net for a VMS deposit model to link it with various types of mapped evidence to produce a hypothesis "favourable for VMS mineralization". The rules for combining evidence are similar to PROSPECTOR, including fuzzy logic and Bayesian updating. All models produce as a final output a map showing variation in VMS potential.

Future work involves incorporating new data collected through the EXTECH program including till geochemistry, lake sediment, geochemistry, airborne radiometrics, airborne VLF and Digital elevation models to enhance existing models.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

### HARRISONITE, $\text{Ca}(\text{Fe}^{2+}, \text{Mg})_6(\text{SiO}_4)_2(\text{PO}_4)_2$ , A NEW GRANULITE-FACIES ROCK-FORMING MINERAL FROM ARCEDECKNE ISLAND, DISTRICT OF FRANKLIN, ARCTIC CANADA

A.C. Roberts<sup>1</sup>, J.A.R. Stirling<sup>1</sup>, J.D. Grice<sup>2</sup>, T. Frisch<sup>3</sup>,  
R.K. Herd<sup>1</sup>, J.L. Jambor<sup>4</sup>

Harrisonite, ideally  $\text{Ca}(\text{Fe}^{2+}, \text{Mg})_6(\text{SiO}_4)_2(\text{PO}_4)_2$ , is a minor but relatively widespread constituent of an iron silicate-quartz-apatite layered body found in granulite facies gneisses on Arcedeckne Island, off northern Boothia Peninsula, District of Franklin, Arctic Canada (latitude 71°54'N, longitude 95°23'W). Harrisonite occurs as both individual, discrete equidimensional grains and as rims around fayalite; associated minerals are quartz, almandine, ferrosillite, fluorapatite, biotite, ilmenite, zircon and monazite-(Ce). Individual grains are anhedral, are varicoloured from yellow-brown to orange-brown, average between 0.2 and 0.5 mm in size, and have a distinctive conchoidal fracture. Physical, chemical, optical and crystallographic properties are tabulated. The mineral name honours

the late Dr. James M. Harrison, former Director of the Geological Survey of Canada, for his many outstanding contributions to Canadian geoscience.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

<sup>2</sup> Mineral Sciences, Canadian Museum of Nature, Ottawa

<sup>3</sup> Continental Geoscience Division, GSC, Ottawa

<sup>4</sup> CANMET, Ottawa

### **STRUCTURE OF THE KENO HILL QUARTZITE: THE EVOLUTION OF GEOLOGICAL SURVEY OF CANADA MAPPING IN THE CENTRAL YUKON**

C. Roots<sup>1</sup>, D. Murphy<sup>1</sup>, R.I. Thompson<sup>1</sup>, D.J. Tempelman-Kluit<sup>1</sup>

Placer gold was discovered in the Keno Hill area about 1895 and argentiferous veins were vigorously sought after 1919. Since Hugh Bostock's original mapping of the regional extent of the quartzite and enveloping schists, the interpretation of age and regional structure has swung widely. The evolution of thought concerning these units illustrates the determination of GSC and other workers to grapple with a structurally complex area.

During regional mapping in the late fifties these rocks were believed to be a Precambrian sheet some 15 000 m thick. In the sixties recumbent folds and thrusts were inferred within the Keno Hill quartzite, and it was traced 300 km westward to the Tombstone area, where its true thickness is 330 m and a Cretaceous age was proposed. In 1985 a limestone horizon within the quartzite yielded a Mississippian conodont, and the far-travelled Tombstone thrust sheet was recognized. Recent studies have concentrated on complex polyphase folding and the proposed genetic link between mineralized veins and Cretaceous plutonism toward a new geological framework for central Yukon.

<sup>1</sup> Cordilleran Division, GSC, Vancouver

### **GEOLOGY AND ALTERATION OF AJAX WEST PORPHYRY CU, AU OREBODY, AFTON MINE, KAMLOOPS, BRITISH COLUMBIA**

K.V. Ross<sup>1</sup>, K.M. Dawson<sup>2</sup>, C.I. Godwin<sup>1</sup>, L. Bond<sup>3</sup>

The Ajax West orebody, on the southeastern side of the alkalic Iron Mask batholith, was developed on copper-gold mineralization at the intersection of three major rock units: two dioritic units of the Iron Mask pluton and a picritic unit of uncertain origin. Porphyry style mineralization is mainly pyrite and chalcopyrite with minor amounts of bornite and chalcocite. Alteration includes intense albitization and less intense K-feldspar, epidote and chlorite ± anhydrite and diopside.

Field work consisted of pit mapping at 1:750 scale and detailed core logging of representative sections. Eleven major lithologies are recognized and arranged in a preliminary chronological order, from oldest to youngest: 1) picrite, 2) monzodiorite, 3) Sugarloaf diorite, 4) pyroxene gabbro, 5) hybrid diorite, 6) pegmatitic hybrid diorite, 7) dioritic dykes, 8) plagioclase porphyry dykes, 9) Cherry Creek monzonite dykes, 10) magnetite-rich dykes and 11) quartz-eye latite dykes.

Future work will refine descriptions of the lithologies and explain alteration and structural relationships.

<sup>1</sup> University of British Columbia, Vancouver

<sup>2</sup> Mineral Resources Division, GSC, Ottawa

<sup>3</sup> Afton Operating Corp., Kamloops

### **ROCK ANALYSIS BY X-RAY FLUORESCENCE**

R.M. Rousseau<sup>1</sup>, C. Veys<sup>1</sup>

The analyst who wishes to analyze rock samples by X-ray fluorescence (XRF) spectrometry will have to solve, at least, four major problems: sample preparation, correction for matrix effects, calibration and availability of appropriate software for concentration calculations. A solution to each of these problems will be proposed and discussed.

The preparation of rock samples as fused disks fulfills all the requirements of accurate XRF analysis.

The Lachance-Traill (LT) algorithm combined with theoretical binary influence coefficients is used for the correction of matrix effects. Corrections for the flux and volatile products are taken into consideration. The application of this theoretical LT method is adapted to experimental reality by an appropriate and efficient calibration process.

There is no need to use a large computer, nor to buy long complicated programs to apply the method. The computer program called CiLT will be proposed as a solution. With it, any IBM-PC or compatible can adequately serve for all computations.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

### **CONCEPTUAL MODELS AS A PART OF RESOURCE EVALUATION OF NUCLEAR ENERGY MINERALS AT THE GEOLOGICAL SURVEY OF CANADA**

V.R. Ruzicka<sup>1</sup>

Knowledge of nuclear energy mineral resources is an important component in formulation of Canadian nuclear energy policy, as Canada is the world leading producer and exporter of uranium and an important member of international nuclear energy organizations. Uranium resource evaluation consists of appraisals of identified mineable resources in metallogenic domains and of estimation of their potential.

Conceptual genetic models, which are of a regional and of a deposit scale, are demonstrated in the context of the appraisal of deposits associated with the sub-Athabasca unconformity. The deposits are spatially related to Archean high-heat uraniferous granitoid domes, which are flanked by Aphebian metasedimentary suites including layers of euxinic rocks. The metamorphosed basement complexes are unconformably overlain by unmetamorphosed Helikian clastic rocks. The structurally controlled mineralization took place at stationary redox fronts.

The resources are quantified by computer-assisted methods, by extrapolation of identified geological attributes, by crustal abundance methods, by a modified MIMIC method and by subjective probability estimations.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

# GEOLOGICAL AND GEOCHEMICAL CLASSIFICATION OF GRENVILLE-TYPE ZINC OCCURRENCES, ONTARIO AND QUEBEC

A.L. Sangster<sup>1</sup>

Structurally complex, stratiform, marble-hosted zinc occurrences in the Central Metasedimentary Belt can be subdivided into 4 types based on lithological association, composition and  $\delta^{34}\text{S}$  composition of contained sphalerite as follows:

to 350°C. Late-stage, Mg-rich chlorite appears to correlate with the collapse of the hydrothermal system and an influx of cold seawater. Mineralization at the Old Mine consists of massive to semi-massive pyrite and chalcopyrite with minor sphalerite. Sulphur isotope ratios range from 2.3 to 6.5 per mil. Transported sulphides, resembling ore from the Buchans Mine are exposed locally. One occurrence contains Zn grades up to 12% and sulphur isotope ratios range from 1.1 to 1.8 per mil and likely represent debris from the adjacent 3B Zone.

<sup>1</sup> University of Waterloo, Waterloo

<sup>2</sup> Mineral Resources Division, GSC, Ottawa

OCCUR. TYPE	HOST ROCKS	ASSOCIATED ROCKS	MAJOR ELEMENTS	TRACE ELEMENTS	$\delta^{34}\text{S}$ sph ‰	EXAMPLE
TYPE I	Calc-silicate rock	Metavolcanic-gneisses	Zn-Pb-Ag-Au	NA	near 0	New Calumet
TYPE II	Siliceous dolomite marble	Dolomite marble with associated volcanic rocks	Zn±Ba±(Pb)	Ng-Cd	near 0	Renfrew, Spry
TYPE III	Dolomitic to siliceous dolomite marble	Calcite marble	Zn±(Pb)	Hg-Cd	6-12	Long Lake, Slave Lake, Lafontaine, Leitch, Bouchette
TYPE IV	Siliceous dolomite marble	Dolomite marble with no associated volcanic rocks	Zn±(Pb)	Hg-Cd	11-17	Salerno Lake, Balmat
NA = not available						

The classification supports existing theories of origin for these deposits; volcanogenic for Type I occurrences and sedimentary exhalative from carbonate basin brines for Types II, III, and IV. The differences in isotopic composition of sulphur suggest a mixed and local sulphur source; dominantly from volcanic lithologies intercalated with carbonated for Type II, from both carbonate and volcanic lithologies for Type III and dominantly from carbonate rocks for Type IV. Their settings mimic the interpreted sulphur source; Types I and II are in areas of metavolcanic rocks, Type II marginal to exposed volcanic rocks and Type IV in sedimentary basins (evaporitic).

