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# F O R U M

# 92

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# Program with Abstracts



Energy, Mines and  
Resources Canada

Énergie, Mines et  
Ressources Canada

Canada

THE ENERGY OF OUR RESOURCES : THE POWER OF OUR IDEAS

L'ÉNERGIE DE NOS RESSOURCES : NOTRE FORCE CRÉATRICE



Geological Survey of Canada

# CURRENT ACTIVITIES FORUM

21-22 January 1992

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**Place:**

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

**Non-Technical Event:**

An informal get-together with cash bar on

Tuesday, 21 January, from

1630h to 1930h in hall A

**Popular Lecture:**

At 1930 on the evening of Monday, 20 January

Mr. Robin Riddihough will present a talk entitled

"150 Years of Exploring Canada: Logan's Legacy"

in Hall E

**Scientific displays:**

Over 100 displays will be on view

after the lecture in Hall A

# PROGRAM

## TUESDAY, 21 January 1992

- 09h00 Introduction  
**E.A. Babcock, R.P. Riddihough**
- 09h20 Imbricate thrusting, reverse faulting, and extensional collapse of the Acadian Orogen, Central Cape Breton Highlands, Nova Scotia  
**G. Lynch**
- 09h40 Structural styles and accretionary history of the Dunnage Zone and post-Ordovician cover rocks of the Quebec Appalachians  
**A. Tremblay, M. Malo, D. Kirkwood**
- 10h00 Taming the intractable: a new generation of geological reconnaissance in northeastern Superior Province  
**J.A. Percival, K.D. Card, R.A. Stern, J.K. Mortensen**
- 10h20 Facies and paleogeographic evolution of an Early Devonian carbonate platform, Gaspésie, Quebec  
**D. Lavoie**
- 10h40 Understanding the geological history of the Ungava orogen (northern Quebec) through GSC mapping from 1885 to 1991  
**S.B. Lucas, M.R. St-Onge**
- 11h00 Landsat thematic mapping with ground truth element distribution: an example from British Columbia's Golden Triangle District  
**S.B. Ballantyne, J. Ma**
- 11h20 "What's in a quartzite?" Fifty years of mapping near Keno Hill, Yukon  
**C. Roots, D. Murphy, R.I. Thompson, D.J. Templeman-Kluit**
- 11h40 GSC activities in Project Lithoprobe: mapping in Canada's 3rd dimension  
**A.G. Jones, B. Milkereit, R.D. Hyndman, C.E. Keen, J.W.H. Monger, G.M. Ross**
- 12h00 New Video: "Secrets of Ice"
- 14h00 Twenty years of marine geoscience research in the Geological Survey of Canada  
**B.D. Loncarevic, D.I. Ross**
- 14h20 Hydrocarbon resource studies of east coast frontier basins: past, present and future  
**M. Williamson**

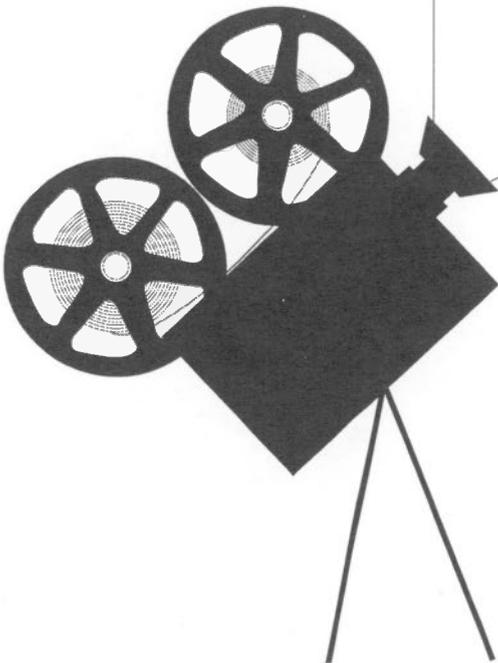
- 14h40 Understanding Alberta's Oil Sands: GSC's 117 year role  
**R.W. Macqueen, P.W. Brooks, M.G. Fowler**
- 15h00 Identification of geomorphic and ecological processes allowing determination of the climatic record, Hot Weather Creek area, Ellesmere Island, N.W.T.  
**Y. Michaud, C. Bégin, M. Garneau**
- 15h20 Postglacial variations in the range of the bowhead whale and paleosea ice conditions, Canadian Arctic  
**A.S. Dyke**
- 15h40 A cross-Canada outdoor radon survey  
**R.L. Grasty**

## WEDNESDAY, 22 January 1992

- 09h00 The National Mapping Program  
**M.E. Cherry, S.B. Lucas, J.E. King**
- 09h20 Digital storage and analysis of geoscientific data: an aid to NATMAP geological projects (Flin Flon-Snow Lake Belt, Slave Province)  
**J. Broome, B. Brodaric, D. Baril, D. Viljoen, S.B. Lucas, J.E. King**
- 09h40 Stratigraphy, sedimentology, and structure of the Henik, Montgomery and Hurwitz groups in the Bray-Montgomery-Ameto Lakes area, southern District of Keewatin: implications for gold exploration  
**L.B. Aspler, T.L. Burse, A.N. LeCheminant**
- 10h00 Application of gamma ray spectrometry to gold exploration  
**B.W. Charbonneau, R.B.K. Shives, M. Legault**
- 10h20 Exploration methods for kimberlite and lamproite-hosted diamond deposits in Canada  
**B.A. Kjarsgaard**
- 10h40 The Geological Survey of Canada's role in the development of drift prospecting in Canada  
**W.W. Shilts, R.N.W. DiLabio**
- 11h00 Rock analysis by X-Ray fluorescence  
**R. Rousseau, C. Veys**
- 11h20 The scientific program of Mineral Resources Division  
**J.M. Duke**

## VIDEO

Screening of "Secrets of Ice". This video looks at some of the newest and most intriguing research under way, including work being conducted from a huge slab of ice adrift in the Arctic Ocean not far from the North Pole, and the extraction of ice cores whose geological records provide us with the key to the Earth's past at 12h00, January 21, in hall E.



# TALKS

## IMBRICATE THRUSTING, REVERSE FAULTING, AND EXTENSIONAL COLLAPSE IN THE ACADIAN OROGEN OF THE CENTRAL CAPE BRETON HIGHLANDS, NOVA SCOTIA

G. Lynch<sup>1</sup>

Deformation within the Acadian orogen of the central Cape Breton Highlands features: a) mid-crustal west-vergent imbricate thrusting within the Silurian Jumping Brook metamorphic suite; b) opposite facing reverse fault systems which displace high grade gneiss metamorphosed during Devonian deformation, over medium to low grade volcanic arc assemblages; and c) late Devonian extension.

Imbricate thrusting is marked by structural repetitions of Silurian turbiditic sequences and associated metavolcanic assemblages, as well as by the emplacement of amphibolite grade rocks over greenschist grade rocks. The thrust system is bounded to the east by west-verging steep reverse faults. The fault styles and contrasts in metamorphic regimes indicate that contraction occurred above a large thrust ramp. Imbrication is thought to have developed along the upper ramp flat, in the foreland portion of the system. Late extension developed in the foreland; shallow dipping mylonite zones are rooted in the thrust and reverse fault systems, which appear to have been reactivated. Kinematic indicators suggest northward movement of the upper sheets during extension.

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

## \*STRUCTURAL STYLES AND ACCRETIONARY HISTORY OF THE DUNNAGE ZONE AND POST-ORDOVICIAN COVER ROCKS OF THE QUEBEC APPALACHIANS.

A. Tremblay<sup>1</sup>, M. Malo<sup>1</sup>, D. Kirkwood<sup>2</sup>

In the Quebec Appalachians, Cambro-Ordovician rocks of the Dunnage Zone record the development of subduction-related terranes. Melanges and overlying forearc basin deposits extend from southern Quebec up to the Gaspé Peninsula. Arc volcanics occur in the southern part of the Dunnage Zone. Late Ordovician to Middle Devonian cover rocks (Gaspé Belt) rest with or without unconformity on the Dunnage sequence. The regional deformation is Acadian-related. In the south, NW-verging folds are coeval with high-angle reverse faults. In the Gaspé, folds are associated with dextral strike-slip faults. In the Matapedia-Temisouata area, strike-slip faults coexist with high-angle reverse faults. These variations reflect the transition from transcurrent tectonics in Gaspé to reverse dip-slip tectonics in southern Quebec.

In Quebec, the Dunnage Zone is believed to be the product of both the sedimentation and tectonic shuffling of oceanic terranes in pre-Middle Ordovician times. Relationships between Dunnage and cover rocks vary as a function of a diachronism in the subduction of Laurentia. Acadian structural variations result from a collision along an irregular margin of accreted terranes.

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

<sup>2</sup> Université Laval, Sainte-Foy

\*This talk will be presented in French

## TAMING THE INTRACTABLE: A NEW GENERATION OF GEOLOGICAL RECONNAISSANCE IN NORTHEASTERN SUPERIOR PROVINCE

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

The Minto block of the Superior Province comprises Archean plutonic and high-grade metamorphic rocks with NNW structural trends. Four lithotectonic domains are distinguished on the basis of their composition, as well as structural, aeromagnetic and isotopic characteristics. The magnetically low Goudalie domain of tonalitic gneiss and amphibolite-facies supracrustal rocks may be the oldest (>2.8 Ga), based on Sm-Nd model ages. To the west the Lake Minto domain with high magnetic relief contains granulite-facies supracrustal rocks cut by major units of pyroxene and (or) hornblende-bearing granodiorite (2725 Ma), diatexite (2712 Ma) and late granite. The magnetically high Tikkerutuk and Utsalik domains to the west and east respectively are magmatic arcs made up entirely of calc-alkaline granodiorite (2724-2721 Ma) and granite (2693 Ma). Nd studies of the major magmatic suites indicate contributions from 2.8-3.1 Ga crust, suggesting that the Minto block represents a magmatic complex developed on a proto-craton like that preserved in the Sachigo subprovince to the west.

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

## FACIES AND PALEO GEOGRAPHIC EVOLUTION OF AN EARLY DEVONIAN CARBONATE PLATFORM, GASPÉSIE, QUEBEC

D. Lavoie<sup>1</sup>

The Early Devonian Upper Gaspé Limestones in Gaspé Peninsula show three depositional belts with a fourth one indirectly recognized by petrographic studies. The northernmost depositional belt shows facies of proximal outer shelf. Farther south and southwest, distal gently sloping outer shelf passing to toe of slope environments are recognized. The facies architecture, in eastern Gaspé, is controlled by active extensional tectonism whereas volcanism is important in the facies array in western Gaspé Peninsula. The Upper Gaspé Limestones belong to the highstand period of a tectonically-driven 20 Ma eons, second order megacycle. In the studied succession, three third order cycle are recognized. The cycles are made up of an initial tectonically-induced transgression followed by progradation of facies under conditions of highstand. Stacking of these cycles is aggradational but inner shelf facies, petrographically recognized in storm layers, never reach the actual preserved outcrop area. Resolution of cyclicity on the outer shelf is restricted to third order cycles due to the absence of their shallow water correlative facies.

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

**UNDERSTANDING THE GEOLOGICAL HISTORY OF  
THE UNGAVA OROGEN (NORTHERN QUEBEC)  
THROUGH GSC MAPPING FROM 1885 TO 1991**

S.B. Lucas<sup>1</sup>, M.R. St-Onge<sup>1</sup>

Geological observations by the GSC on the northern Ungava Peninsula were first made during the coastal voyages of Bell (1885) and Low (1899, 1902). Their recognition of both "diabasic trap" rocks (Cape Smith Belt basalts) and Ni-Cu showings was followed up by Gunning (1934). This early work sparked the interest of mineral exploration companies, and since 1950 the area has been extensively studied by industry, MERQ, GSC and university geoscientists. Building on Taylor's (1982) 1:250 000-scale maps, the Cape Smith Belt was remapped at 1:50 000-scale by the MERQ (1983-89) and the GSC (1985-87), and its northern hinterland was remapped by the GSC (1989-91). This recent work has shown that (1) the Cape Smith Belt was thrust southward over the Superior Province basement, (2) autochthonous basement is exposed in two half-windows coring a large-scale antiform north of the belt, (3) the belt contains a 2.00 Ga ophiolite, and (4) the hinterland is characterized by a 1.86-183 Ga magmatic arc terrane which collided with the Superior Province continental margin at ca. 1.82 Ga (Ungava orogeny).