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

## AN ALTERATION AND SULPHUR ISOTOPE STUDY OF THE PILLEY'S ISLAND MASSIVE SULPHIDE DEPOSIT, CENTRAL NEWFOUNDLAND

F. Santaguida<sup>1</sup>, M.D. Hannington<sup>2</sup>, C. Jowett<sup>1</sup>

Massive sulphides on Pilley's Island have been studied at the Old Pilley's Island Mine and in a new sulphide zone (3B Zone). The deposits occur within a 200m thick, shallowly-dipping sequence of altered felsic volcanics which are well exposed at surface and in more than 24 km of drill core. The sulphide horizons are enclosed by a zoned alteration envelope of stockwork-associated chlorite with widespread quartz-sericite + K-feldspar. Several stages of chlorite are recognized and mineralization is most closely associated with a distinct, Fe-rich chlorite. Application of a chlorite geothermometer indicates thermally intensifying hydrothermal activity from 240°C

## MINERALIZATION AND DIAGENESIS RELATIONSHIPS – DOLOMITIZATION AT THE GAYS RIVER PB-ZN DEPOSIT, NOVA SCOTIA

M. Savard<sup>1</sup>

The Gays River Pb-Zn deposit is hosted by the Gays River Formation (Viséan), a thin dolomitic horizon which lies between clastic rocks of the underlying Meguma Group, and the younger evaporites of the Carrolls Corner Formation.

A pervasive early, anhedral, replacive micro-dolomite mainly composes the dolostones. It post-dates marine cementation, and precedes dolomite cementation, microscale brecciation and fracturing, mineralization, calcite cementation and stylolitization. The replacive dolomite has  $\delta^{18}\text{O}$ -values as low as -9 ‰ (PDB) which is markedly lower than that for estimated Viséan marine dolomites (0 to +4 ‰), and even lower than theoretical signals for mixed-water dolomites (-4 to -6 ‰). Moreover, its 0.3 to 1.1 and 0.1 to 0.4 (weight %) for Fe and Mn are much higher than the average contents of modern surficial dolomites. These geochemical attributes do not support a simple dolomitization in a hypersaline or mixed water system as advocated in other studies. Instead,  $^{18}\text{O}$  depletion and Fe and Mn enrichment suggest direct dolomitization or re-equilibration of early dolomites by hot, possibly mineralizing (?) fluids.

<sup>1</sup> Quebec Geoscience Centre, Sainte-Foy



## GEODATA FROM GREENLAND

H.K. Schønwandt<sup>1</sup>

Since 1946, Geological Survey of Greenland (GGU) has been carrying out systematic base mapping of the land portions of the country. In addition, the GGU has embarked on many special projects related to economic minerals, including hydrocarbon projects on and off-shore.

The GGU is also responsible for the archiving and public access to company work reports, samples and diamond drill core submitted in respect to mineral concessions.

An overview will be presented of the available maps, regular reports and bulletins, special reports and databases as applicable to the scientific sector and the mineral industry.

<sup>1</sup> Geological Survey of Greenland

## SEDIMENTOLOGICAL AND GEOCHEMICAL EFFECTS OF LIMING SULPHIDE TAILINGS ON LACUSTRINE SYSTEMS, RUTTAN MINE, MANITOBA

W.W. Shilts<sup>1</sup>, W.B. Coker<sup>2</sup>, G.E.M. Hall<sup>2</sup>, J.D. Adshead<sup>3</sup>

Sulphide-rich tailings from Ruttan Mine have formed a substantial delta in Ruttan Lake, causing its water to have a pH of 2.5 and a load of dissolved zinc exceeding 17 ppm. To prevent contamination of nearby Churchill River, a lime solution is injected into the outflow, radically raising the pH and forming a thick precipitate in Brehaut Lake into which Ruttan empties. The precipitate consists of cyclically banded carbonate, sulphate, and several varieties of oxyhydroxide minerals. The zinc content of the precipitate exceeds 2 percent, but the highly alkaline water at the proximal end of Brehaut Lake has less than 3 ppb dissolved zinc. The liming process apparently effectively limits the dispersion of zinc through the drainage system, water and sediment concentrations in the distal end of Brehaut Lake being similar to those in nearby Alto Lake, which is in a different drainage basin and has restricted access. Studies are underway to assess the chemical status of water and sediment samples from Rusty Lake and Churchill River which are directly downstream from Brehaut Lake. Water samples were also collected from ponded drainage beside the Ruttan Lake Road, 20 km east and west of the mine. A dense cover of manganese nodules covers the bottom of Churchill River where the Ruttan/Brehaut/Rusty Lakes drainage enters via Vermillion River. Significant questions that we hope to answer are: (1) what will happen to the Zn-rich carbonate precipitate if liming is discontinued and Brehaut Lake is flooded with 2.5 pH water; (2) what is the cause of the Mn-nodules in the Churchill River and are they in any way related to or affected by the Ruttan outflow; and (3) what is the geochemical effect on regional drainage of constructing the 30 km-long access road using sulphide-bearing mine waste which already shows signs of significant weathering alteration?

<sup>1</sup> Terrain Sciences Division, GSC, Ottawa

<sup>2</sup> Mineral Resources Division, GSC, Ottawa

<sup>3</sup> Sedimentary Processes Research, Manotick

## AIRBORNE AND GROUND RADIOMETRIC MAPPING IN THE QUESNEL TROUGH, BRITISH COLUMBIA

R.B.K. Shives<sup>1</sup>, K.L. Ford<sup>1</sup>, P.B. Holman<sup>1</sup>

Since 1969, the GSC has been collecting regional airborne gamma ray spectrometry (GRS) data and demonstrating practical mapping and exploration applications in various geological settings, where variations in radioelement (K, U, Th) concentrations reflect geochemical differences between bedrock lithologies, their altered/mineralized equivalents, or related surficial materials.

In British Columbia, mapping and exploration for large, porphyry Cu-Au and epithermal Ag-Au deposits within the Quesnel Trough is hampered in many places by thick overburden, few outcrops. Our work has recently focussed on this problem, in the context of the multi-disciplinary "buried porphyry halo" exploration model presented in a related poster by Ballantyne et al.

Our preliminary ground GRS orientation surveys indicate that radioelements can serve as geochemical pathfinders to:

1. detect and quantitatively delineate potassic alteration in both bedrock and overburden, beyond visually established alteration boundaries;
2. distinguish visually similar, potassically altered parental lithologies, via differences in U or Th contents;
3. map overburden compositional changes (ie. till vs glacial-fluvial outwash);
4. assist regional bedrock and surficial mapping.

Examples from several properties and deposits are displayed.

To evaluate airborne GRS survey applicability, a multiparameter (GRS/MAG/VLF-EM) airborne survey was flown September 1991, over the Mount Milligan area (93N/1, 93N/2E, 93 O/4W). Available results will be displayed at this poster.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

## GAMMA RAY, MAGNETOMETER, VLF-EM SURVEYS IN THE SNOW LAKE AND RUSTY LAKE AREAS, MANITOBA

R.B.K. Shives<sup>1</sup>, P.B. Holman<sup>1</sup>, R.J. Héту<sup>1</sup>

Combined airborne gamma ray spectrometric - Magnetometer - VLF-EM surveys flown over the Snow Lake and Rusty Lake areas, Manitoba, were released April 1991, as GSC Open File 2300.

Follow-up ground spectrometry and sampling were conducted in July 1991, to relate the airborne patterns to known VMS deposits, regional and detailed surficial, and bedrock geological mapping.

Initial field results (lithogeochemistry in progress):

1. Direct association of radioelement patterns with mineralisation at Chisel Lake is not obvious. Potassic (microcline) alteration along the Ruttan mine horizon east of the deposit is apparent on the airborne survey and can be quantitatively mapped using ground spectrometry.