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

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

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

**"WHAT'S IN A QUARTZITE?" FIFTY YEARS OF  
MAPPING NEAR KENO HILL, YUKON**

C.F. Roots<sup>1</sup>, D.M. Murphy<sup>1</sup>, R.I. Thompson<sup>1</sup>,  
D.J. Templeman-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, Vancouver

**GSC ACTIVITIES IN PROJECT LITHOPROBE:  
MAPPING IN CANADA'S 3RD DIMENSION**

A.G. Jones<sup>1</sup>, B. Milkereit<sup>1</sup>, R.D. Hyndman<sup>1</sup>, C.E. Keen<sup>2</sup>,  
J.W.H. Monger<sup>3</sup>, G.M. Ross<sup>4</sup>

LITHOPROBE is Canada's national, collaborative, multidisciplinary earth science research program created to answer fundamental questions on the nature and evolution of our continental, and bounding oceanic, crust and underlying uppermost mantle. More than 300 university, government (federal and provincial) and industry scientists coordinate their research efforts along designated corridors - or transects - across key geological structures in order to map them into the third dimension - depth. The eight currently active transects span Canada geographically (from the east to west coasts), geologically (cover virtually all major geological phenomena), and temporally (from modern crust formation to events occurring in the first half of the earth's history).

The GSC has been a full partner with NSERC in LITHOPROBE since its inception in 1984 - both in terms of funding and in the research programs of many individual scientists from almost all scientific Divisions. This talk will present some of the main highlights of the LITHOPROBE program to date, emphasizing the contributions made by GSC staff.

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

<sup>2</sup> Atlantic Geoscience Centre, Dartmouth

<sup>3</sup> Cordilleran Division, Vancouver

<sup>4</sup> Institute of Sedimentary and Petroleum Geology, Calgary

## GETTING OUR FEET WET: TWENTY YEARS OF MARINE GEOSCIENCE RESEARCH IN THE GEOLOGICAL SURVEY OF CANADA

B.D. Loncarevic<sup>1</sup>, D.I. Ross<sup>1</sup>

Water is a principal agent of geological change and covers 70% of the Earth's surface. Describing and understanding the undersea geology has always been a challenge to geologists.

GSC involvement in marine research goes back to Logan's mapping at Joggins, Nova Scotia, and includes A.P. Low's expedition to Hudson Bay and the Arctic on board CGS NEPTUNE, Willmore's onshore/offshore seismic experiments based on Prince Edward Island and Sable Island, Morley's shipborne magnetometer measurements on hydrographic surveys, and Pelletier's studies in the Arctic.

Offshore geoscience acquired a focus with the establishment of the Bedford Institute of Oceanography (1962) with various components of GSC as an integral part of the Institute's program.

Today, marine research utilizes ships, submersibles, airplanes and ice islands as platforms and laboratories. The work is accelerating as our society reaches further and further for resources, and the protection of the environment from human and natural factors becomes of increasing concern.

<sup>1</sup> Atlantic Geoscience Centre, Dartmouth

## HYDROCARBON RESOURCE STUDIES OF EAST COAST FRONTIER BASINS: PAST, PRESENT AND FUTURE

M.A. Williamson<sup>1</sup>

Canada's eastern offshore has witnessed over 30 years of hydrocarbon exploration (and lately production) activity. The resulting large volume of geophysical, geological and engineering data coupled to favourable regulations regarding its availability and to other data sets collected by university and government bodies represents a multi billion dollar resource. This investment fuels academic, industry and government activities that develop and test basic models of basin formation, fill, structure; and that can numerically simulate the movement and accumulation of hydrocarbons within these dynamic frameworks. Early work in the 1960s and 70s delineated the basic litho-biostratigraphic and structural framework of the margin. This led to the collaborative, multidisciplinary studies of the late 70s and 80s which made full use of integrated data sets. In the 1980s emphasis was placed on regional syntheses creating products such as the Geology of North America series (Geology of Canada, no. 2, East Coast) and the East Coast Basin Atlas series (Labrador, Scotian Shelf). Integrating and building on this framework using new and innovative basin simulation technologies is the Hydrocarbon Charge Modelling Project. This project will oversee a series of studies quantifying the source rock, primary migration, secondary migration and entrapment characteristics of the basins. Maximum utility of these studies will be gained from their merge to provide the necessary quantitative platforms for idea and concept testing, resource assessment, management, and prediction throughout the 1990s.

<sup>1</sup> Atlantic Geoscience Centre, Dartmouth

## UNDERSTANDING ALBERTA'S OIL SANDS: GSC'S 117 YEAR ROLE

R.W. Macqueen<sup>1</sup>, P.W. Brooks<sup>1</sup>, M.G. Fowler<sup>1</sup>

Alberta's immense heavy oil/bitumen reserves provide ~15% of Canada's annual hydrocarbon production, from two mining operations. Between 1875 and ~1900, GSC scientists Macoun, Bell, McConnell and Hoffmann established the characteristics of the oil sands, and conducted the first drilling in hopes of finding crude oil. Although none was discovered, this early work provided basic data and lent credibility to oil sands study: it directly stimulated later work conducted by the Alberta Research Council and others. One hundred years later, GSC's role lies in understanding the geochemistry/origin of these vast deposits in their basinal context. Our recent organic geochemical studies demonstrate that the oil sands/bitumens are biodegraded, former "conventional" crude oils; all deposits share numerous chemical features; oil sands/bitumens relate closely to conventional Cretaceous-Mississippian crude oils; and biodegradation levels are variable, requiring advance knowledge for successful *in situ* extraction. Leading GSC field work of the last century has given way to leading GSC geochemical work of this century: both approaches are required for these deposits to reach their full potential.

<sup>1</sup> Institute of Sedimentary and Petroleum Geology, Calgary

## \*IDENTIFICATION OF GEOMORPHIC AND ECOLOGICAL PROCESSES ALLOWING DETERMINATION OF THE CLIMATIC RECORD, HOT WEATHER CREEK AREA, ELLESMERE ISLAND, N.W.T.

Y. Michaud<sup>1</sup>, C. Bégin<sup>1</sup>, M. Garneau

During the Holocene, several environmental changes have been recorded by different natural processes. Detailed study of the dynamics of these processes allows the reconstruction of paleoenvironments at different time scales. In the High Arctic, except studies performed on ice cores, the majority of geomorphic and ecological processes that are sensitive to climatic fluctuations have a low temporal resolution, thus only yielding a record of natural fluctuations at time scales of a thousand years. For instance, the study of floral composition changes in organic deposits allows the recognition of distinct climatic periods as well as periods of activity of geomorphic processes. It provides information on permafrost dynamics (patterned ground evolution), mass movements and water level fluctuations of lakes. Some peat sequences dating back to at least 7100 years BP (GSC-5180) provide a record of climatic as well as edaphic changes.

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

## POSTGLACIAL VARIATIONS IN THE RANGE OF THE BOWHEAD WHALE AND PALEOSEA ICE CONDITIONS, CANADIAN ARCTIC

A.S. Dyke<sup>1</sup>

The remains of about 1000 bowhead whales have been excavated from raised marine deposits at 52 sites between M'Clintock Channel and Navy Board Inlet in the central and eastern Canadian Arctic; several hundred samples have been radiocarbon dated. Whale remains are moderately abundant in the central Arctic (one animal per 20-100 km<sup>2</sup>) and very abundant in the eastern Arctic (up to 20 animals per km<sup>2</sup>). The remains are clustered in two age

\*This talk will be presented in French

groups, reflecting changes of access controlled by sea ice. An early Holocene peak abundance (11-8 ka) was followed by a period when the whales were excluded by severe sea ice from much of their former summer range until a strong, but more geographically limited, resurgence (6-2 ka), in turn terminated by the Neoglacial deterioration.

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

## A CROSS-CANADA OUTDOOR RADON SURVEY

R.L. Grasty<sup>1</sup>

In the summer of 1990, 150 outdoor <sup>222</sup>Rn (radon) detectors were installed in 31 communities across Canada. These high sensitivity alpha-track detectors were placed between 2 and 3 metres above the ground for a period of 3 months. Large regional variations were found with the average outdoor levels for the provinces of Manitoba (59 Bq/m<sup>3</sup>) and Saskatchewan (61 Bq/m<sup>3</sup>) exceeding the average indoor levels for the United States of 55 Bq/m<sup>3</sup>. These regional differences showed little correlation with the uranium concentration of the ground and were attributed to changes in soil moisture. All measurements above 30 Bq/m<sup>3</sup> were found to be in dry climatic regions where the average annual rainfall was less than 550 mm. These were regions where the soil was drying out during the summer.

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

## THE NATIONAL MAPPING PROGRAM

M.E. Cherry<sup>1</sup>, S.B. Lucas<sup>1</sup>, J.E. King<sup>1</sup>

The National Mapping Program (NATMAP) is an initiative designed to increase the level of bedrock and surficial geological mapping in Canada through multi-disciplinary, multi-institutional projects related to (1) development of mineral resources; (2) filling gaps in fundamental geological knowledge; and/or (3) environmental concerns. Two NATMAP projects were initiated in 1991. The Shield Margin project is studying the base metal- and gold-rich Flin Flon-Snow Lake Belt (Manitoba and Saskatchewan) in order to develop a digital database for the area and an interpretive map of the sub-Paleozoic continuation of the belt. It will integrate the results of bedrock and surficial mapping and topical studies by the GSC, provincial surveys and universities, and data derived from the Trans-Hudson Lithoprobe transect. The Slave Province project (NWT) is focused on a north-south corridor which has high gold and base metal potential. Cooperative reconnaissance mapping by the GSC, DIAND and GNWT has established new understanding of complex stratigraphic-structural relations. Continued work should produce new perspectives on Slave Province mineralization and tectonics, and will also generate a digital geoscience database for GIS analysis.

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

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, Ottawa

## STRATIGRAPHY, SEDIMENTOLOGY, AND STRUCTURE OF THE HENIK, MONTGOMERY 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. Burse<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, Ottawa

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

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

## APPLICATION OF GAMMA RAY SPECTROMETRY TO GOLD EXPLORATION

B.W. Charbonneau<sup>1</sup>, R.B.K. Shives<sup>2</sup>, M.I. Legault<sup>3</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> Continental Geoscience Division, Ottawa

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

<sup>3</sup> University of Ottawa, 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 for finding both kimberlites and lamproites. One of the most commonly utilized exploration methods for locating kimberlite and lamproite is the use of indicator minerals 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 reviews 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, Ottawa

#### THE GEOLOGICAL SURVEY OF CANADA'S ROLE IN THE DEVELOPMENT OF DRIFT PROSPECTING IN CANADA

W.W. Shilts<sup>1</sup>, R.N.W. DiLabio<sup>1</sup>

Drift compositional studies were initiated at the Geological Survey of Canada in the mid-1960s in projects that drew heavily on the technology and approaches developed in Fennoscandia over the previous century. As this research progressed and expanded in the 1970s, its Fennoscandian character diminished and, like the geochemical exploration research program which it closely paralleled, drift prospecting began to acquire a distinctly Canadian

character, imposed by the geographical and logistical constraints of climate and asymmetric population distribution. Our research has increasingly focused on understanding and explaining the geochemical expression of the mineralogical composition of glacial sediments that are unaltered or only slightly altered by postdepositional weathering. Because glacial sediments are generated largely by crushing and abrasion, their various mineral components attain characteristic size modes based on physical properties such as cleavage and hardness. This size sorting by physical properties is expressed geochemically by chemical partitioning in various size ranges. Also, the crushing process disaggregates fresh bedrock and incorporates all of its mineral components, labile as well as stable, into glacial sediment. Our research has concentrated on the best ways to sample and analyze drift to avoid the compositional size bias and potential weathering alterations of labile minerals, so that geochemical analyses truly representative of *provenance* may be attained. As we have become confident that we can filter provenance signals from noise generated by weathering, partitioning, sediment facies misidentification, stratigraphic misidentification, etc., the principles of glacial dispersal of components of economic and environmental significance have been clarified and dispersal patterns mapped.

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#### ROCK ANALYSIS BY X-RAY FLUORESCENCE

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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-Trail (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.

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#### THE SCIENTIFIC PROGRAM OF MINERAL RESOURCES DIVISION

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# POSTERS

## GEOSCIENCE SURVEYS

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

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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.

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### 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 5 tectonic assemblages are important in the evolution of northwestern Stikinia and northeastern Coast Belt:

- 1) undated, quartzite, siliceous argillite and marble of a possible continental margin assemblage;
- 2) Stikine assemblage including Lower Devonian limestone, chert, and tuff, middle Carboniferous limestone and pillowed lava, and Permian limestone (and volcanic rocks?);
- 3) Triassic to Middle Jurassic volcanic arc and associated basinal rocks;
- 4) Upper Jurassic Bowser Basin overlap assemblage rocks; and
- 5) post-tectonic Tertiary plutonic rocks. The assemblages record at least one pre-Triassic, and Early Jurassic and a post-Late Jurassic, pre-Eocene deformations.

The poster emphasizes elements of the metallogenically and biostratigraphically important Mesozoic evolution including: Late Triassic, Early Jurassic, and Middle Jurassic volcanism and plutonism, development of intra-arc and back-arc sedimentary basins, and mineral deposition. Local deformation of rocks of Late Triassic and Early Jurassic age may have led to a widespread, sub-Toarcian unconformity.

Deformation related to the Skeena fold belt involved overlying Middle and Upper Jurassic siliciclastic rocks but pre-dated Eocene intrusion of undeformed, felsic Coast Belt plutons.

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### 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. Burse<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).

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

<sup>3</sup> Continental Geoscience Division, 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 0.72-0.78 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 South 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.

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## METAMORPHIC MAP OF THE CANADIAN SHIELD: SOME NEW PERSPECTIVES

R.G. Berman<sup>1</sup>, M. Schau<sup>1</sup>, B. Brodaric<sup>1</sup>, U.K. Mader<sup>1</sup>

A new metamorphic compilation of the Canadian Shield has been initiated as part of a joint GSC-USGS-CGMW project to compile a metamorphic map of North and Central America. Implementation of digital compilation and cartographic methods includes modifications of the Fieldlog system to facilitate data entry and improve data storage. The emphasis of this compilation is on metamorphic pressures and pressure differences because of their tectonic significance. Accordingly, petrogenetic grids have been constructed that allow consistent estimation of metamorphic grade and pressures for pelitic, mafic, and carbonate rocks. Newly developed geobarometers for amphibole-bearing assemblages allow improved estimation of pressures in greenschist to granulite grade rocks.

This methodology has been applied to 40 000 km<sup>2</sup> on Melville Peninsula, NWT, where Archean granulite grade orthogneisses are thrust onto amphibolite grade granites, gneisses and supracrustals. Ductile shearing and the formation of later anastomosing high strain zones locally retrograde some of the higher grade assemblages. The array of structural levels exposed by latitudinal brittle faults illustrates many important features of the compilation techniques.

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## EVOLUTION OF THE THERMAL MATURATION IN THE UPPER GASPÉ LIMESTONES, FROM FORILLON PENINSULA TO MURDOCHVILLE, QUEBEC

R. Bertrand<sup>1</sup>, D. Lavoie<sup>1</sup>, F. Goodarzi<sup>2</sup>

The Upper Gaspé Limestones (Lower Devonian) constitutes a carbonate interval in the terrigenous sedimentation that characterizes the Post-Taconian Gaspé Basin.

The organic matter contains a great variety of organoclasts: solid bitumen, zooclasts, marine and continental phytoclasts, that allow correlation of the reflectance (Ro) of the standard vitrinite with that of marine zooclasts, and proposal of a wide range correlation scales.

From east to west, the 100 km wide studied area contains three thermic domains. From Forillon to about 40 km east of Murdochville, the Ro fluctuates between 0.7 and 1.2% at surface, but never exceeds 1.6% at the base of synclines. Burial depth and basement anisotropy control the syn- and post-Acadian thermal maturation. In the following 30 km wide domain, the Ro increases to 2.0% (end of catagenesis). The Ro moves up to 3.0% in the first 5 km of the westernmost domain and climbs to 8.0% (epizone) when reaching the skarn zone, 6 km further. Burial influence then vanishes, and the maturation becomes strictly related to the ore body proximity.

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

D.E. 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.

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## COMPILATION MAPPING OF SURFICIAL DEPOSITS, SOUTHERN QUEBEC

A.M. Bolduc<sup>1</sup>

About 90% of the Shawinigan (31INE) and Trois-Rivières (31ISE) areas are covered by surficial deposits, bare areas are located mainly in the Laurentians. The main sediment types are till, fluvio-glacial sediments, marine clays, regressive sands, and organic deposits. Landforms are few, the St. Narcisse moraine being the most spectacular. Minor moraines, eskers, deltas, shoreline features, and dunes are also present. Maximum level of the Champlain Sea is about 213 m a.s.l. Striae indicate that Late Wisconsinan ice flow was to the southeast (135° to 170°). Tills have a sand-silt matrix, with numerous sand stringers, indicating deposition during melting of the glacier. The geochemical composition of the till matrix, and the lithological composition of the pebble fraction, show that tills are

closely related to underlying bedrock. Canadian shield pebbles, however, have been transported throughout the area, for a minimum distance of glacial transport of 70 km.

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#### 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 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.

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

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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.

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

T.L. Bursley<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.

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#### AEROMAGNETIC MAPS – PAST AND PRESENT

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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.

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## ARCHEAN ROCKS IN THE NORTHWESTERN GRENVILLE PROVINCE, AN EASTERN EXTENSION OF THE SUPERIOR PROVINCE

A. Ciesielski<sup>1</sup>

In the north-west central Grenville Province, Archean orthogneiss and metagreywackes define the Parautochthonous Domain (PD), a lithotectonic entity, extending a 1000 km SE of the Grenville Front (GF) bounded to the SE by the Allochthon Front, the limit of Grenvillian tectonites. East of Chibougamau, the Neoproterozoic PD orthogneisses are mainly affected by Kenoran deformation and contain metavolcanic, metasedimentary and meta-anorthositic inclusions; they show tonalite compositions and low K trondhjemitic affinity, a wide range of major and trace element compositions, intermediate REE fractionation and positive Eu anomalies. East of Val d'Or, granulite grade Neoproterozoic orthogneiss and minor orthogneiss show Kenoran deformation and are equivalent to the Pontiac metagreywackes. The PD tonalitic orthogneisses are considered syn-volcanic or syn-sedimentary forming the substrate or the basement to the eastern Abitibi Belt extending east of the GF prior to the Grenvillian Orogeny.

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## SUBDIVISION OF THE SUPERIOR PROVINCE REVISITED

A. Ciesielski<sup>1</sup>

A reassessment of the subdivisions of the Superior Province is proposed, based on previous work and new data. The criteria of subdivision and the terminology used are described. Nineteen subdivisions are defined mainly by lithologic, structural, metamorphic and magnetic characteristics; the province comprises metamorphic (high-grade), plutonic-gneissic, volcano-plutonic and metasedimentary-metaplutonic subprovinces. The southwestern part of the Superior Province can be regarded as a tectonic collage of large distinct EW-trending lithologic terrane mostly separated by main fault zones. The northeast part is mainly plutonic, gneissic and metamorphic; its lithologic and metamorphic subdivisions show gradational or intrusive contacts. It is considered as a Neoproterozoic magmatically accreted terrane on which the SW Superior Province was tectonically juxtaposed during the Kenoran Orogeny.

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## PROTEROZOIC COMPRESSIONAL DEFORMATION ON THE ANDERSON PLAINS, N.W.T.

K. Coflin<sup>1</sup>

Industry reflection seismic data reveal that beneath a thin (1 to 3 km) and relatively undeformed Proterozoic section there are large southeast directed thrust faults. The regional geology is under constrained but it is possible to make a tentative stratigraphic correlation to the seismic profiles. The reflection character of the area is very predictable, implying that the Proterozoic rocks have a well behaved layered stratigraphy. It is interpreted that beneath the sub-Paleozoic unconformity, rocks of the Mackenzie Mountains Supergroup are found in the western part of the study area and Dismal Lakes Group rocks in much of the eastern part. The Dismal Lakes Group on the seismic profiles is relatively uniform and conformably overlies a westward thickening Hornby Bay Group. Several periods of compression are recognized. The age of the major

period of deformation is syn- and post- deposition of the Dismal Lakes Group. This period of compression produced thrust faults with strike lengths up to 70 km and individual displacements of 5 to 20 km. The total compressional shortening is at least 20% over 150 km. Individual faults sole out into a northwest dipping detachment surface inferred to exist at 12 to 15 km, at or near the base of the seismic profiles. Some Proterozoic age faults have been reactivated during Phanerozoic deformation periods.

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## A HISTORY OF GRAVITY MAPPING IN CANADA

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The first measurements of gravity in Canada were made in 1820 by E. Sabine who timed the period of a swinging pendulum on Melville Island. During the first half of this century, scientists O. Klotz, F. McDiarmid and A. Miller of the Dominion Observatory measured gravity at some 150 locations throughout Canada using pendulums as part of an initiative by the Observatory to study the planet Earth. With the advent of the relatively lightweight, portable, spring-balance type of gravity meter in the late 1940s, gravity mapping became much more practicable. Using automobiles and fixed-wing aircraft in the 1950s, M. Innes and others were able to make thousands of additional gravity observations. The availability in the 1960s of helicopters for land surveys and the development of precise, stabilized-platform dynamic gravity meters and navigation systems for marine gravity surveys in the 1970s enabled large-scale, systematic regional gravity surveys to be carried out so that we now have approximately 700,000 observations spread over Canada to contribute to geodetic investigations and to geological studies of the Earth's crust and upper mantle.

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## AIRBORNE RADIOACTIVITY MAPS OF THE CENTRAL METASEDIMENTARY BELT OF EASTERN ONTARIO AND PART OF 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. Héту<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.

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## **POLAR MARGIN AEROMAGNETIC PROGRAM**

D.A. Forsyth<sup>1</sup>, D.J. Teskey<sup>2</sup>, A.V. Okulitch<sup>3</sup>, R.F. Macnab<sup>4</sup>,  
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Since 1989, a cooperative survey project involving the Institute of Aerospace Research, the Geological Survey of Canada, and Defense Research Establishment Pacific has produced the highest resolution magnetic data yet acquired in the high Arctic. The first phase of the program completed mapping the enigmatic area of the Lincoln Sea north of Nares Strait including adjacent areas on Ellesmere Island and Greenland. A first order extension of the proposed Wegener Fault from Nares Strait is not evident. The complex anomaly pattern that reflects the intricate plate tectonic adjustments at the juncture of Ellesmere Island, Greenland and the ridge structures beneath the adjacent Arctic Ocean is one focus of future study.

The second phase of the program began in 1991 with a survey to map the shelf area between Ellesmere Island and Ellef Ringnes Island. This and future surveys will provide the first magnetic data over parts of the western Pearya terrain on northern Ellesmere Island as well as providing the first magnetic map of the area covered by the Frontier Geoscience seismic refraction program.

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<sup>3</sup> Institute of Sedimentary and Petroleum Geology, Calgary

<sup>4</sup> Atlantic Geoscience Centre, Dartmouth

<sup>5</sup> Defense Research Establishment Pacific

<sup>6</sup> Institute of Aerospace Research

## **THE MARINE VISEAN OF ATLANTIC CANADA: REGIONAL LITHOSTRATIGRAPHIC FRAMEWORK**

P.S. Giles<sup>1</sup>

The earliest record of marine deposition in the Viséan of Atlantic Canada is a distinctive carbonate rock unit, which is well accepted as a regional stratigraphic datum. As many as 12 higher marine carbonate markers within the 300-1500 m thick Late Viséan succession can be correlated with varying confidence (largely dependant upon data quality and availability) between widely separated structural basins in Nova Scotia. Continuity of similar cyclic marine bands northerly to the Magdalen Islands and western Newfoundland, argues strongly for a cohesive lithostratigraphic framework for the entire Gulf of St. Lawrence region. These time-significant carbonate markers provide the skeleton for reconstruction of this large depositional regime during transgressive maxima. Intervening marginal-marine and non-marine strata record variations in sedimentation rates and facies which are at least in part a reflection of the tectonic setting. Regional understanding of this systematic and coherent stratigraphic framework is fundamental not only to paleogeographic reconstruction, but to a growing appreciation for significant post-Viséan tectonism.

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## **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.C. 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.

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## **LONG-TERM TIME VARIATIONS OF THE GEOMAGNETIC FIELD AND THEIR APPLICATION TO THE EARTH'S DEEP INTERIOR**

A.K. Goodacre<sup>1</sup>

The first Canadian magnetic observatory was established in 1840 in Toronto. Observations at Toronto soon showed that the Earth's magnetic field is not immutable but undergoes changes over a wide range of time scales. Observed secular changes in the Earth's magnetic field allow geophysicists to study various problems such as determining spatial variations of electrical conductivity in the crust and mantle. Another application of secular changes of the Earth's magnetic field is, under various simplifying assumptions, to study fluid motions in the Earth's core and concomitant movements of mantle material. Recalling that the Earth's surface can be split into "continental" and "oceanic" hemispheres, spatial variations in the rate of change of the magnetic vector potential suggest that fluid flow in the Earth's outer core is more vigorous on the continental side and that flow in the core is coupled to convection in the mantle.

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

## **THE INTEGRATION OF AIRBORNE RADAR AND GEOPHYSICAL DATA FOR RECONNAISSANCE GEOLOGICAL MAPPING IN THE MARATHON-SCHREIBER AREA, NORTHWESTERN ONTARIO**

D.F. Graham<sup>1</sup>, C. Bowie<sup>1</sup>, K.L. Ford<sup>1</sup>

High sensitivity gamma ray spectrometer data collected by the Geological Survey of Canada (GSC) have been effectively applied to both regional and detailed bedrock and surficial geology mapping and multi-element mineral exploration programs in many areas in Canada.