2. Phases of the Sneath Lake subvolcanic tonalitic intrusion, are radiometrically distinct. Extrusive equivalents of these phases may show similar variation, (some rhyolites and dacites are radiometrically distinct) thus assisting detailed mapping within the Chisel Basin.
3. Many contrasts between existing regional geological mapping and airborne geophysical patterns offer assistance to future mapping, especially in gneissic/plutonic terranes.
4. Beach sand deposits and Lake Agassiz clays in many areas have unique, well defined signatures.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

## QUANTITATIVE MINERAL RESOURCE ASSESSMENT AT THE U.S. GEOLOGICAL SURVEY

D.A. Singer<sup>1</sup>

Because of its ability to respond to diverse issues and to use different methodologies, a three-part quantitative form of assessment has been applied by the U.S. Geological Survey since 1975 to assess approximately  $3.2 \times 10^6 \text{ km}^2$  at 1:1 000 000;  $0.5 \times 10^6 \text{ km}^2$  at 1:500 000;  $0.25 \times 10^6 \text{ km}^2$  at 1:250 000; and  $0.5 \times 10^6 \text{ km}^2$  at other scales in all or parts of Colombia, Costa Rica, Bolivia, Venezuela, and the United States; altogether representing nearly half the area of the United States. In three-part assessments; (1) areas are delineated according to types of deposits permitted by the geology, (2) deposit characteristics are estimated by means of grade-tonnage models, and (3) the number of undiscovered deposits of each type is estimated.

Three-part assessments are consistent with any type of resource problem, are quantitative and thus useful for analysis, incorporate all available information, explicitly represent uncertainty, can be improved with more information, and are almost independent of economic considerations. Although several deposits have recently been discovered in assessed areas, these assessments have had their greatest effect on land-use decisions in Alaska and wilderness designations.

<sup>1</sup> U.S. Geological Survey, Menlo Park

## GROUND ELECTROMAGNETIC AND MAGNETIC SURVEYS OVER SULPHIDE DEPOSITS NEAR SNOW LAKE, MANITOBA

A.K. Sinha<sup>1</sup>, G.J. Palacky<sup>1</sup>

Ground electromagnetic and magnetic investigations were performed over four sulphide deposits (Cook Lake North, Linda-2, Joanie, Copperman) in the Snow Lake greenstone belt in Manitoba. Multi-frequency horizontal loop and VLF electromagnetic methods were used to determine the resistivity characteristics of the sulphide deposits and host rocks. Information on magnetic properties was obtained by interpreting ground total field and vertical magnetic gradient values.

Despite some differences in geological setting and mineralogical composition, this investigation has shown that all four sulphide bodies are poorly conductive (conductance values range from 0.1 to 2 Siemens). Some conductors are distinctly magnetic, but over other sulphide bodies, the magnetic trend is not coincident with EM anomalies. Such characteristics are quite unlike those observed in other greenstone belts, where massive sulphides have important implications for mineral exploration in the Snow Lake greenstone belt, since many potentially economic targets could have remained

unrecognized during the previously conducted time-domain airborne electromagnetic surveys, which were not sufficiently sensitive to respond to poorly conductive targets.

<sup>1</sup> Mineral Resources Division, GSC, Ottawa

## TECTONIC ASSEMBLAGES OF ONTARIO

G.M. Stott<sup>1</sup>

On May 4, 1891, the Ontario Bureau of Mines was founded to encourage the exploration and development of the province's mineral resources. During the 1991-92 centennial celebrations, the Ontario Geological Survey is producing a folio of 1:1 000 000 scale geoscience maps to accompany a two part volume: *The Geology of Ontario*. On one of these sets of maps – Tectonic Assemblages of Ontario – patterns of tectonostratigraphy, ages and structures are shown. The basic unit of subdivision of Precambrian rocks on this map is a tectonic assemblage, which represents volcanic or sedimentary strata deposited during a discrete interval of time, in a common setting bounded by faults and unconformities. To our knowledge, this approach has not previously been applied to the rocks of any other Archean craton. For the overlying Paleozoic and Mesozoic rocks, the map displays a new subdivision of the strata into depositional sequences. Accompanied by a set of charts, which show the time-space distribution of assemblages, sequences, and plutonic bodies, the map will be published early this year.

<sup>1</sup> Ontario Geological Survey, Toronto

## THE GEOLOGY OF ONTARIO: A MULTIDISCIPLINARY SYNTHESIS

P.C. Thurston<sup>1</sup>, H.R. Williams<sup>1</sup>, R.H. Sutcliffe<sup>1</sup>, G.M. Scott<sup>2</sup>

The Geology of Ontario is a series of maps at 1:1M and a volume published to celebrate the centenary of Ontario government geological services. The maps include: Bedrock, Tectonic Assemblages, Quaternary, Total Field and derived magnetic maps and Bouguer and derived gravity maps. The volume is organized based upon the major tectonic subdivision of the Province. We use the tectonic assemblage as the principal descriptive unit of Precambrian rocks, building up to subprovincial and orogen-scale analysis. The Paleozoic and Mesozoic sedimentary basins are analyzed in terms of sequence stratigraphy, and a full review is offered of Quaternary deposits and processes.

This synthesis incorporates computer-processed potential field data, geochronology and the application of tectonic analysis to Precambrian geology. Results include changes in the subdivision of the Superior Province, e.g., north and south younging of strata, plutonism and tectonism on a provincial scale. Analysis of the Proterozoic, Paleozoic and Mesozoic incorporates new suggestions based upon this, the first provincial-scale synthesis. Samples of many of the maps and the Table of Contents of the volume form part of the poster.

<sup>1</sup> Ontario Geological Survey, Toronto

<sup>2</sup> Ontario Geological Survey, Sudbury

## STRUCTURAL SETTING OF GOLD OCCURRENCES IN NORTHERN NEW BRUNSWICK

A. Tremblay<sup>1</sup>, B. Dubé<sup>2</sup>, S. Faure<sup>2</sup>

Structural characteristics of gold occurrences were studied along the Rocky Brook-Millstream and related faults in northern New Brunswick. In the Bathurst area, the Elmtree deposit occurs within

a mafic intrusion which displays evidence of both sub-horizontal and sub-vertical tectonic movements. A contractional duplex geometry related to the Elmtree fault is inferred. Other gold showings of the area are found in the Chaleur Group along various settings related to the Rocky Brook-Milstream (RBM) fault. In the Upsalquitch Forks area, gold occurs within intrusions spatially related to the RBM fault system. The Simpsons Field and McCormack-Jonpol showings show the interaction of isoclinal folding and faulting. The analysis of striated fault planes suggests a rotation of stress tensors associated with the RBM and related faults.

In both areas, ore-related structures are compatible with dextral faulting along the RBM fault. Gold is associated with brittle-ductile structures and is found in the Chaleur Group rocks, or in mafic to felsic intrusions.

<sup>1</sup> INRS-Géoresources, Sainte-Foy

<sup>2</sup> Québec Geoscience Centre, Sainte-Foy

#### CHARACTER OF HYDROTHERMAL MOUNDS AND ADJACENT ALTERED SEDIMENTS, MIDDLE VALLEY: EVIDENCE FROM ALVIN PUSH CORES

R.J.W. Turner<sup>1</sup>, C.H.B. Leitch<sup>1</sup>, D.E. Ames<sup>2</sup>, T. Höy<sup>3</sup>,  
J.M. Franklin<sup>2</sup>, W.D. Goodfellow<sup>2</sup>

The youngest sediments on hydrothermal mounds are altered fragments of presently active sulphide-poor anhydrite chimneys. Underlying sulphide-rich clastic layers indicate that higher temperature black smoker discharge (>300°C) occurred recently. The predominance of clastic material suggests chimney collapse has an important role in mound formation. In situ growth of saponite, talc, chalcopyrite, isocubanite, sphalerite and galena, and pyrite and marcasite replacement of pyrrhotite indicate in situ alteration within the mound. Subhorizontal talc-saponite fractures may suggest inflation as a process contributing to mound growth. Authigenic silicates are zoned from talc-saponite in mounds to illite-smectite in proximal sediments. Detrital chlorite, mica and illite occur in distal sediments.

<sup>1</sup> Mineral Resources Division, GSC, Vancouver

<sup>2</sup> Mineral Resources Division, GSC, Ottawa

<sup>3</sup> B.C. Ministry of Energy, Mines and Petroleum Resources, Victoria

#### NORTHWEST TERRITORIES COMPUTERIZED MINERAL SHOWINGS DATABASE AND MINERAL RESOURCES MAP PROJECT – PROGRESS REPORT<sup>1</sup>

H. Wolf<sup>2</sup>, R.D. Branson<sup>3</sup>, L. Covello<sup>4</sup>, D.W. Wind<sup>5</sup>,  
C.W. Jefferson<sup>6</sup>, D. Atkinson<sup>7</sup>, R.M. Laramée<sup>6</sup>, C. Ellis<sup>7</sup>

This collaborative project was begun in August 1991 to remedy the lack of an effective computerized mineral showings database (CMSD) and comprehensive mineral resources map (MRM) for the NWT. We are reviewing minerals database systems that are in use or being developed by industry, academia and government departments. We plan to develop or adapt a user-friendly CMSD which will be manipulated using personal microcomputers and integrated with a geographic information system (GIS). Data will be entered jointly by Canada - NWT Minerals Initiatives geologists and DIAND geologists based in Yellowknife who will use it as a convenient tool for their work and will manage the routine dissemination of non-confidential information from the CMSD to the public. From this database a new MRM of the entire NWT will be developed in a GIS for use in mineral policy and regional planning of scientific programs. Prototype examples of detailed MRMs are now being constructed for the central Slave Structural Province and South Nahanni River area, for use in map production, mineral exploration and resource assessment.