Data sets used for this study include: Airborne radar acquired by the Canada Centre for Remote Sensing, and airborne gamma ray spectrometry and total field magnetics collected by the Mineral

## LIMS: A LONG PERIOD INTELLIGENT MAGNETOTELLURIC SYSTEM

R.D. Kurtz<sup>1</sup>, D.E. Boerner<sup>1</sup>, A.G. Jones<sup>1</sup>, R. Charbonneau<sup>1</sup>, K. Harding<sup>1</sup>, J.A. Parmelee<sup>1</sup>, and D.F. Trigg<sup>1</sup>

A low-power, microprocessor-controlled long period magnetotelluric system has been developed for unattended recording of data in the period range from 15 Hz to 2 days.

It is designed to be small (40 cm x 28 cm x 25 cm) and portable (5 kg including the internal battery pack for memory backup). Recording time is limited only by the memory (5 Mbyte) and the power source.

The magnetic sensor is a three-component ring core fluxgate (sensitivity of 0.016 nT/RHz mounted with a levelling assembly in a waterproof cylinder).

The system incorporates selectable digital low-pass filtering and decimation which permit a wide variety of recording bands and sampling rates.

Data are transferred from the LIMS system via an RS232 port, usually to IBM-compatible personal computers.

Preliminary hardware and software plans for the second generation of LIMS include a 32 Mflop DSP (Digital Signal Processor) chip. The DSP-based system will undertake real time data analysis, time series data quality evaluation, and recording in an number of frequency bands to reduce the data storage requirements for extended deployments.

<sup>1</sup> Continental Geoscience Division

## NARSAJUAQ TERRANE, UNGAVA PENINSULA, QUEBEC: TECTONIC HISTORY OF AN EARLY PROTEROZOIC MAGMATIC ARC IN THE UNGAVA OROGEN

S.B. Lucas<sup>1</sup>, M.R. St-Onge<sup>1</sup>, J.M. Dunphy<sup>2</sup>, and R.R. Parrish<sup>1</sup>

Narsajuaq terrane is an assemblage of metasedimentary and metaplutonic rocks which was accreted to the Superior Province. Metaplutonic rocks include an older layered unit of tonalite (1863 Ma) and quartz diorite which is intruded by sheets of granodiorite (1861 Ma), quartz diorite (1844 Ma), monzogranite (1836-1834 Ma), and tonalite (1830 Ma). Metasedimentary rocks include semipelite, quartzite, pelite, ironstone, marble, and calc-silicate rock. Detrital zircons from a quartzite sample indicate erosion of both Archean and 1863-1830 Ma rocks followed by deformation and metamorphism ca. 1830 Ma. The terrane records an early episode of synmagmatic, granulite grade metamorphism (1825 Ma) and dextral transcurrent deformation prior to accretion as a wedge at the base of the Cape Smith Thrust Belt. In total, Narsajuaq terrane appears to record 1863-1830 Ma arc magmatism, coeval underplating of subducted sedimentary rocks derived in part from the arc itself, and post-1825 Ma collision with the Superior Province.

<sup>1</sup> Continental Geoscience Division  
<sup>2</sup> Université de Montréal, Montreal

## DIP AND DEPTH EXTENT OF AN INCLINED PLANAR GEOLOGICAL BOUNDARY DERIVED FROM HORIZONTAL DERIVATIVES OF AN UPWARD-CONTINUED GRAVITY PROFILE

P.H. McGrath<sup>1</sup>

Computer and graphical methods were developed to derive the dip, vertical extent, and location of a truncated horizontal-plate model from its gravity profile. The methods are based on lateral offsets of the zero-crossover point of second horizontal derivatives of a gravity profile which has been upward-continued over a fixed interval to several elevations above ground level. Upward-continuation and horizontal derivation are achieved by Fourier techniques. Application requires that the distance to the upper surface of the model be known. Numerical tests indicate useful results are obtained when both the length of the gravity profile, and the finite-strike length of the model are at least three times the maximum depth extent of the model. Random noise with standard deviations up to 0.3 mGal are tolerated given an anomaly amplitude of 70 mGal. An interpretation example from the Trans-Hudson orogen of central Manitoba indicates that the Kiseynew metasedimentary gneisses extend over a vertical distance of 15 to 18 km, and are separated from the Baldock Batholith to the north by a near-vertical boundary.

<sup>1</sup> Continental Geoscience Division

## THE SAINT-MAURICE TECTONIC ZONE: A MAJOR STRUCTURE OF THE CENTRAL GRENVILLE OROGEN, QUEBEC

L. Nadeau<sup>1</sup> and D. Corrigan<sup>2</sup>

The Saint-Maurice tectonic zone is a regional-scale easterly dipping mid- to deep crustal ductile shear zone that separates the allochthonous monocyclic belt (AMB) on the west from the Laurentides park plutonic complex, part of the allochthonous polycyclic belt (APB), to the east.

A section across this structure shows that its eastern margin is a steeply dipping zone of subhorizontal sinistral shearing. Farther to the west, the shear zone dips gently to the east and projects structurally above the AMB. Kinematic constraints suggest that the shear zone is the product of northwest-directed compression. However, the large-scale tectonic flow pattern is complex and reflects changing boundary conditions.

Published regional interpretations of the southwestern part of the Grenville orogen show the AMB to be overthrust onto the APB. Although overthrusting is well established in western Quebec and Ontario, our observations at the Saint-Maurice tectonic zone show that the history of the eastern border of the AMB does not fit such a simplified model.

<sup>1</sup> Quebec Geoscience Centre, Ste-Foy  
<sup>2</sup> Ottawa-Carleton Geoscience Centre, Ottawa

## A PRELIMINARY MAGNETIC ANOMALY MAP OF THE ARCTIC PRODUCED FROM DIGITAL DATA

G. Oakey<sup>1</sup>, K.G. Shih<sup>1</sup>, R.F. Macnab<sup>1</sup>, J. Verhoef<sup>1</sup>, and S.P. Srivastava<sup>1</sup>

Within the last two years a project has been underway to compile magnetic data from the Arctic and North Atlantic regions to produce a comprehensive data base to be used for advanced analyses and the production of high quality maps. Data have been received from many international agencies in both original profiles and digital grids. These data have been combined using various conversion and adjustment techniques to produce a data base in excess of 20 million original observations supplemented by grid sets covering a similar sized area.

This poster features a 1:6 million scale map of all data north of 60°N and to date is the most comprehensive magnetic anomaly map of the Arctic region. The data sets still require further adjustment and levelling, and there remains important gaps where data are not yet available. However, the map serves a useful purpose by focusing attention on the blank areas that need to be filled, whether by contributions of existing data or by future surveys.

<sup>1</sup> Atlantic Geoscience Centre, Dartmouth

## THE CONODONT AS A TOOL IN CORDILLERAN GEOSCIENCE

M.J. Orchard<sup>1</sup>

A conodont is a remarkably versatile phosphatic microfossil with highly variable age-diagnostic morphology, temperature-dependent colour (CAI), a crystallinity that changes with diagenetic/metamorphic effects, and trace element/isotopic chemistry through which paleo-oceanographic conditions and absolute age may be determined. The extinct animal that bore the tooth-like elements was environmentally and paleogeographically differentiated, thus facilitating use of conodonts in the depositional basin and tectono-stratigraphic terrane analysis.

During the last decade, several thousand conodont collections have been extracted from Cordilleran strata through acid digestion. Thus far, the major application of the conodont tool has been in the relative dating of often metamorphosed calcareous and siliceous rocks. Through the use of new (particularly Triassic) conodont zonations, and the adaptation of existing ones, a temporal framework for Paleozoic-Triassic strata has been constructed and is routinely used to elucidate Cordilleran geology.

Examples of significant progress in our understanding of the stratigraphy, structure, and tectonic evolution of each of the major Cordilleran terranes, and of the epicratonal autochthon are summarized.

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

## MAPPING OF QUATERNARY SEDIMENTS NEAR KAPUSKASING, ONTARIO, WITH A HELICOPTER ELECTROMAGNETIC SYSTEM

G.J. Palacky<sup>1</sup>, J.S. Holladay<sup>2</sup>, and P.W. Walker<sup>2</sup>

Results of test surveys in northeastern Ontario demonstrate that multifrequency helicopter electromagnetic (EM) surveys can be effectively used in mapping of Quaternary sediments. Airborne

geophysical surveys are inherently cost-effective over large areas. Statistical analysis of electrical properties of clay, till, and sand layers has shown that all three sediment types have distinct conductivities. Therefore, lithology can be determined from conductivity maps or pseudosections. Correlation of airborne and ground EM data with the results of Rotasonic drilling has indicated that determinations of conductivity of overburden are reliable in most situations. Estimates of overburden thickness, which is another parameter of interest, critically depend on the quality of raw data and the type of interpretation technique used. Two methods have been used to process helicopter EM data: a) inversion based on singular value decomposition; and b) centroid depth approach developed by P. Sengpiel of Bundesanstalt für Geowissenschaften und Rohstoffe. While the second method appears more robust, both are sensitive to levelling errors. The poster depicts field examples obtained in different geological situations along the Kapuskasing transect.

<sup>1</sup> Mineral Resources Division  
<sup>2</sup> Aerodat Ltd., Toronto

## MULTIDISCIPLINARY STUDIES ALONG THE SOUTHERN CORDILLERAN LITHOPROBE TRANSECT

R.R. Parrish<sup>1</sup>, C. Spencer<sup>1</sup>, A.G. Jones<sup>1</sup>, M. Thomas<sup>1</sup> and the LITHOPROBE Southern Cordillera Working Groups

The Southern Cordillera Transect of LITHOPROBE is near completion following more than five years of multidisciplinary scientific activity. Seismic reflection data show that the Moho is remarkably planar across most of the Cordillera, despite the large structural relief resulting from Mesozoic compression and Eocene extension. Major features that have been identified by geophysical and geological methods include the Eocene Slokan Lake normal fault, Late Cretaceous to Paleocene thrust zones in Valhalla and Monashee complexes, a Cretaceous west-vergent thrust zone in the eastern Coast Plutonic Complex, a high amplitude (magmatic?) reflector in the upper crust near Holocene volcanic centres, and a near-continuous linkage of reflectors beneath the mainland Cordillera with those beneath Vancouver Island. The data constitute a nearly complete record of crustal structure from the active downgoing slab to the stable craton of Alberta, providing new insights into the tectonic evolution of the Cordillera.

<sup>1</sup> Continental Geoscience Division

## A GEOLOGICAL TRANSECT OF THE MINTO SUB-PROVINCE, SUPERIOR PROVINCE, ACROSS THE UNGAVA PENINSULA, QUEBEC

J.A. Percival<sup>1</sup>, K.D. Card<sup>1</sup>, R.A. Stern<sup>1</sup>, N.J. Bégin<sup>2</sup>, and J.K. Mortensen<sup>1</sup>

The Minto Subprovince is a 450 km wide, dominantly plutonic region with north-northwest structural trends. A 400 km long transect from Hudson to Ungava Bay crosses four distinct lithotectonic domains, from west to east: 1) Tikkerutuk terrane, containing granodiorite and granite with hornblende-biotite assemblages; 2) Lake Minto terrane, with metasedimentary and metavolcanic remnants cut by orthopyroxene-bearing granodiorite and granite; 3) Goudalie terrane of predominant tonalite, with supracrustal relics and deformed mafic dykes; and 4) Utaslik terrane consisting of granodiorite and granite with both hornblende-biotite and pyroxene-bearing assemblages. Terranes 2) and 3) have independent lithotec-

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.B. Luca<sup>1</sup>, A. Leclair<sup>1</sup>, R.A. Stern<sup>1</sup>, P. Lenton<sup>2</sup>, A.H. Bailes<sup>2</sup>, E.C. Syme<sup>3</sup>, D. Thomas<sup>4</sup>, B. Reilley<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, Ottawa

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

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

#### **IMBRICATE THRUSTING, REVERSE FAULTING, AND EXTENSIONAL COLLAPSE OF THE ACADIAN OROGEN, CENTRAL CAPE BRETON HIGHLANDS, NOVA SCOTIA**

G. Lynch<sup>1</sup>

Deformation within the Acadian orogen of the central Cape Breton Highlands features: a) mid-crustal west-vergent imbricate thrusting within the Silurian Jumping Brook metamorphic suite; b) opposite facing reverse fault systems which displace high grade gneiss metamorphosed during Devonian deformation, over medium to low grade volcanic arc assemblages; and c) late Devonian extension.

Imbricate thrusting is marked by structural repetitions of Silurian turbiditic sequences and associated metavolcanic assemblages, as well as by the emplacement of amphibolite grade rocks over greenschist grade rocks. The thrust system is bounded to the east by west-verging steep reverse faults. The fault styles and contrasts in metamorphic regimes indicate that contraction occurred above a large thrust ramp. Imbrication is thought to have developed along the upper ramp flat, in the foreland portion of the system. Late extension developed in the foreland; shallow dipping mylonite zones

are rooted in the thrust and reverse fault systems, which appear to have been reactivated. Kinematic indicators suggest northward movement of the upper sheets during extension.

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

#### **INTERPRETATION OF THE DARNLEY BAY GRAVITY AND MAGNETIC ANOMALIES**

P.H. McGrath<sup>1</sup>, D.W. Halliday<sup>2</sup>

Major coextensive gravity and magnetic anomalies occur in the Darnley Bay area of the northwest Territories. These anomalies extend over an area of approximately 4000 km<sup>2</sup>, and attain amplitudes of 130 mGal and 1400 nT, respectively. The geological body producing these anomalies occurs within Precambrian crystalline basement, which in this area is buried beneath a few kilometres of Phanerozoic sedimentary strata. Renewed interest in this body has resulted in the collection of 105 gravity observations during the summer of 1991 along two SW-NE profiles passing over the central and southeastern parts of the gravity anomaly. The nominal station spacing was 2 km as contrasted with the 10-12 km spacing of the original regional gravity survey data. Combined interpretation of these new gravity data and of aeromagnetic data obtained by the GSC in 1973, hopefully will not only improve the definition of the shape of the causative body, but will also delineate the area where its upper surface is shallowest and most amenable to exploration by drilling.

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

<sup>2</sup> Geophysics Division, Ottawa

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

B. Milkereit<sup>1</sup>, A.G. 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>

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, 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

## 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>

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.

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

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

## GEOLOGY OF LA BOSTONNAIS COMPLEX AND THE ST. MAURICE TECTONIC ZONE, GRENVILLE OROGEN, QUEBEC

L. Nadeau<sup>1</sup>, D. Corrigan<sup>2</sup>, P. Brouillette<sup>1</sup>, E. Gauthier<sup>3</sup>,  
S. Lévesque<sup>3</sup>

Three lithotectonic domains comprise the Grenville orogen in the Portneuf-St.Maurice region. The Laurentides Park plutonic complex (part of the Allochthonous Polycyclic Belt) is separated to the west from the Mékinac domain (an extension of the Allochthonous Monocyclic Belt ?) by a third domain 40 km-wide underlain by amphibolite facies easterly-dipping plutonic and subordinate supracrustal rocks. The last includes meso-scale layers and boudins of mafic gneiss in migmatitic aluminous paragneiss and the relatively lower-grade metasedimentary and metavolcanic rocks of the Montauban area. The high-grade plutonic rocks comprise those of La Bostonnais complex which range from pyroxene-hornblende diorite to hornblende-biotite granodiorite, all with a few scattered small bodies of ultramafic rocks. Taken together, the rocks of this belt have been interpreted to constitute a major break, the "St.Maurice tectonic zone". The initial suggestion that this break was a major shear zone is reevaluated. Alternative interpretations are examined.

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<sup>2</sup> Ottawa-Carleton Geoscience Centre, Ottawa

<sup>3</sup> Université Laval, Sainte-Foy

## EVOLUTION OF THE GRAVITY MAP OF CANADA

D. Nagy<sup>1</sup>, R.K. McConnell<sup>1</sup>, D.B. Hearty<sup>1</sup>, R.A. Gibb<sup>1</sup>

The rationale for systematic measurement of the gravity field in Canada as a basic input to geoscience research was established by F.A. McDiarmid of the Dominion Observatory in 1914. Early measurements, laboriously carried out with pendulums, accumulated slowly. In 1929, an isostatic gravity map of Western Canada, incorporating a few dozen measurements, was published.

The first edition of the Gravity Map of Canada, appearing in 1939, was based on some 150 measurements. The rate of data acquisition was greatly increased in the 1940s with the introduction of spring-type relative gravimeters. After some experimentation to determine optimum station spacing for regional mapping, the specifications for the present National Gravity Mapping program were established. Subsequent editions of the Gravity Map of Canada in 1957, 1967, 1974 and 1980 illustrated the development of the mapping program. A computerized display illustrates the building of the National Gravity Data Base from Lieutenant Edward Sabine's arctic measurement in 1820 to the present day.

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

## BY COMPASS AND CANOE – THE GROWTH OF GEOMAGNETISM IN CANADA

L.R. Newitt<sup>1</sup>

The first known magnetic observation in Canada was made in 1559, thus making the study of magnetism one of the earliest scientific endeavours undertaken in this country. Magnetism was of great practical importance in those early days since the magnetic compass was an essential instrument for navigation. Thus explorers routinely determined magnetic declination wherever they travelled. Most inland travel at that time was by canoe, following major rivers and lakes. A map of the magnetic observations during that era shows a clear outline of the major canoe routes of the country. Starting in the early nineteenth century, magnetism moved from the realm of the amateur observer to that of the trained professional. However, during his monumental magnetic survey of 1843-44, John Henry Lefroy still travelled by canoe with Hudson Bay Company voyageurs along the ancient water routes. By the twentieth century, the train had replaced the canoe as the normal means of transportation for magnetic observers, but as late as the 1920s, observers were still making summer-long canoe trips into the remote parts of the country.

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## TILL COMPOSITION IN EASTERN ABITIBI, QUEBEC

S.J. Paradis<sup>1</sup>, S. Gagnon<sup>2</sup>

During summer field work carried out in eastern Abitibi, in summers, '89, '90 and '91, two tills were identified on the basis of stratigraphic position and of simple criteria such as colour, texture, grain size, and effervescence in dilute HCL.

A better definition of the composition of the two tills is obtained using preliminary results. The regional till is a diamicton with a sandy matrix that was deposited directly from glacier ice and which is essentially composed of Precambrian rocks. The silt-clay fraction usually represents less than 30% of the matrix. The younger, clay-rich till which is present in the northwest corner of the study area was deposited by a glacier that readvanced over Lake Ojibway varves, causing a marked enrichment in silt and clay which compose more than 60% of the till matrix. This clay-rich till which contains carbonate clasts derived from the Paleozoic basins of James Bay and Hudson Bay, was apparently deposited in Lake Ojibway directly by glacier ice.

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

<sup>2</sup> Université Laval, Québec

## ICE-FLOW PATTERNS AND TILL GEOCHEMISTRY IN THE EASTMAIN RIVER AREA, QUEBEC

M. Parent<sup>1</sup>

The study area (33 B/SW), located some 175 km east of James Bay, is underlain by a segment of the Eastmain River greenstone belt. Glacial striae, esker systems and fluted moraines indicate a single ice-flow direction towards WSW, across this and adjacent areas. Evidence of previous ice-flow directions, if any, was completely obliterated by this last glacial phase, which developed on the west side of the New-Québec Ice Dome. Surface till was sampled at a local scale (1 sample/2 km<sup>2</sup>) in an area of recognized mineral potential. Trace element geochemical analyses for precious and base metals were carried out on the silt + clay fraction of till. Early results indicate that the composition of the till largely reflects the underlying bedrock and thus, that distances of glacial transport are rather short.

<sup>1</sup> Quebec 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 Vizienz greenstone belt. The WNW-striking belt, about 40 x 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> Continental Geoscience Division, Ottawa

## FROM CANOES TO COMPUTERS: 99 YEARS OF MAPPING AT DUBAWNT LAKE, N.W.T.

T.D. Peterson<sup>1</sup>

Despite being near the geographical centre of the country, Dubawnt Lake is in one of the most inaccessible and poorly explored regions in Canada. Samuel Hearne walked around Dubawnt Lake - the third largest lake in the NWT - in 1770, during his second attempt to reach the Coppermine River. The next Europeans came 123 years later in a GSC party led by J.B. Tyrrell. This epic canoe voyage across the Barren Lands began at Lake Athabasca in February 1893, ending at Churchill in October after much hardship. With no maps, the party charted the land with compass, sextant, and chronometer. From 1952-1955, Operations Thelon, Baker, and Keewatin,

mounted by the GSC, mapped the Barrens with two new tools - airphotos and helicopters - in a fraction of the time it took Tyrrell to explore it in canoes. A. Donaldson continued the GSC's explorations 10 years later in studies of the Dubawnt Group. In 1991, geological data collected at Dubawnt Lake was recorded onto digital basemaps, collated into databases, and used to generate publication-quality maps while still in the field.

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

## INTERNATIONAL COLLABORATION ON MARINE SEDIMENT TRANSPORT STUDIES

D.J.W. Piper<sup>1</sup>, P. Cochonat<sup>2</sup>, H. Christian<sup>1</sup>, M.L. Morrison<sup>3</sup>

There has been a long history of international collaboration in geoscience in the Maritimes. Buried trees in the coalfields of Nova Scotia 150 years ago demonstrated the antiquity of geological time: international collaboration brought this knowledge to the world. Today, the same factors - world class geological features, a need for new ideas, and a need for expertise not available nationally - continue to lead to international collaboration.

Failure of sediments to lead to international slope resulting from the 1929 "Grand Banks" earthquake provides a case study applicable to instability on the Fraser and Var deltas and other slopes. The mechanisms of failure and subsequent sediment transport were investigated using the French module geotechnique and SAR deep-water sidescan, the AGC Lancelot pore-pressure sensor and long coring system, the MUN heat flow probe, and PISCES IV. Failure was promoted by high pore pressures and surficial biological strengthening of sediment: we are still assessing the role of gas hydrates. Retrogressive slumping persisted for many hours and turbidity currents were initiated by ignition on local slopes of > 10°.

<sup>1</sup> Atlantic Geoscience Centre, Dartmouth

<sup>2</sup> IFREMER, Brest (France)

<sup>3</sup> Memorial University of Newfoundland, St. John's

## ARCHEAN AND EARLY PROTEROZOIC TECTONOSTRATIGRAPHIC ASSEMBLAGES IN THE UNGAVA OROGEN (NORTHERN QUEBEC): ACCRETION OF AN ISLAND-ARC TERRANE

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Fieldwork in the northwestern part of the Ungava orogen has documented a crustal architecture which mirrors that of the northeastern part of the orogen, with autochthonous footwall basement exposed in an antiformal window through the south-verging thrust belt. Similarities in lithology and structural-metamorphic history between the structural basement and the Superior Province exposed in the eastern part of the orogen suggest that rocks in the northwestern basement window also belong to the Archean Superior Province. The basement window is overthrust on its south side by Parent Group intermediate to felsic lavas and volcanoclastic sedimentary rocks, and on its north side by the Narsajuaq arc. The Narsajuaq arc is a distinct terrane (ca. 1.86-1.83 Ga) comprised of a layered calc-alkaline plutonic sequence and relatively deepwater sedimentary rocks cut by voluminous tonalite, quartz diorite and granite plutons. Syn-magmatic, granulite-grade metamorphic assemblages in all Narsajuaq arc lithologies are overprinted by amphibolite-grade

assemblages clearly associated with the collision between the magmatic arc (Parent Group arc edifice and Narsajuaq arc plutonic core) and the Superior Province margin at ca. 1.82 Ga.

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#### Fe AND Mn IN CL ZONES BY SIMS – A LIMITATION TO THE APPLICATION OF CEMENT STRATIGRAPHY

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Cathodoluminescence (CL) zones are frequently used for cement stratigraphy and correlated on a basin wide scale. The Mn-Fe ratio is generally presented as control of the CL intensities in calcite (nonluminescent, dull and luminescent). However, this dogma is mostly based on electron probe results, i.e. on data frequently near the detection limits of the technique. In order to test the above model, Fe and Mn contents of uniform CL zones were measured with Secondary Ion Mass Spectrometry (SIMS). Three domains emerge clearly in the Fe-Mn space. Above 1500 ppm of Fe, the zones are dull. Below this threshold, points with more than 225 ppm of Mn are luminescent. The third domain, with lesser Mn and Fe contents, can display any of the CL intensities. This implies: (1) that the Fe-Mn pair do not entirely control the luminescence of calcite and, (2) that stratigraphy of cements based solely on CL petrography is not valid.

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#### DEVELOPMENT OF INTERPRETATION TECHNIQUES FOR GROUND AND AIRBORNE VLF-EM DATA

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The VLF electromagnetic method is used widely for detecting shallow conductors and has applications in mineral exploration, engineering investigations and geological mapping. In ground surveys, the measured parameters are either the tilt angle and ellipticity of the VLF magnetic field or its in-phase and quadrature components. For airborne measurements, the total VLF magnetic field and the vertical quadrature components are measured.