<sup>1</sup> Contribution to the Canada-Northwest Territories Mineral Development Agreement 2

<sup>2</sup> Allegra Management Company, Ottawa

<sup>3</sup> A.J. Robinson & Associates Inc., Kanata

<sup>4</sup> Covello Bryan and Associates Ltd., Yellowknife

<sup>5</sup> D.W. Wind and Associates, Yellowknife

<sup>6</sup> Mineral Resources Division, GSC, Ottawa

<sup>7</sup> Indian and Northern Affairs Canada, Yellowknife

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# Authors

G. Abbott  
Indian and Northern Affairs Canada  
Exploration and Geological Services  
200 Range Road  
Whitehorse, Yukon  
Canada Y1A 3V1  
tel: (403) 667-3200  
fax: (403) 668-2176

E. Adam  
École polytechnique  
Inst. Recherches en Exploration Minière  
2900 Edouard Montpetit  
Montréal, Québec  
Canada H3T 1J4  
tel: (514) 340-4564  
fax: (514) 340-4191

J.D. Adshead  
Sedimentary Processes Research  
1382 River Road  
Manotick, Ontario  
Canada K0A 2N0  
tel: (613) 692-6175  
fax: (613) 692-6213

F.P. Agterberg  
Geological Survey of Canada  
Mineral Resources Division  
695-601 Booth St.  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 996-2374  
fax: (613) 996-3726

D. Aldrick  
B.C. Energy, Mines & Petroleum  
Resources  
Geological Survey Branch  
553 Superior Street  
Victoria, B.C.  
Canada V8V 1X4  
tel: (604) 356-2848  
fax: (604) 356-8153

D.E. Ames  
Geological Survey of Canada  
Mineral Resources Division  
637-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 943-1165  
fax: (613) 996-9820

R.G. Anderson  
Geological Survey of Canada  
Cordilleran Division  
100 West Pender Street  
Vancouver, B.C.  
Canada V6B 1R8  
tel: (604) 666-2693  
fax: (604) 666-1124

L.B. Aspler  
Geological Survey of Canada  
Continental Geoscience Division  
461-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 995-4850  
fax: (613) 995-7997

D. Atkinson  
Indian and Northern Affairs Canada  
NWT Geology Division  
Box 1500  
Yellowknife, NWT  
Canada X1A 2R3  
tel: (403) 920-8221  
fax: (403) 873-5763

B.C. Geological Survey Branch  
c/o David Lefebvre, Economic Geology  
Section  
Energy, Mines & Petroleum Resources  
553 Superior Street  
Victoria, British Columbia  
Canada V8V 1X4  
tel: (604) 356-5174  
fax: (604) 356-8153

A.H. Bailes  
Manitoba Energy and Mines  
Geological Services  
555-330 Graham Avenue  
Winnipeg, Manitoba  
Canada R3C 4E3  
tel: (204) 945-6555  
fax: (204) 945-0586

D.A. Baldwin  
Manitoba Energy and Mines  
Geological Services  
555-330 Graham Avenue  
Winnipeg, Manitoba  
Canada R3C 4E3  
tel: (204) 945-6551  
fax: (204) 945-0586

S.B. Ballantyne  
Manitoba Survey of Canada  
Mineral Resources Division  
508-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 995-4836  
fax: (613) 996-3726

D. Baril  
Geological Survey of Canada  
Continental Geoscience Division  
1-9 Observatory Crescent  
Ottawa, Ontario  
Canada K1A 0Y3  
tel: (613) 995-2121  
fax: (613) 992-8836

R. Beach  
Geological Survey of Canada  
Geophysics Division  
3-17 Observatory Cres.  
Ottawa, Ontario  
Canada K1A 0Y3  
tel: (613) 996-9414  
fax: (613) 952-8987

G. Beaudoin  
Geological Survey of Canada  
Mineral Resources Division  
575-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 992-6559  
fax: (613) 996-9820

M. Beaumier  
Ministère de L'Energie et des  
Ressources  
5700 - 4e Avenue Ouest  
Charlesbourg, Québec  
Canada G1H 6R1  
tel: (418) 643-4601  
fax: (418) 644-3814

J.H. Bédard  
Commission géologique du Canada  
Centre géoscientifique de Québec  
2700, rue Einstein  
Sainte-Foy, Québec  
Canada G1V 4C7  
tel: (418) 654-2671  
fax: (418) 654-2615

R.T. Bell  
Geological Survey of Canada  
Mineral Resources Division  
284d-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 995-4611  
fax: (613) 996-9820

G. Bernius  
Geological Survey of Canada  
Mineral Resources Division  
124-401 Lebreton Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 995-3850  
fax: (613) 992-2468

M.L. Bevier  
Geological Survey of Canada  
Continental Geoscience Division  
505-601 Booth St.  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 995-4805  
fax: (613) 995-7997

T. Birkett  
Geological Survey of Canada  
Quebec Geoscience Centre  
2700 Einstein St., P.O. Box 7500  
Sainte Foy, Québec  
Canada G1V 4C7  
tel: (418) 654-2566  
fax: (418) 654-2615

B. Blair  
Geological Survey of Canada  
National Geoscan Centre  
180-601 Booth St.  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 996-9502  
fax: (613) 996-8748

D.E. Boerner  
Geological Survey of Canada  
Continental Geoscience Division  
Rm. 3, Bldg. 7, Observatory Cresce  
Ottawa, Ontario  
Canada K1A 0Y3  
tel: (613) 995-8844  
fax: (613) 992-8836

L. Bond  
Afton Operations Corp.  
Kamloops, British Columbia  
Canada

G.F. Bonham-Carter  
Geological Survey of Canada  
Mineral Resources Division  
694-601 Booth St.  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 996-3387  
fax: (613) 996-3726

J. Bossé  
Université de Québec à Montréal  
Dept. des sciences de la Terre  
b.p. 888, stn. A  
Montréal, Québec  
Canada H3C 3P8  
tel: (514) 987-4194  
fax: (514) 987-7749

W.S. Bowman  
Canmet  
Min. Sc. Lab  
634-555 Booth St.  
Ottawa, Ontario  
Canada K1A 0G1  
tel: (613) 992-3537  
fax: (613) 996-9041

D.R. Boyle  
Geological Survey of Canada  
Mineral Resources Division  
506-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 995-4796  
fax: (613) 996-3726

R.D. Branson  
A.J. Robinson & Associates Inc.  
P.O. Box 13130  
Kanata, Ontario  
Canada K2K 1X3  
tel: (613) 592-6060  
fax: (613) 592-5995

B. Brodarc  
Geological Survey of Canada  
Continental Geoscience Division  
234b-615 Booth Street  
Ottawa, Ontario  
Canada K1A 0E9  
tel: (613) 992-3562  
fax: (613) 995-9273

J. Broome  
Geological Survey of Canada  
Continental Geoscience Division  
Rm. 24a, Bldg. 1, Observatory Cres  
Ottawa, Ontario  
Canada K1A 0Y3  
tel: (613) 992-6914  
fax: (613) 992-8836

T.L. Bursey  
Carleton University  
Dept. of Earth Sciences  
Ottawa, Ontario  
Canada K1S 5B6  
tel: (613) 788-4400  
fax: (613) 788-4490



I. Butt  
Geological Survey of Canada  
Geophysics Division  
Rm. 3, Bldg. 5, Observatory Cresce  
Ottawa, Ontario  
Canada K1A 0Y3  
tel: (613) 992-6408  
fax: (613) 992-2787

K.D. Card  
Geological Survey of Canada  
Continental Geoscience Division  
614-615 Booth St.  
Ottawa, Ontario  
Canada K1A 0E9  
tel: (613) 995-2147  
fax: (613) 995-9273

J. Caron  
Geological Survey of Canada  
National Geoscan Centre  
180-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 992-9550  
fax: (613) 996-8748

J.J. Carrière  
Geological Survey of Canada  
Mineral Resources Division  
673-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 992-9792  
fax: (613) 996-9820

J.M. Carson  
Geological Survey of Canada  
Mineral Resources Division  
592-601 Booth St.  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 996-2325  
fax: (613) 996-9295

D. Chao  
Alberta Research Council  
Alberta Geological Survey  
P.O. Box 8330, Stn. F  
Edmonton, Alberta  
Canada T6H 5X2  
tel: (403) 438-7555  
fax: (403) 438-3364

B.W. Charbonneau  
Geological Survey of Canada  
Mineral Resources Division  
596-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 996-2294  
fax: (613) 996-9295

B. Chen  
Geological Survey of Canada  
Geoscience Information and  
Communication Division  
G70-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 995-4177  
fax: (613) 996-8748

Q. Cheng  
University of Ottawa  
Ottawa-Carleton Geoscience Centre  
Ottawa, Ontario  
Canada K1N 6N5  
tel: (613) 564-3480  
fax: (613) 564-9916

A. Cinq-Mars  
Geological Survey of Canada  
Mineral Resources Division  
598-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 992-1083  
fax: (613) 996-9295

W.B. Coker  
Geological Survey of Canada  
Mineral Resources Division  
563-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 992-2378  
fax: (613) 996-3726

P. Corriveau  
Geological Survey of Canada  
Geoscience Information and  
Communication Division  
407-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 996-9354  
fax: (613) 996-8748

L. Covello  
Covello Bryan and Associates Ltd.  
Sub P.O. No. 1  
Yellowknife, NWT  
Canada X1A 2S9  
tel: (403) 920-2729  
fax: (403) 873-3816