Despite its popularity and wide use, methods for quantitative interpretation of VLF-EM data are not yet fully developed. The purpose of this work was to develop appropriate techniques for quantitative interpretation of ground and airborne VLF data using the model of a two-dimensional plate conductor located inside a host rock with finite resistivity. Ground and airborne VLF responses of this model were obtained on a computer for various model parameters. The results were used to prepare characteristic interpretation diagrams for routine use in the field. The method requires prior knowledge of the host rock resistivity which may be obtained independently. The technique was used successfully to interpret ground VLF data from Ontario.

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#### A STRUCTURAL INTERPRETATION OF PORT AU PORT PENINSULA, WESTERN NEWFOUNDLAND: A CARBONATE PLATFORM AND BASEMENT-CORED TRIANGLE ZONE

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Geological mapping at 1:12 500 scale, coupled with structural constraints from nearby offshore industry reflection seismic data, suggest that the Cambro-Ordovician carbonate platform and its sedimentary cover underlying the Port au Port Peninsula, western Newfoundland, are allochthonous rather than autochthonous as traditionally interpreted; this has substantial implications for hydrocarbon exploration and for understanding the regional tectonic evolution. The platform rocks, and their cover of Taconian (Middle Ordovician) flysch and transported rocks of the Humber Arm Allochthon, are interpreted to lie within a west-vergent structural triangle zone (tectonic wedge). The zone is an Acadian (Siluro-Devonian) feature, on the basis of ages of westward-tilted foreland clastics above the upper detachment and an undeformed overlap succession. Extrapolation of seismic data, known nearby structural involvement of crystalline Precambrian basement, plus geometric constraints from cross-section balancing indicate that basement rocks are structurally involved in the triangle zone.

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#### REGIONAL AEROMAGNETIC SURVEYS IN THE YUKON, BRITISH COLUMBIA, ALBERTA, SASKATCHEWAN AND MANITOBA

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A high sensitivity aeromagnetic survey in the Yukon to study the structure of the Taiga foldbelt on the margin of the Cordillera and the structure of the basement to the north was carried out under two contracts. Data and maps from the first contract were released in early 1991, while those from the second contract are expected to be released in mid-1992.

The second year of an aeromagnetic survey of southern Alberta, extending to the foothills and Rocky Mountains has been completed, with a third phase planned for 1992. This operation has been a joint venture between the GSC and a number of oil and mining companies and will result in a high quality aeromagnetic data base for the area.

The initial year of a second cost-sharing survey with industry and the Provinces in southern Saskatchewan and Manitoba has also been completed with the search for diamantiferous kimberlites providing the incentive for the participating mining companies. These surveys are also being funded under GSC A-base and Canada-Saskatchewan and Canada-Manitoba Mineral Development Agreements. The data for both these surveys will be invaluable for studying the structure of the basement as a contribution to Lithoprobe projects and for mineral and hydrocarbon exploration.

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## TECTONIC HISTORY AND ECONOMIC POTENTIAL OF THE GIBSON LAKE – MELIADINE LAKE REGION, DISTRICT OF KEEWATIN, N.W.T.

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The Archean lithologies in the Gibson Lake area are dominated by polydeformed quartzofeldspathic gneiss, migmatite, granitoid plutons, pelitic schist, amphibolite, and garnetiferous, silicate iron-formation. Folded high-strain zones, that contain tectonized remnants of anorthosite, gabbro, pegmatite, transect the gneisses. Four sets of folds and one event of amphibolite grade regional metamorphism can be recognized. The regional distribution of lithologies is controlled by west-plunging, upright F<sub>3</sub> folds.

In the Meliadine Lake area to the south, gneissic rocks are overlain by Archean (ca 2.63 Ga) greenstone-metasedimentary sequence of the Rankin Inlet Group. The sequence forms a southeast-plunging, Archean F<sub>2</sub> syncline. Previous studies identified pre-F<sub>2</sub> ductile thrusts. Along the north limb of a regional scale F<sub>2</sub> syncline, three sets of pre-F<sub>2</sub> mesoscopic folds are present in the locally auriferous oxide iron-formation. An assemblage of biotite + chlorite in silicate-rich layers of the iron-formation is overprinted by random intergrowths of fine-grained grunerite+hornblende +carbonate with pyrrhotite, and coarse hornblende +/- biotite with arsenopyrite. The textural relations suggest that gold mineralization is associated with S, Ca and CO<sub>2</sub> metasomatism. The sulphidized and auriferous iron formation is hosted in a turbidite sequence, and the epigenetic gold mineralization appears to be controlled by the youngest set of pre-F<sub>2</sub> folds which acted as structural traps.

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## INTERPRETATION OF GRAVITY AND MAGNETIC ANOMALIES ALONG THE LITHOPROBE TRANS-HUDSON OROGEN TRANSECT

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The LITHOPROBE Trans-Hudson Orogen Transect comprises several line segments that cross fundamental lithotectonic domains and their boundaries. These include the Thompson Belt along the Trans-Hudson Orogen-Superior Province boundary, the Flin Flon-Snow Lake Belt and its boundaries with the Kisseynew Gneiss Belt and Hanson Lake Domain, the belt of Missi Suite rocks within the Kisseynew Gneiss Belt and the Tabernor Fault System. Existing gravity and aeromagnetic maps show many of these features to be associated with prominent anomalies, which can be modelled to provide quantitative information on the size and shape of the causative crustal elements. In order to obtain detailed information, gravity measurements spaced 1 or 2 km apart have been measured along the transect and these supplement regional gravity coverage provided by measurements spaced 10 to 15 km apart. Ground magnetic surveys and related rock magnetism studies are also planned. A series of gravity and magnetic profiles and derived models is presented.

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## PRELIMINARY REPORT ON THE GEOLOGY AND STRUCTURAL EVOLUTION IN THE EARLY PROTEROZOIC KOMAKTORVIK ZONE, NORTHERN LABRADOR

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The Early Proterozoic Komaktorvik Zone is a north-south belt of highly-strained gneisses at amphibolite to granulite facies. Two groups of rocks were recognized; 1) re-worked Archean gneisses and deformed, cross-cutting Early Proterozoic mafic dykes of the Nain Province, and 2) Early Proterozoic meta-igneous rocks that range from oldest mafic diorite, through tonalite, to youngest granodiorite, granite and pegmatite. Group 2 rocks were emplaced into the rocks of group 1 and grade westward into the charnockitic rocks of the Burwell terrane. They may represent the easternmost remnants of a more extensive continental arc and/or crust-derived melts.

The structural evolution of the Komaktorvik Zone involved oblique sinistral, east-side-up shearing at granulite through amphibolite facies. Late folding of shear fabrics took place on steeply north-plunging axes, in a continuum of deformation. The emplacement of group 2 magmas may have, in part, accompanied this deformation. Subsequent west-side-up shearing produced narrow zones of ultramylonite. Fourteen samples of the Early Proterozoic rock units, and of syn-kinematic granitic rocks were sampled for U-Pb zircon geochronology.

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## MINERALS

### AN INTEGRATED APPROACH AND MODEL FOR THE DISCOVERY OF BLIND Cu-Au PORPHYRY SYSTEMS

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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.

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

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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.

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

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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 deposition of 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.

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

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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 Helikean-hosted Gayna deposits. This is tentatively interpreted to indicate coeval mineralization in these deposits which are separated by approximately 60 km.

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## DIAGENESIS AND ALTERATION OF THE LITHOLOGICAL UNITS HOSTING CU AND BA MINERALIZATIONS IN THE UPTON-ACTON VALE AREA, QUEBEC

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The clay mineralogy, petrography and reflectance of organic matter (O.M.) were determined for 54 samples from the Upton-Acton Vale area. The clay mineral assemblages, the chemical composition of some mineral species like chlorite, and the characteristics of the organic matter define 4 distinct domains: the Upton quarries, the Acton Vale quarry, outcrops between Upton and Acton Vale and the Upton Ba deposit. Field observations and laboratory analysis lead to the following conclusions: 1) the mineralization accompanies O.M. and clay mineral alteration, 2) these alterations were produced, at the earliest, at maximum depth of burial, 3) the alteration are syn- or post- tectonic, 4) in the Acton Vale quarry, the alteration would be late with respect to the maximum heating event.

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## GEOLOGICAL SETTINGS OF ECONOMIC INTEREST (Au, Ni, PGE, Gp) IN THE LAC NOMININGUE AREA, CENTRAL METASEDIMENTARY BELT, QUEBEC

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Four geological settings favourable for mineral exploration have been identified in the Lac Nominigüe area during study of the accretionary history of the Central Metasedimentary Belt (CMB) in the Grenville Province of Québec. The area (31J/6) consists of an orthogneissic domain surrounded by supracrustal sequences rich in marble (west) or quartzite (north and east). Vertically layered mafic intrusions, porphyritic monzonite bodies, K-rich alkaline plutons and dykes of lamprophyre with ultramafic xenoliths are also present. An high-strain ductile zone (~ 10x3 km) with late brittle deformation marked by quartz-carbonate-pyrite veins represents a favorable setting for gold mineralization showing similarities with the Robertson Lake Mylonite Zone (CMB of Ontario). Metamorphosed massive Fe-sulphides (5x0.3 m) and late Fe-sulphides disseminations are also present. Vertically layered mafic intrusions offer a good potential for unmetamorphosed Ni-Cu (PGE) mineralization. They consist of undeformed ophitic gabbros and anorthosite with minor magnetite-rich (50%) rhythmic layers and

sulphide-bearing pyroxenite. Two zones of metasediments are anomalous in having outcrops with more than 5% graphite. Apatite is abundant in K-rich alkaline pyroxenite (up to 20 %).

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#### **ANALYSIS OF GEOLOGICAL MATERIALS BY DIRECT POWDER INTRODUCTION – INDUCTIVELY COUPLED PLASMA SPECTROMETRY**

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Inductively coupled plasma emission (ICP-ES) and mass spectrometry (ICP-MS) have evolved to be among the most popular analytical techniques available to the geoanalyst. However, almost all the approaches used for sample introduction to the ICP are solution based techniques. That requires dissolution of solid materials via tedious, time consuming and error-prone digestion procedures.

Analytical instrumentation and methods are being developed at the GSC for the analysis of geological materials by direct introduction of dry powders into the ICP. Direct Powder Introduction-Inductively Coupled Plasma Emission Spectrometry (DPI-ICP-ES) has the potential: (1) to simplify analytical procedures by saving cost, time, and effort; (2) to eliminate acidic wastes with improved safety; (3) to improve detection limits, precision and accuracy. Replicate measurements using 40 mg quantities of dry powders (NIM-P reference material) yielded measurement precision <5%.

Unlike the measurements followed by traditional solution chemistry, DPI-ICP-ES can also provide information about the sample homogeneity and its mineralogical characteristics in addition to the bulk concentration of elements in the subsamples.

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#### **SEAWEED GEOCHEMISTRY – A NEW APPROACH TO MINERAL EXPLORATION ALONG THE COAST OF BRITISH COLUMBIA**

C.E. Dunn<sup>1</sup>

There are many species of seaweed (macro algae) that cover the rocky shorelines of British Columbia. Of the three main types - green, brown and red - the brown is the most common. Recent studies show that these seaweeds can accumulate metals washed down from the mountainous slopes.

A reconnaissance-level survey (1 per 20 km<sup>2</sup>) of Howe Sound, north of Vancouver, involved the collection of common rockweed (*Fucus gardneri*). This proved sufficient to outline the dispersion halo of metals derived from the abandoned Britannia copper mine. Ashed seaweed contains up to 3200 ppm Cu, compared to a background of 70 ppm, and the dispersion halo is tens of square kilometres. Other metals enriched in the seaweeds from this area include Zn (up to 1500 ppm), Au (up to 58 ppb), and Fe (up to 1.1%), whereas there is a negative arsenic anomaly.

Results suggest that rockweed (and perhaps other species) may be a useful reconnaissance-level sample medium for assessing the mineral potential of the mountains which rise above the many long and steep-sided fjords comprising Canada's western coast.

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

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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.

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#### **APPLIED MINERALOGY AND GEOCHEMICAL SURVEYS OF COPPER-GOLD PORPHYRY SYSTEMS IN NORTHERN QUESNEL TROUGH, BRITISH COLUMBIA**

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

The discovery of the Mount Milligan deposit in 1987 has increased exploration activities in the northern Quesnel Trough. However, the area contains little outcrop and is covered by 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 sulphide, malachite and cuprite.

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

B.A. Kjarsgaard<sup>1,2</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 for finding both kimberlites and lamproites. One of the most commonly utilized exploration methods for locating

kimberlite and lamproite is the use of indicator minerals from till and soil samples. However, in Canada, application of this exploration method is problematic due to the numerous 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 reviews 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.

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

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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.

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### 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  $Mg:Fe^{2+} + Si^{4+} = 2 Al^{3+}$  exchange favors the coupled substitution of Mg<sup>2+</sup> and Si<sup>4+</sup> 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.

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

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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 lithochemical 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.

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### MISE-À-LA-MASSE 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, 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, Ottawa

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

G.J. Palacky<sup>1</sup>, A.K. Sinha<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 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 sulphide deposit are highly conductive. The results of this study 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, 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 (°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, Ottawa

## 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, Ottawa

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

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

R.H. Rainbird<sup>1</sup>, W. Darch<sup>2</sup>, C.W. Jefferson<sup>3</sup>, R. Lustwerk<sup>2</sup>, M. Rees<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 (~400m). 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 (200-300m), 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, Ottawa

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

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

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

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

### INTEGRATION OF REMOTELY SENSED AND GEOLOGICAL DATA FOR MINERAL EXPLORATION: CASE STUDY IN NORTHERN BRITISH COLUMBIA

A. Rencz<sup>1</sup>, S.B. Ballantyne<sup>1</sup>, R. Balma<sup>1</sup>

A variety of geological and remotely sensed data was integrated for an area in northern British Columbia (104 M) to indicate areas favourable for gold mineralization. Geological data included a geological map that was digitized. Geochemical media consisted of moss mat samples, silt samples, stream samples and litho-geochemical samples that were analyzed for Au and "gold indicator elements". Geochemical data were statistically treated in a GIS, using a moving average technique, to illustrate patterns in concentration levels. In addition the location of 18 known mineral occurrences were used.

Remotely sensed data were analyzed to highlight structural patterns and to identify alteration zones that may be indicative of gold mineralization. To mitigate topographic effects a digital elevation model was incorporated into the analysis.

The information derived from the analysis of the geological and remotely sensed data were integrated and modelled to produce a map illustrating zones of favourability to gold mineralization.

<sup>1</sup> Mineral Resources Division, 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 and of estimation of their potential in metallogenic domains.

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 uraniumiferous granitoid domes, which are flanked by Archean 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, Ottawa

### Pb-Zn OCCURRENCES HOSTED BY LOWER PALEOZOIC SEDIMENTARY ROCKS, NORTHERN APPALACHIANS, QUEBEC

K. Schrijver, G. Beaudoin, R. Doig, E. Marcoux, P. Rhéaume, D.F. Sangster, A.E. Williams-Jones

Of 25 Pb-Zn occurrences in the Lower St. Lawrence region, 21 are veins, two are disseminations, and two consist of both types of mineralization. Most occurrences can be subdivided according to their dominant gangue and sulphide species, correlated with their clustered spatial and stratigraphic distribution, and lithotype of host: (1) barite-galena (-sphalerite) in Cambrian sandstones and conglomerates; (2) quartz-pyrite-sphalerite-galena in Upper Ordovician shales; and (3) carbonate-galena and/or sphalerite in Lower Devonian limestones. All are epigenetic and probably epithermal. Despite their simple mineral composition, no single sequence of precipitation is applicable to all occurrences. Only the baritic occurrences were studied in detail by structural, microthermometric and isotopic work; some results of this work are illustrated on our poster. The  $\delta^{34}\text{S}$  values suggest sulphide-S came mainly from pyrite and organic matter, that of barite from evaporite. For carbonates, using appropriate fractionation factors at 110°C

(value from Th of primary inclusions), the fluid  $\delta^{18}\text{O}$  and  $\delta^{13}\text{C}$  indicate seawater was the major O source whereas C was derived from both seawater C and from organic matter leached from the host rocks.

### AIRBORNE AND GROUND GAMMA RAY SPECTROMETRIC 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, Ottawa

### STEREO IMAGERY USING SCANNING ELECTRON MICROSCOPY

D.A. Walker<sup>1</sup>, L.K. Radburn<sup>1</sup>

One of the fundamental differences between a scanning electron microscope and an electron microprobe is the ability of the S.E.M. to display images from three-dimensional objects in a variety of orientations and working distances. Additionally, there is the ability to display these images in stereo, either dynamically (ie. live), from stored computer files or from hard copy photographs. This relatively straight forward approach to stereo imaging often reveals surface microstructure that is not immediately obvious from a two dimensional image, especially in those cases where the image is complex with regard to surface morphology. Knowing certain operating conditions under which the stereo images were captured,

it is possible to perform distance measurements of any morphological feature, either offline using polarized stereo images or online using anaglyph images.

Permanent copies of stereo or conventional images are available as photographs, colour thermal prints, and as computer images to be viewed on a personal computer. As computer images, they can be viewed, coloured, analyzed, annotated, and placed in computer slide shows with accompanying text.

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

## ENVIRONMENT

### MELTWATER-INDUCED COOLING IN THE GREAT LAKES - ST. LAWRENCE REGION AT 9.6 TO 8.3 KA BP

T.W. Anderson<sup>1</sup>, C.F.M. Lewis<sup>2</sup>

Enhanced meltwater discharge from upstream proglacial lakes Agassiz and Barlow-Ojibway at 9.6 to 8.3 ka BP raised lake levels, expanded outflows, and suppressed summer warming of the surface lake water in the Great Lakes basin. It also induced climatic cooling of terrestrial areas bordering the Great Lakes and Gulf of St. Lawrence enroute to the Atlantic Ocean as shown by pollen stratigraphy from several sites in the Great Lakes - St. Lawrence region.

Sites in and around Lake Huron and Georgian Bay show a return to spruce dominance (commencing about 9.6 ka) following a period of pine-dominated woodland from about 10.5 to 10 ka BP. Other sites bordering the Great Lakes and Gulf of St. Lawrence indicate a prolonged persistence of spruce and delay in the migration of pine at 9.6-8.0 ka. Coastal sites in western Newfoundland show spruce had reverted at about 9.5 ka to a previous shrub birch-dominated vegetation, whereas in mountainous southwest Newfoundland and in eastern Newfoundland tundra prevailed until 8.5 to 8.0 ka giving way at this time to a tree birch-spruce-fir succession.

Diversion of lakes Agassiz and Barlow-Ojibway drainage to Hudson Bay after about 8.4 ka B.P. reinstated summer warming of the surface water in the Great Lakes - St. Lawrence system bringing the 9.6-8.3 ka cool period to a close.

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

<sup>2</sup> Atlantic Geoscience Centre, Dartmouth

### LANDSLIDES INVENTORY, MACKENZIE VALLEY TRANSPORTATION CORRIDOR

J.M. Aylsworth<sup>1</sup>, A. Duk-Rodkin<sup>1</sup>, P.A. Egginton<sup>1</sup>,  
S.R. Dallimore<sup>1</sup>

A compilation map of landslides occurring in the Mackenzie Valley Transportation Corridor is underway at 1:1million scale with the objective of establishing a regional inventory of landslides along Mackenzie Corridor - a 1000 km segment of Mackenzie Basin running from the Beaufort Sea to the confluence of Mackenzie and Liard rivers. This area includes a variety of materials, permafrost conditions, and topography; it also represents a major potential 'corridor' for development in the N.W.T. In the first phase the inventory will provide a regional documentation of landslide types and material associations and, in some cases, sequential photographs

will bracket landslide age. Planned field studies will yield information on failure mechanisms and dates of occurrence of key landslide types.

The compilation map is based on a combination of recent field mapping projects, recent airphoto interpretation, and previously published maps. Landslide types are represented by symbols on a base of generalized surficial geology. The map is accompanied by a database of information on landslide location, type, size, aspect, sediment, active/nonactive status, and estimated age.

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

## **GROUNDWATER QUALITY IN THE MONCTON AREA, NEW BRUNSWICK**

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

A detailed multi-element ground water geochemical survey has been carried out over the Maritime Carboniferous Basin region of Moncton, New Brunswick. A number of cation exchange and water/rock interaction processes have led to the formation of a complex suite of ground waters, many of which can be highly fluoriferous and manganiferous. Such waters are generally strongly alkaline (pH greater than 8.5) but regions characterized by ground waters with pH values less than that of acid rain (pH 4.5) have also been detected.

The data can be used in applications concerned with A) land planning management, B) industrial and recreational water uses, C) drinking water quality studies, D) agriculture and aquaculture water uses, E) effects of acid precipitation, and F) health risk assessments.

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

## **GEOTECHNICAL INVESTIGATIONS IN PERMAFROST – YAMAL EXPEDITION 1991: CANADA-USSR CO-OPERATIVE ARCTIC GEOSCIENCE RESEARCH**

R.A. Burns<sup>1</sup>, J.A.M. Hunter<sup>1</sup>, A.S. Judge<sup>1</sup>, P.J. Kurfurst<sup>1</sup>,  
B.J. Todd<sup>1</sup>

Under the Canada-USSR Cooperative Arctic Geoscience Research Agreement, a joint program was developed focussing on comparative studies of the geocryological conditions of petroleum-bearing regions in the Canadian and Soviet Arctic. Special emphasis has been placed on geophysical/geotechnical methods used for the detection and mapping of ice-rich sediments in areas of oil and gas well sites and pipelines.

Five permafrost specialists from the Terrain Dynamics Subdivision worked on the Yamal and Gydan peninsulas, Western Siberia, with their Soviet counterparts. Joint Soviet-Canadian geophysical studies were applied to the detection and delineation of a massive body of ground ice. A new seismic field technique for mapping shallow massive ice was developed. Preliminary field maps and sections of lithology, topography, landforms, ground probing radar, apparent conductivity and resistivity were constructed using Canadian computers and software. Geotechnical boreholes were drilled and sampled to fill in gaps in the existing geological information. All boreholes were logged lithologically and geophysically, using combined teams of Canadian and Soviet scientists and technology.

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

## **GEOMAGNETIC EFFECTS ON POWER SYSTEMS**

R.L. Coles<sup>1</sup>, D.H. Boteler<sup>1</sup>

During a severe geomagnetic disturbance on March 13, 1989, geomagnetically induced currents in the Hydro-Quebec power system caused a system collapse resulting in a loss of power to 6 million people for over 9 hours. These currents are induced in power systems by variations of the earth's magnetic field that occur during a geomagnetic disturbance, and cause problems ranging from misoperation of relays to burnout of transformers. The Geophysics Division, GSC, in collaboration with electric power utilities, is investigating how frequently such severe geomagnetic disturbances can be expected and how factors such as the characteristics of the magnetic field variations and the regional conductivity structure of the earth affect the currents induced in the power systems.

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

## **QUATERNARY PALEO GEOGRAPHY OF THE SALLUIT AND NUVILIK LAKES AREA, NUNAVIK, QUEBEC**

R.A. Daigneault<sup>1</sup>

The surficial geology map of the Salluit (35J) and Lacs Nuvilik (35G) area is the first of the three 1: 250 000 maps planned during the current investigation of the northern Nunavik. In this area, only deposits associated with the last glaciation and subsequent retreat are present. During the last glacial maximum, the Ancestral Labrador Ice Divide extended across the southern part of the area along an WNW-ESE axis. A thin, generally featureless till sheet was deposited during that episode. Regional deglaciation took place from north to south. In the northern part of the study area, marine invasion of the fjords occurred immediately following deglaciation, and most of the fjords provide a record of deltaic sedimentation up to about 150 m ASL. Further inland, raised shorelines and deltas prove the existence of several glaciolacustrine water bodies; however, the lack of fine-grained deposits and the poor development of several of these shorelines suggest that these glacial lakes were short-lived.

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

## **BREAK-UP OF LIMESTONE BEDROCK BY FROST HEAVE AND CHEMICAL WEATHERING, IGLOOLIK ISLAND AND NORTHERN MELVILLE PENINSULA**

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

Northern Melville Peninsula and Igloolik Island are underlain by flat-lying silty textured limestone strata susceptible to frost heaving and chemical weathering. Frost heave occurs where water freezes into and expands vertical joints and horizontal partings in the rock. Heave along bedding planes is greatest near the ground surface and dissipates to a depth of about 1 m. The process has produced extensive areas covered with flags, which subsequently split into conchoidal lenticular gravel and finer particles. Where the rock breaks down into mixed sizes, a surface pattern of "rosette mudboils" develops as a result of seasonal frost sorting.

In slabby limestone, the bedrock is buckled upward to a height of 1.5 m along joint lines. Where the limestone is massive and fine textured, the rock weathers along joints into a yellow mud. Toppling of large blocks along cliff faces is also caused by joint expansion and detachment of blocks from the coherent parent mass.

Chemical weathering causes pitting on the exposed limestone fragments and the precipitation of secondary carbonate onto their lower surfaces.