D.A. Cranstone  
Mineral Policy Sector, EMR Canada  
Financial and Corporate Analysis  
460 O'Connor Street  
Ottawa, Ontario  
Canada K1A 0E4  
tel: (613) 995-1118  
fax: (613) 992-5893

A. Czich  
Mineral Policy Sector, EMR Canada  
Financial and Corporate Analysis Div.  
1111-460 O'Connor Street  
Ottawa, Ontario  
Canada K1A 0E4  
tel: (613) 992-2623  
fax: (613) 992-8581

B.M. Czornobay  
Saskatchewan Energy and Mines  
Geology and Mines Division  
1914 Hamilton Street  
Regina, Saskatchewan  
Canada S4P 4V4  
tel: (306) 787-2436  
fax: (306) 787-2488

W. Darch  
Noranda Exploration Co. Ltd.  
4-2130 Notre Dame Ave.  
Winnipeg, Manitoba  
Canada R3H 0K1  
tel: (204) 633-7252  
fax: (204) 632-6794

E.E. Davis  
Geological Survey of Canada  
Pacific Geoscience Centre  
9860 Saanich Road West  
Sidney, B.C.  
Canada V8L 4B2  
tel: (604) 356-6453  
fax: (604) 356-6739

K.M. Dawson  
Geological Survey of Canada  
Mineral Resources Division  
100 West Pender Street  
Vancouver, British Columbia  
Canada V6B 1R8  
tel: (604) 666-0260  
fax: (604) 666-1124

R.N.W. DiLabio  
Geological Survey of Canada  
Terrain Sciences  
229-401 Lebreton Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 992-1380  
fax: (613) 992-2468

D-J. Dion  
Ministère de L'Energie et des  
Ressources  
5700 - 4e Avenue Ouest  
Charlesbourg, Québec  
Canada G1H 6R1  
tel: (418) 643-4601  
fax: (418) 644-3814

A. Doiron  
Commission géologique du Canada  
Centre géoscientifique de Québec  
2700, rue Einstein  
Sainte-Foy, Québec  
Canada G1V 4C7  
tel: (418) 654-2646  
fax: (418) 654-2615

B. Dubé  
Commission géologique du Canada  
Centre géoscientifique de Québec  
2700, rue Einstein  
Sainte-Foy, Québec  
Canada G1V 4C7  
tel: (418) 654-2669  
fax: (418) 654-2615

B.E. Elliott  
Geological Survey of Canada  
Mineral Resources Division  
575-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 996-3958  
fax: (613) 996-9295

C. Ellis  
Indian and Northern Affairs Canada  
NWT Geology Division  
Box 1500  
Yellowknife, NWT  
Canada X1A 2R3  
tel: (403) 920-8220  
fax: (403) 873-5763

R.W. Embley  
National Oceanic & Atmospheric  
Administration  
Hatfield Marine Science Center  
Newport, Oregon  
U.S.A. 97365  
tel: (503) 867-0274  
fax: (503) 867-3907

D. Evans  
Government of Newfoundland and  
Labrador  
Department of Mines and Energy  
P.O. Box 8700  
St. John's, Newfoundland  
Canada A1B 4J6  
tel: (709) 729-5975  
fax: (709) 729-3493

H. Falck  
Indian Affairs and Northern Development

NWT Geology Division  
P.O. Box 1500  
Yellowknife, NWT  
Canada X1A 2R3  
tel: (403) 920-8552  
fax: (403) 920-5763

M.A.F. Fedikow  
Manitoba Energy and Mines  
Geological Services  
555-330 Graham Avenue  
Winnipeg, Manitoba  
Canada R3C 4E3  
tel: (204) 945-6562  
fax: (204) 945-0586

T.D. Feeney  
Geological Survey of Canada  
Cordilleran Division  
100 West Pender Street  
Vancouver, B.C.  
Canada V6B 1R8  
tel: (604) 666-0517  
fax: (604) 666-1124

K.J. Ferreira  
Manitoba Energy and Mines  
Geological Services  
555-330 Graham Ave.  
Winnipeg, Manitoba  
Canada R3C 4E3  
tel: (204) 945-6545  
fax: (204) 945-0586

C. Finch  
Newfoundland Mines and Energy  
Geological Survey Branch  
P.O. Box 8700  
St. John's, Newfoundland  
Canada A1B 4J6  
tel: (709) 729-2301  
fax: (709) 729-3493

K.L. Ford  
Geological Survey of Canada  
Mineral Resources Division  
594-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 992-1235  
fax: (613) 996-9295

J.M. Franklin  
Geological Survey of Canada  
Mineral Resources Division  
750-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 995-4137  
fax: (613) 996-9820

T. Frisch  
Geological Survey of Canada  
Continental Geoscience Division  
608-615 Booth St.  
Ottawa, Ontario  
Canada K1A 0E9  
tel: (613) 943-8884  
fax: (613) 995-9273

A.G. Galley  
Geological Survey of Canada  
Mineral Resources Division  
537-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 992-7867  
fax: (613) 996-9820

S.S. Gandhi  
Geological Survey of Canada  
Mineral Resources Division  
284a-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 995-4642  
fax: (613) 996-9820

M. Gauthier  
Université de Québec à Montréal  
Dept. des Sciences de la Terre  
b.p. 888, Stn. A  
Montreal, Québec  
Canada H3C 3P8  
tel: (514) 987-4194  
fax: (514) 987-7749

G. Gebert  
EMPR/DIAND  
Mineral Initiatives Office  
Box 1320  
Yellowknife, NWT  
Canada X1A 2L9  
tel: (403) 920-8552  
fax: (403) 873-5763

M. Gent  
Saskatchewan Energy and Mines  
Geological Survey  
1914 Hamilton Street  
Regina, Saskatchewan  
Canada S4P 4V4  
tel: (306) 787-2568  
fax: (306) 787-7338

J.W. Gill  
Aur Resources Inc.  
1 Adelaide Street East, Suite 2501  
Toronto, Ontario  
Canada M5C 2V9  
tel: (416) 362-2614  
fax: (416) 367-0427

R. Girard  
Min. de l'Energie et des Ressources du Québec  
Service géologique du nord-ouest  
400 boul. Lamaque  
Val d'Or, Québec  
Canada J9P 3L4  
tel: (819) 825-7514  
fax: (819) 825-4689

G. Gobert  
R.R. #2, Box 16  
Portage La Prairie, Manitoba  
Canada R1N 3A2  
tel: (204) 239-5311

C.I. Godwin  
University of British Columbia  
Dept of Geol. Sciences  
6339 Stores Road  
Vancouver, British Columbia  
Canada V6T 1Z4  
tel: (604) 822-2449  
fax: (604) 822-6088

W.D. Goodfellow  
Geological Survey of Canada  
Mineral Resources Division  
190-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 996-8163  
fax: (613) 996-9820

S.P. Gordey  
Geological Survey of Canada  
Cordilleran Division  
100 West Pender St.  
Vancouver, B.C.  
Canada V6B 1R8  
tel: (604) 666-2116  
fax: (604) 666-1124

J.A. Grant  
Geological Survey of Canada  
Mineral Resources Division  
591-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 992-1082  
fax: (613) 996-9295

A.J. Green  
Geological Survey of Canada  
Continental Geoscience Division  
7-19 Observatory Cres.  
Ottawa, Ontario  
Canada K1A 0Y3  
tel: (613) 995-5490  
fax: (613) 992-8836

D.C. Grégoire  
Geological Survey of Canada  
Mineral Resources Division  
721-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 995-4213  
fax: (613) 943-1286

J.D. Grice  
Canadian Museum of Nature  
Mineral Sciences Section  
P.O. Box 3443, Stn "D"  
Ottawa, Ontario  
Canada K1P 6P4  
tel: (613) 952-3513  
fax: (613) 952-3510

M.J. Gunning  
University of Western Ontario  
Department of Geology  
London, Ontario  
Canada N6A 5B7  
tel: (519) 661-3187  
fax: (519) 661-3292

P.B. Hale  
Mineral Policy Sector, EMR Canada  
Mineral Policy and Planning Division  
460 O'Connor Street  
Ottawa, Ontario  
Canada K1A 0E4  
tel: (613) 992-8589  
fax: (613) 992-8581

G.E.M. Hall  
Geological Survey of Canada  
Mineral Resources Division  
702-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 992-6425  
fax: (613) 996-9990

D.W. Halliday  
Geological Survey of Canada  
Geophysics Div.  
2 - 5 Observatory Cres.  
Ottawa, Ontario  
Canada K1A 0Y3  
tel: (613) 995-5518  
fax: (613) 952-8987

W. Hamilton  
Alberta Research Council  
Alberta Geological Survey  
P.O. Box 8330, Station F  
Edmonton, Alberta  
Canada T6H 5X2  
tel: (403) 438-7634  
fax: (403) 438-3364

M.D. Hannington  
Geological Survey of Canada  
Mineral Resources Division  
754-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 996-4865  
fax: (613) 996-9820

D.C. Harris  
Geological Survey of Canada  
Mineral Resources Division  
755-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 992-4495  
fax: (613) 943-1286

R. Hearst  
McMaster University  
Department of Geology  
Hamilton, Ontario  
Canada L8S 4L8  
tel: (416) 525-4513  
fax: (416) 522-3141

J.R. Henderson  
Geological Survey of Canada  
Continental Geoscience Division  
379/386 601 Booth St.  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 992-5446  
fax: (613) 995-7997

M.N. Henderson  
Geological Survey of Canada  
Mineral Resources Division  
642-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 992-9821  
fax: (613) 996-9820

P.J. Henderson  
Henderson Geological Services  
671 Wavell Ave.  
Ottawa, Ontario  
Canada K2A 3A9  
tel: (613) 729-8677

R.K. Herd  
Geological Survey of Canada  
Mineral Resources Division  
G85-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 992-4042  
fax: (613) 943-1286

R.J. Hétu  
Geological Survey of Canada  
Mineral Resources Division  
590-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 992-4279  
fax: (613) 996-9295

P.B. Holman  
Geological Survey of Canada  
Mineral Resources Division  
585-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 992-1237  
fax: (613) 996-9295

P.J. Hood  
Geological Survey of Canada  
Mineral Resources Division  
559-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 995-4913  
fax: (613) 992-5694

T. Hôy  
B.C. Ministry of Energy Mines and Petrol  
Geological Survey Branch  
553 Superior Street  
Victoria, B.C.  
Canada V8V 1X4  
tel: (604) 356-2853  
fax: (604) 356-8153

L. Hulbert  
Geological Survey of Canada  
Mineral Resources Division  
457-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 992-7216  
fax: (613) 996-9820

O.E. Inglis  
Geological Survey of Canada  
Geoscience Information and  
Communication Division  
290c-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 995-2863  
fax: (613) 996-8748

M. Irving  
NWT Energy, Mines & Petroleum  
Resources  
EMPR/DIAND Mineral Initiatives Office  
Yellowknife, N.W.T.  
Canada X1A 2L9  
tel: (403) 920-3344  
fax: (403) 873-0254

V. Jackson  
Indian Affairs and Northern Development  
NWT Geology Division  
P.O. Box 1500  
Yellowknife, N.W.T.  
Canada X1A 2R3  
tel: (403) 920-8552  
fax: (403) 873-5763

J.L. Jambor  
CANMET  
Min. Sc. Lab.  
211-555 Booth St.  
Ottawa, Ontario  
Canada K1A 0G1  
tel: (613) 992-1352  
fax: (613) 996-9673

J. Janveau  
Geological Survey of Canada  
Geophysics Division  
5-2 Observatory Cres.  
Ottawa, Ontario  
Canada K1A 0Y3  
tel: (613) 992-6270  
fax: (613) 992-2787

C.W. Jefferson  
Geological Survey of Canada  
Mineral Resources Division  
640-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 992-9862  
fax: (613) 996-9820

I.R. Jonasson  
Geological Survey of Canada  
Mineral Resources Division  
752-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 996-2766  
fax: (613) 996-9820

T. Jones  
Cambrian College  
Sudbury, Ontario  
Canada P3A 3V8  
tel: (705) 566-8101  
fax: (705) 524-7329

C. Jowett  
University of Waterloo  
Dept. of Earth Sciences  
Waterloo, Ontario  
Canada N2L 3G1  
tel: (519) 885-1211  
fax: (519) 746-7484

A.S. Judge  
Geological Survey of Canada  
Terrain Sciences  
141-401 Lebreton St.  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 996-9323  
fax: (613) 992-2468

C.A. Kaszycki  
Consultant  
108 Granite Crescent  
Thompson, Manitoba  
Canada R8N 0V8  
tel: (204) 677-2507  
fax: (204) 778-8741

P.B. Keating  
Geological Survey of Canada  
Geophysics Division  
Rm. 134, Bldg. 3, Observatory Cres  
Ottawa, Ontario  
Canada K1A 0Y3  
tel: (613) 996-9318  
fax: (613) 952-8987

P.G. Killeen  
Geological Survey of Canada  
Mineral Resources Division  
577-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 996-2312  
fax: (613) 996-9295

J.E. King  
Geological Survey of Canada  
Continental Geoscience Division  
234-615 Booth St.  
Ottawa, Ontario  
Canada K1A 0E9  
tel: (613) 992-4882  
fax: (613) 995-9273

R.V. Kirkham  
Geological Survey of Canada  
Mineral Resources Division  
671-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 995-4656  
fax: (613) 996-9820

F. Kiss  
Geological Survey of Canada  
Geophysics Division  
Rm. 1, Bldg. 4, Observatory Crescen  
Ottawa, Ontario  
Canada K1A 0Y3  
tel: (613) 996-9624  
fax: (613) 952-8987

B. Kjarsgaard  
Geological Survey of Canada  
Continental Geoscience Division  
375-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 995-5705  
fax: (613) 995-7997

R.A. Klassen  
Geological Survey of Canada  
Terrain Sciences Division  
233-401 Lebreton Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 992-6234  
fax: (613) 992-2468

A.G. Kopf-Johnson  
Geological Survey of Canada  
National GEOSCAN Centre  
180-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 992-9550  
fax: (613) 996-8748

L.J. Kornik  
Geological Survey of Canada  
Continental Geoscience Division  
Rm. 26, Bldg. 1, Observatory Cresc  
Ottawa, Ontario  
Canada K1A 0Y3  
tel: (613) 995-4841  
fax: (613) 992-8836

R. Koski  
U.S.G.S  
Branch of Pacific Marine Geology  
345 Middlefield Road, MS 999  
Menlo Park, California  
U.S.A. 94025  
tel: (415) 853-8300  
fax: (415) 354-3224

R.D. Kurtz  
Geological Survey of Canada  
Continental Geoscience Division  
Rm. 14b, Bldg. 7, Observatory Cres  
Ottawa, Ontario  
Canada K1A 0Y3  
tel: (613) 992-4998  
fax: (613) 992-8836

M. Lambert  
Geological Survey of Canada  
Continental Geoscience Division  
236-615 Booth Street  
Ottawa, Ontario  
Canada K1A 0E9  
tel: (613) 992-0938  
fax: (613) 995-9273

R.M. Laramée  
Geological Survey of Canada  
Mineral Resources Division  
652b-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 992-9834  
fax: (613) 996-9820

K. Lauzière  
Geological Survey of Canada  
Quebec Geoscience Centre  
2700 Einstein St, C.P. 7500  
Sainte-Foy, Québec  
Canada G1V 4C7  
tel: (418) 654-2658  
fax: (418) 654-2615

L. Lawley  
Geological Survey of Canada  
Geophysics Division  
5-8 Observatory Cres.  
Ottawa, Ontario  
Canada K1A 0Y3  
tel: (613) 996-8465  
fax: (613) 992-2787

M.E. Leaver  
Canada Centre for Mineral & Energy  
Techn  
Mineral Sciences Laboratories  
316-555 Booth Street  
Ottawa, Ontario  
Canada K1A 0G1  
tel: (613) 992-1055  
fax: (613) 943-0573

A.N. LeCheminant  
Geological Survey of Canada  
Continental Geoscience Division  
383-601 Booth St.  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 995-4850  
fax: (613) 995-7997

A. Leclair  
Geological Survey of Canada  
Continental Geoscience Division  
475-601 Booth St.  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 992-0641  
fax: (613) 995-7997

M. Legault  
University of Ottawa  
Ottawa-Carleton Geoscience Centre  
Ottawa, Ontario  
Canada K1N 6N5  
tel: (613) 564-3480  
fax: (613) 564-9916

C.H.B. Leitch  
Geological Survey of Canada  
Mineral Resources Division  
100 West Pender Street  
Vancouver, British Columbia  
Canada V6B 1R8  
tel: (604) 666-4902  
fax: (604) 666-1124

P.G. Lenton  
Manitoba Energy and Mines  
Geological Services Branch  
555-330 Graham Avenue  
Winnipeg, Manitoba  
Canada R3C 4E3  
tel: (204) 945-6553  
fax: (204) 945-0586

D.R. Lentz  
Geological Survey of Canada  
Mineral Resources Division  
P.O. Box 50  
Bathurst, N.B.  
Canada E2A 3Z1  
tel: (506) 547-2070  
fax: (506) 546-3994

LITHOPROBE Abitibi-Grenville transect  
Group  
c/o R.D. Kurtz,  
Geological Survey of Canada  
Continental Geoscience Division  
Rm. 14b, Bldg. 7, Observatory Cres  
Ottawa, Ontario  
Canada K1A 0Y3  
tel: (613) 992-4998  
fax: (613) 992-8836

S.B. Lucas  
Geological Survey of Canada  
Continental Geoscience Division  
603-615 Booth Street  
Ottawa, Ontario  
Canada K1A 0E9  
tel: (613) 995-4534  
fax: (613) 995-9273

R. Lustwerk  
Noranada Exploration Co. Ltd.  
4-2130 Notre Dame Ave.  
Winnipeg, Manitoba  
Canada R3H 0K1  
tel: (204) 633-7252  
fax: (204) 632-6794

J. Lutz  
Alberta Geological Survey  
Alberta Research Council  
P.O. Box 8330, Stn. F  
Edmonton, Alberta  
Canada T6H 5X2  
tel: (403) 438-7571  
fax: (403) 430-0839

J.W. Lydon  
Geological Survey of Canada  
Mineral Resources Division  
481-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 992-8243  
fax: (613) 996-9820

G. Lynch  
Commission géologique du Canada  
Centre géoscientifique de Québec  
2700, rue Einstein  
Sainte-Foy, Québec  
Canada G1V 4C7  
tel: (418) 654-2675  
fax: (418) 654-2615

J.J. Lynch  
Geological Survey of Canada  
Mineral Resources Division  
490-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 992-2470  
fax: (613) 996-3726

J. Ma  
Ministry of Metallurgical Industries, China  
Tianjin Geological Academy  
c/o 508-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 995-4836  
fax: (613) 996-3726

N. Marchildon  
Rensselaer Polytechnic Institute  
Department of Geology  
Troy, New York  
U.S.A. 12180  
tel: (518) 276-6475  
fax: (518) 276-8627

B.M. McClelland  
University of California  
Dept. of Geological Sciences  
Santa Barbara, California  
U.S.A. 93106  
tel: (805) 893-3471  
fax: (805) 893-2314

J.W. McConnell  
Dept. of Mines and Energy  
Geological Survey Branch  
P.O. Box 8700  
St. John's, Newfoundland  
Canada A1B 4J6  
tel: (709) 729-2301  
fax: (709) 729-3493

P.H. McGrath  
Geological Survey of Canada  
Continental Geoscience Division  
1-23, Obs. Cres.  
Ottawa, Ontario  
Canada K1A 0Y3  
tel: (613) 995-4075  
fax: (613) 992-8836

G.P. McLaren  
Energy, Mines and Petroleum Resources  
Mineral Policy Branch  
553 Superior Street  
Victoria, British Columbia  
Canada V8V 1X4  
tel: (604) 387-3787  
fax: (604) 387-5713

W. Miles  
Geological Survey of Canada  
Geophysics Division  
5-7, Obs. Cres.  
Ottawa, Ontario  
Canada K1A 0Y3  
tel: (613) 992-6634  
fax: (613) 992-2787

B. Milkereit  
Geological Survey of Canada  
Continental Geoscience Division  
Rm. 13, Bldg. 7, Observatory Cresc  
Ottawa, Ontario  
Canada K1A 0Y3  
tel: (613) 995-8844  
fax: (613) 992-8836

J.W.H. Monger  
Geological Survey of Canada  
Cordilleran Division  
100 West Pendee St.  
Vancouver, British Columbia  
Canada V6B 1R8  
tel: (604) 666-6743  
fax: (604) 666-1124

J. Moorhead  
Ministère de l'Énergie et des Ressources  
Service Géologique du Nord-Ouest  
400 Boul. Lamaque  
Val D'or, Québec  
Canada J9P 3L4  
tel: (819) 825-7514  
fax: (819) 825-4689

W.C. Morgan  
Geological Survey of Canada  
Geoscience Information and  
Communication  
268 - 601 Booth St.  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 995-8141  
fax: (613) 996-8748

R. Morin  
Ministère de l'Energie et des Ressources  
5700 - 4e Avenue Ouest  
Charlebourg, Québec  
Canada G1H 6R1  
tel: (418) 643-4601  
fax: (418) 644-3814

W.A. Morris  
McMaster University  
Department of Geology  
Hamilton, Ontario  
Canada L8S 4L8  
tel: (416) 525-4513  
fax: (416) 522-3141

J. Mortensen  
Geological Survey of Canada  
Continental Geoscience Division  
480-601 Booth St.  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 995-8935  
fax: (613) 995-7997

D.M. Murphy  
Geological Survey of Canada  
Cordilleran Division  
100 West Pender St.  
Vancouver, British Columbia  
Canada V6B 1R8  
tel: (604) 666-1128  
fax: (604) 666-1124

C.J. Mweniumbo  
Geological Survey of Canada  
Mineral Resources Division  
581-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 992-6520  
fax: (613) 996-9295

G. Nadaradju  
University of British Columbia  
Dept. of Geological Sciences  
6339 Stores Road  
Vancouver, British Columbia  
Canada V6T 1Z4  
tel: (604) 822-6136  
fax: (604) 822-6088

A.J. Naldrett  
Department of Geology  
University of Toronto  
22 Russel Street  
Toronto, Ontario  
M5S 3B1  
tel: (416) 978-3030  
fax: (416) 391-2170

E. Nielsen  
Manitoba Energy and Mines  
Geological Services  
555-330 Graham Avenue  
Winnipeg, Manitoba  
Canada R3C 4E3  
tel: (204) 945-6506  
fax: (204) 945-0586

Nova Scotia Dept. of Natural Resources  
c/o Paul Smith, Mineral Resources  
Division  
P.O. Box 698  
Halifax, Nova Scotia  
Canada B3J 2T9  
tel: (902) 424-4700  
fax: (902) 424-0527

G.J. Palacky  
Geological Survey of Canada  
Mineral Resources Division  
105-401 Lebreton St.  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 995-5427  
fax: (613) 996-9295

S. Paradis  
Commission géologique du Canada  
Centre géoscientifique de Québec  
2700, rue Einstein  
Sainte-Foy, Québec  
Canada G1V 4C7  
tel: (418) 654-2651  
fax: (418) 654-2615

M. Parent  
Commission géologique du Canada  
Centre géoscientifique de Québec  
2700, rue Einstein  
Sainte-Foy, Québec  
Canada G1V 4C7  
tel: (418) 654-2657  
fax: (418) 654-2615

D. Paul  
Geological Survey of Canada  
Continental Geoscience Division  
236-615 Booth St.  
Ottawa, Ontario  
Canada K1A 0E9  
tel: (613) 995-5347  
fax: (613) 995-9273

J.A. Percival  
Geological Survey of Canada  
Continental Geoscience Division  
604-615 Booth Street  
Ottawa, Ontario  
Canada K1A 0E9  
tel: (613) 995-4723  
fax: (613) 995-9723

J.B. Percival  
Geological Survey of Canada  
Mineral Resources Division  
753-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 992-4496  
fax: (613) 943-1286

J.M. Peter  
Geological Survey of Canada  
Mineral Resources Division  
192-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 992-2376  
fax: (613) 996-9820

W. Petruk  
Canmet  
Min. Sc. Lab.  
217-555 Booth St.  
Ottawa, Ontario  
Canada K1A 0G1  
tel: (613) 992-1376  
fax: (613) 996-9673

J.A. Pilon  
Geological Survey of Canada  
Terrain Sciences Division  
239-401 Lebreton Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 996-9315  
fax: (613) 992-2468

A. Plouffe  
Geological Survey of Canada  
Terrain Sciences Division  
143-401 Lebreton Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 992-5667  
fax: (613) 992-2468

N. Prasad  
Geological Survey of Canada  
Mineral Resources Division  
284c-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 992-7484  
fax: (613) 996-9820

M. Price  
Alberta Geological Survey  
Alberta Research Council  
P.O. Box 8330, Stn. F  
Edmonton, Alberta  
Canada T6H 5X2  
tel: (403) 438-7631  
fax: (403) 438-3364

R.H. Rainbird  
Geological Survey of Canada  
Continental Geoscience Division  
373-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 943-2212  
fax: (613) 995-7997

N.C. Reardon  
Geological Survey of Canada  
Mineral Resources Division  
188-601 Booth St.  
Ottawa, Ontario  
Canada  
tel: (613) 996-8916  
fax: (613) 996-9820

R.K.T. Reddy  
c/o G. Bonham-Carter, Geol. Survey of  
Canada  
Mineral Resources Division  
694-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 996-3387  
fax: (613) 996-3726

M. Reese  
Noranda Expl. Co. Ltd.  
4-2130 Notre Dame Ave.  
Winnipeg, Manitoba  
Canada R3H 0K1  
tel: (204) 633-7252  
fax: (204) 632-6794

B. Reilly  
Sask. Energy and Mines  
Sask. Geol. Survey  
1914 Hamilton St.  
Regina, Saskatchewan  
Canada S4P 4V4  
tel: (306) 787-2568  
fax: (306) 787-7338

A.C. Roberts  
Geological Survey of Canada  
Mineral Resources Division  
762-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 992-2802  
fax: (613) 943-1286

C.F. Roots  
Geological Survey of Canada  
Cordilleran Division  
100 West Pender Street  
Vancouver, B.C.  
Canada V6B 1R8  
tel: (604) 666-1129  
fax: (604) 666-1124

K.V. Ross  
University of British Columbia  
Department of Geological Sciences  
6339 Stores Road  
Vancouver, B.C.  
Canada V6T 1Z4  
tel: (604) 822-2804  
fax: (604) 822-6088

R.M. Rousseau  
Geological Survey of Canada  
Mineral Resources Division  
707-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 992-6001  
fax: (613) 943-1286

V.R. Ruzicka  
Geological Survey of Canada  
Mineral Resources Division  
281-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 995-4558  
fax: (613) 996-9820

A.L. Sangster  
Geological Survey of Canada  
Mineral Resources Division  
489-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 992-8603  
fax: (613) 996-9820

D.F. Sangster  
Geological Survey of Canada  
Mineral Resources Division  
699-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 995-5500  
fax: (613) 996-9820

F. Santaguida  
University of Waterloo  
Dept. of Earth Sciences  
Waterloo, Ontario  
Canada N2L 3G1  
tel: (519) 888-4521  
fax: (519) 746-7484

M. Savard  
Commission géologique du Canada  
Centre géoscientifique de Québec  
2700, rue Einstein  
Sainte-Foy, Québec  
Canada G1V 4C7  
tel: (418) 654-2634  
fax: (418) 654-2615

H.K. Schonwandt  
Geological Survey of Greenland  
DK-3900 Nuuk  
Greenland  
tel: (299) 2 30 00  
fax: (299) 2 46 93

R.F.J. Scoates  
Geological Survey of Canada  
Mineral Resources Division  
684-601 Booth Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 996-4561  
fax: (613) 996-9820

G.M. Scott  
Ontario Geological Survey  
6th floor, 200 Brady St., Mailbag 3000  
Sudbury, Ontario  
Canada P3A 5W2  
tel: (705) 675-4441  
fax: (705) 675-6473

S.D. Scott  
University of Toronto  
Marine Geology Research Laboratory  
22 Russell St.  
Toronto, Ontario  
Canada M5S 3B1  
tel: (416) 978-3022  
fax: (416) 978-3938

W.W. Shilts  
Geological Survey of Canada  
Terrain Sciences Division  
149-401 Lebreton Street  
Ottawa, Ontario  
Canada K1A 0E8  
tel: (613) 995-4523  
fax: (613) 992-2468

<p>R.B.K. Shives Geological Survey of Canada Mineral Resources Division 593-601 Booth Street Ottawa, Ontario Canada K1A 0E8 tel: (613) 996-3695 fax: (613) 996-9295</p>	<p>M. Stuble NWT Energy, Mines and Petroleum Resource EMPR/DIAND Mineral Initiatives Office Yellowknife, NWT Canada X1A 2L9 tel: (403) 920-3344 fax: (403) 873-0254</p>	<p>R.I. Thompson Geological Survey of Canada Cordilleran Division 100 West Pender Street Vancouver, British Columbia Canada V6B 1R8 tel: (604) 666-0408 fax: (604) 666-1124</p>	<p>W. Wagner Energy Mines and Resources Mineral Policy Sector 460 O'Connor St. Ottawa, Ontario Canada K1A 0E4 tel: (613) 996-5951 fax: (613) 992-8581</p>
<p>D.A. Singer U.S. Geological Survey 345 Middle Field Rd., Mail Stop 98 Menlo Park, CA U.S.A. 94025 tel: (415) 329-5370 fax: (415) 329-5110</p>	<p>R.H. Sutcliffe Ontario Geological Survey 77 Grenville St. Toronto, Ontario Canada M7A 1W4 tel: (416) 965-1827 fax: (416) 324-4933</p>	<p>P.C. Thurston Ontario Geological Survey 77 Grenville Street Toronto, Ontario Canada M7A 1W4 tel: (416) 965-1827 fax: (416) 324-4933</p>	<p>H.R. Williams Ontario Geological Survey 77 Grenville St. Toronto, Ontario Canada M7A 1W4 tel: (416) 965-1827 fax: (416) 324-4933</p>
<p>A.K. Sinha Geological Survey of Canada Mineral Resources Division 104-401 Lebreton Street Ottawa, Ontario Canada K1A 0E8 tel: (613) 995-5489 fax: (613) 996-9295</p>	<p>E.C. Syme Manitoba Energy and Mines Geological Services Branch 555-330 Graham Ave. Winnipeg, Manitoba Canada R3C 4E3 tel: (204) 945-6556 fax: (204) 945-0586</p>	<p>J.E. Tilton Colorado School of Mines Mineral Economics Department Golden, Colorado U.S.A. 80401 tel: (303) 273-3485 fax: (303) 273-3278</p>	<p>D.W. Wind D.W. Wind and Associates 5013 57th Street Yellowknife, NWT Canada X1A 1Y4 tel: (403) 920-7242 fax: (403) 920-7242</p>
<p>W.L. Slimmon Sask. Energy and Mines Geology and Mines Division 1914 Hamilton Street Regina, Saskatchewan Canada S4P 4V4 tel: (306) 787-2436 fax: (306) 787-2488</p>	<p>E.I. Tanczyk Geological Survey of Canada Continental Geoscience Division 580-601 Booth St. Ottawa, Ontario Canada K1A 0E8 tel: (613) 943-1319 fax: (613) 995-7997</p>	<p>J. Tod Geological Survey of Canada Geophysics Division 4-1, Obs. Cres. Ottawa, Ontario Canada K1A 0Y3 tel: (613) 995-0735 fax: (613) 992-6438</p>	<p>H. Wolf A.J. Robinson &amp; Associates c/o C. Jefferson, GSC 640-601 Booth Street Ottawa, Ontario Canada K1A 0E8 tel: (613) 992-9868 fax: (613) 996-9820</p>
<p>P.L. Smith University of British Columbia Dept. of Geoscience 6339 Stores Road Vancouver, British Columbia Canada V6T 1Z4 tel: (604) 822-6136 fax: (604) 822-6088</p>	<p>K. Telmer University of Ottawa Geology Department Ottawa, Ontario Canada K1N 6N5 tel: (613) 564-3480 fax: (613) 564-9916</p>	<p>A. Tremblay Commission géologique du Canada Centre géoscientifique de Québec 2700, rue Einstein Sainte-Foy, Québec Canada G1V 4C7 tel: (418) 654-2568 fax: (418) 654-2615</p>	<p>D.F. Wright Geological Survey of Canada Mineral Resources Division 690-601 Booth Street Ottawa, Ontario Canada K1A 0E8 tel: (613) 995-4718 fax: (613) 996-3726</p>
<p>R. Stern Geological Survey of Canada Continental Geoscience Division 475-601 Booth St. Ottawa, Ontario Canada K1A 0E8 tel: (613) 992-0641 fax: (613) 995-7997</p>	<p>D.J. Tempelman-Kluit Geological Survey of Canada Cordilleran Division 100 West Pender St. Vancouver, B.C. Canada V6B 1R8 tel: (604) 666-0529 fax: (604) 666-1124</p>	<p>R.J.W. Turner Geological Survey of Canada Mineral Resources Division 100 West Pender Street Vancouver, British Columbia Canada V6B 1R8 tel: (604) 666-4852 fax: (604) 666-1124</p>	<p>P. Zhang c/o R.D. Kurtz Continental Geoscience Division 7-14b, Obs. Cres. Ottawa, Ontario Canada K1A 0Y3 tel: (613) 992-4998 fax: (613) 992-8836</p>
<p>J.A.R. Stirling Geological Survey of Canada Mineral Resources Division 753-601 Booth Street Ottawa, Ontario Canada K1A 0E8 tel: (613) 943-0270 fax: (613) 943-1286</p>	<p>D.J. Teskey Geological Survey of Canada Geophysics Division 3-114, Obs. Cres Ottawa, Ontario Canada K1A 0Y3 tel: (613) 992-9763 fax: (613) 952-8987</p>	<p>J.E. Vaive Geological Survey of Canada Mineral Resources Division 606-601 Booth Street Ottawa, Ontario Canada K1A 0E8 tel: (613) 992-6730 fax: (613) 943-1286</p>	
<p>H.R. Stockford Aur Resources Inc. 1 Adelaide Street East, Suite 2501 Toronto, Ontario Canada M5C 2V9 tel: (416) 362-2614 fax: (416) 367-0427</p>	<p>D. Thomas Sask. Energy and Mines Sask. Geol. Survey 1914 Hamilton St. Regina, Saskatchewan Canada S4P 4V4 tel: (306) 787-2568 fax: (306) 787-7338</p>	<p>J.J. Veillette Geological Survey of Canada Terrain Sciences Division 209-401 Lebreton Street Ottawa, Ontario Canada K1A 0E8 tel: (613) 992-3630 fax: (613) 992-2468</p>	
<p>P. Stone Geological Survey of Canada Geophysics Division 4-1 Obs. Cres. Ottawa, Ontario Canada K1A 0Y3 tel: (613) 995-0753 fax: (613) 995-7176</p>	<p>M.D. Thomas Geological Survey of Canada Continental Geoscience Division 1-24B, Obs. Cres. Ottawa, Ontario Canada K1A 0Y3 tel: (613) 995-5582 fax: (613) 992-8836</p>	<p>C. Veys Geological Survey of Canada Mineral Resources Division 712-601 Booth Street Ottawa, Ontario Canada K1A 0E8 tel: (613) 995-4391 fax: (613) 943-1286</p>	
<p>G.M. Stott Ontario Geological Survey 6th Floor, 200 Brady Street, Mailbag 3000 Sudbury, Ontario Canada P3A 5W2 tel: (705) 675-4441 fax: (705) 675-6473</p>	<p>J.F.H. Thompson University of British Columbia Mineral Deposits Research Unit 6339 Stores Road Vancouver, B.C. Canada V6T 1Z4 tel: (604) 822-2449 fax: (604) 822-6088</p>	<p>D. Viljoen Geological Survey of Canada Continental Geoscience Division 1 - 24a, Obs. Cres. Ottawa, Ontario Canada K1A 0Y3 tel: (613) 992-6914 fax: (613) 992-8836</p>	





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