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

#### LANDSLIDE RESEARCH AT THE GEOLOGICAL SURVEY OF CANADA: 1842-1992

S.G. Evans<sup>1</sup>

Landslide research at the Geological Survey of Canada began with its first Director, Sir William Logan, who authored the first scientific paper on a Canadian landslide in 1842. The subject was the 1840 Maskinongé landslide (est. vol.  $8 \times 10^6 \text{ m}^3$ ) which occurred in sensitive Champlain Sea sediments in April 1840.

Other large landslides in sensitive clays investigated in later years included those at St. Thuribe (1898), Poupore (1903), and Notre Dame de la Salette (1908). The paper on the St. Thuribe landslide (est. vol.  $5 \times 10^6 \text{ m}^3$ ) by G.M. Dawson remains a classic description of spreading failure in sensitive sediments.

A report by Survey geologists R.G. McConnell and R.W. Brock on the 1903 Frank Slide, Canada's biggest landslide disaster, was published by the GSC in 1904. Data from the report (including cross-sections) still appear in landslide text books and represents an important first step in the understanding of rock slope behaviour in the Canadian Cordillera.

Later in this century, work on landslides in Cretaceous shales in the Prairies culminated in GSC Paper 66-37 by J.S. Scott and E.W. Brooker. The paper was one of the first to document and analyze the importance of bentonite layers in slope stability in the region.

Landslide research in recent years has been concentrated in the Cordillera, the most landslide prone region of the country. Major progress has been made in mapping the distribution and in the analysis of mountain slope deformation and catastrophic rock avalanches. In addition, many catastrophic landslides have been dated using radiocarbon techniques.

Landslide research at the Geological Survey has made significant contributions to understanding the role of geology in landslide occurrence and behaviour as they affect economic development, public safety, and the environment in Canada.

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

#### CURRENT RESEARCH ACTIVITIES IN ENVIRONMENTAL GEOCHEMISTRY IN THE ANALYTICAL METHOD DEVELOPMENT SECTION

G.E.M. Hall<sup>1</sup>

This poster will illustrate highlights of the following projects: (1) Development of methods to measure As, Sb, Se, Te and Bi at natural levels in waters with application studies in Newfoundland (MDA 2) and the U.K. (GSC-BGS Memorandum of Understanding); (2) Development of methods to measure REEs in waters at natural abundances with an application study in Baie d'Espoir, Newfoundland; and (3) Use of anodic stripping voltammetry on-site at Larder Lake tailings pond to measure the dispersion of base metals (joint project with National Water Research Institute).

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

#### GEOLOGICAL SURVEY OF CANADA'S PALEOECOLOGICAL DATABASE

H. Jetté<sup>1</sup>

The Geological Survey of Canada has created a data base designed to contain all paleoecological information available throughout Canada. This data base contains all the information produced by the different paleoecological laboratories of the Survey since 1960: fossil word identifications, pollen analyses, diatom analyses, bryophyte identifications, plant macrofossils and insect macroremains. In addition the staff is attempting to obtain pollen counts from all published sites so that they may be added to a central data bank which can be accessed by the scientific community.

About 1200 sites, mainly pollen sites, have been listed and will be used to establish environmental reconstruction and to produce a series of paleoecological maps that will constitute an integral part of a paleoecological atlas of the northern area of North America.

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

#### QUATERNARY GEOLOGY, SOUTH GREAT SLAVE REGION, N.W.T.

D.S. Lemmen<sup>1</sup>

Late Wisconsinan and Holocene glacial and lacustrine deposits are the dominant surficial materials south of Great Slave Lake, Northwest Territories. Drift thickness, which ranges from exposed bedrock on the Shield to  $>300 \text{ m}$  over the Cretaceous rocks of the Cameron Hills, reflects both lithological and topographic controls on ice dynamics. Evidence of glaciotectionism is restricted to the Cameron Hills area.

Ice flow features record northeast to southwest dispersal across the region during the last glaciation. Ice retreat began  $>11 \text{ ka}$ . A series of small, short-lived lakes formed along the ice margin and these drained catastrophically. Ice retreat across the present Great Slave Lake basin occurred rapidly, with glacial Lake McConnell forming in the isostatically enhanced basin peripheral to the ice sheet. At  $10 \text{ ka}$  this vast lake covered most of the region below  $300 \text{ m a.s.l.}$  with a discontinuous blanket of lacustrine sediment. The demise of Lake McConnell was a product of differential glacioisostatic tilting. The  $200 \text{ km}$  progradation of the Holocene Slave River delta was in response to the continuous lake lowering.

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

#### HIGH RESOLUTION BROAD BAND SEISMOMETRY – RESEARCH POSSIBILITIES FOR THE NEW CANADIAN NATIONAL SEISMOGRAPH NETWORK (CNSN)

R.G. North<sup>1</sup>, A.L. Bent<sup>1</sup>

The CNSN is being completely modernized over the period 1990-95. A key element of the new network is the replacement of older and mostly analogue systems with broad band seismometers feeding into high-resolution ( $140 \text{ dB}$  dynamic range) digitisers. The new seismometers respond to earth vibrations over a very wide range of frequencies, from  $0.001 \text{ Hz}$ , corresponding to "free oscillations" of the entire earth after very large earthquakes, to  $20 \text{ Hz}$ , seen only at short distances from smaller events. The high resolution of the digitiser permits such signals to be recorded on-scale for events ranging from the very smallest to the very largest earthquakes. The

broad band nature of the seismometers, and the large dynamic range of the recording systems, lead to new avenues of research which were impossible with the narrow band (0.01-0.10 and 0.5-10 Hz) and low resolution (less than 60 dB) of the analogue systems which they are replacing.

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

#### **DETECTION OF ICE-BONDED PERMAFROST ON THE BEAUFORT SHELF BY HORIZONTAL-LOOP ELECTROMAGNETIC SURVEYS**

G.J. Palacky<sup>1</sup>, L.E. Stephens<sup>1</sup>

Accurate knowledge of the location of ice-bonded permafrost is essential in planning major infrastructure projects such as pipelines in the Arctic. Field experiments recently carried out on the Beaufort Shelf indicate that multifrequency horizontal-loop electromagnetic (HLEM) measurements are a fast and cost-effective means for their detection. Previously, refraction and shallow reflection seismic surveys and drilling have been used for this purpose. HLEM field data have been processed using ridge regression inversion techniques. The results are presented as resistivity sections. The uppermost layer, sea ice, is highly resistive (5000 2.m). The second layer, seawater and seawater-saturated sediments (average resistivity 1 2.m), is underlain by ice-bonded permafrost (5000 2.m). The basement is formed by conductive unfrozen sediments. A comparison with the results of drilling and seismic surveys indicates that the detection of ice-bonded permafrost by HLEM method is reliable.

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

#### **GEOCHEMICAL STUDIES IN HOWE SOUND DRAINAGE BASSIN, BRITISH COLUMBIA**

J.B. Percival<sup>1</sup>, A. Mudroch<sup>1</sup>, G.E.M. Hall<sup>1</sup>, C.E. Dunn<sup>1</sup>

In July 1991, reconnaissance geochemical surveys were conducted in the Howe sound drainage basin to identify sources and dispersion of natural and anthropogenic inorganic constituents. These surveys comprise part of a newly established multidisciplinary study to examine the physical, biological and chemical attributes and processes that characterize the Sound.

The reconnaissance surveys involved the collection of several types of samples: surface waters from creeks draining the eastern side of the Sound, and a few at depth within some bays; bottom sediments from several bays; seaweed from rocks along all shorelines, and foliage from western red cedar and western hemlock from sites nearby. For detailed study, creekwaters, acid mine waters and mineral precipitates were collected from the Britannia mine site.

Preliminary results show that metal concentrations (e.g., Cu, Zn, Fe) are anomalous in waters, sediments and seaweed in the Britannia Beach area. This reflects the direct contribution from acidic waters that drain the abandoned Britannia Cu mine. Although the concentrations of Cu and Zn are within drinking water guidelines, they are far in excess for freshwater aquatic life.

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

#### **MORE THAN 150 YEARS OF EARTHQUAKE RECORDING IN CANADA**

A.E. Stevens<sup>1</sup>

Government employees have been writing reports on earthquakes in Canada for more than two centuries, as illustrated by the examples selected for this poster. The earliest technical reports were prepared by Gaspard Chassegras de Lery, chief engineer for New France. He noted damage and repair costs in Montréal following a moderate earthquake in September 1732, which had been widely felt in New France and New England. Several anecdotal reports of earthquakes in Lower Canada were gathered in the 1820s during geological and geographical surveys under the direction of Joseph Bouchette, surveyor-general for Lower Canada. A minor earthquake experienced in Ottawa in May 1856 by Elkanah Billings, geologist with the Geological Survey of Canada (GSC), served as introduction to his essay on the causes of earthquakes.

The first stations in Canada devoted to continuous recording of earthquakes were established at Toronto in 1897 and at Victoria (B.C.) in 1898 by the Meteorological Service of the Department of Marine and Fisheries. From this modest beginning evolved the current national network of more than 150 seismograph and accelerograph stations operated by the GSC. From 1906 to 1970, the Dominion Observatory conducted most of the research on Canadian earthquakes. Ernest Hodgson, Dominion Seismologist, published comprehensive reports on the major earthquakes of 1925 (Charlevoix-Kamouraska, Québec), 1935 (Témiscaming, Québec-Ontario border) and 1946 (Vancouver Island, B.C.), which included some practical advice for coping with earthquakes, advice still relevant today.

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

#### **MEASURING RATES OF POSTGLACIAL UPLIFT IN CANADA**

M. Tushingham<sup>1</sup>, A. Lambert<sup>1</sup>, W. Petrachenko<sup>1</sup>, J. Kouba<sup>1</sup>

Former glaciers and ice sheets were responsible for shaping much of Canada's terrain and continue to affect Canada's coastline through the delayed effects of glacial unloading. Studies of the effect of inland ice on the Canadian landscape were carried out by William Logan at the Geological Survey of Canada as early as 1845. With the advent of radiocarbon dating of organic materials a hundred years later these studies were broadened to take into account the earth's slow recovery from ice-sheet loading. The next phase in the study of large-scale postglacial dynamics affecting the Canadian landmass has now begun with the introduction of new techniques in high-precision positioning and gravimetry. The techniques of very long baseline interferometry, the global positioning system and absolute gravimetry are being employed by the Geophysics Division to measure postglacial movements in real time in regions never before monitored. In the next 3-6 years one or more of these techniques should detect vertical movements in the Hudson Bay region where the rates are suspected to be largest.

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

## INFORMATION

### DIGITALLY COLOUR SEPARATED MAPS USING THE MIG SYSTEM

R. Allard<sup>1</sup>, R.A. Burns<sup>1</sup>

The Cartography Section and the Computer Technology Section of the Geoscience Information Division of the GSC are applying digital technologies to automate map production. Author's map originals are now scanned, edited, colour coded and processed into colour separates on computer systems. The use of digital systems greatly reduces the amount of work required to colour separate maps and provides improved methods of editing manuscripts. Proof plots, colour separate screens, and final prints will be demonstrated as will the conversion of digital geological outlines into a GIS format.

<sup>1</sup> Geoscience Information Division, Ottawa

### INTEGRATED DIGITAL GRAPHICS

R.A. Burns<sup>1</sup>

Powerful desktop computers have had a major impact on the scientific and production projects of the Geological Survey of Canada. Nowhere has the presence of computers been more strongly felt than in the area of Digital Graphics. Early use of computers for graphic applications tended to focus on stand-alone task-specific systems. Computer Technology and Cartography staff are involved in a number of initiatives to provide links between diverse digital graphics systems in an effort to make digital data more useful. This display presents many of the hardware and software systems used in digital graphics and the methods of exchanging information between these systems.

<sup>1</sup> Geoscience Information Division, Ottawa

### AIRBORNE VIDEO SURVEYS FOR COASTAL MAPPING AND ENVIRONMENTAL MANAGEMENT

D.L. Forbes<sup>1</sup>, D. Frobel<sup>1</sup>, R.B. Taylor<sup>1</sup>, J. Shaw<sup>1</sup>

Low-level airborne video imaging has become a key tool for documenting physical shore-zone characteristics and human activities along the coast. The Atlantic Geoscience Centre has now obtained more than 10,000 km of coastal imagery in the Beaufort Sea, Arctic Islands and Atlantic Provinces. Data on the type and distribution of coastal landforms and processes, depositional environments, sediment types, engineering structures, aggregate extraction, industrial development, recreation and navigation facilities, access, and other physical features and infrastructure are extracted from the video imagery. These data provide the basis for decision making related to a variety of management issues, including oil spill clean-up, park development, beach maintenance, shoreline erosion, land-use zoning, and for scientific requirements including analysis of coastal processes and stability. The video tapes also provide a convenient and cost-effective means of viewing a chosen section of coastline on short notice in the event of emergencies or other requirements.

<sup>1</sup> Atlantic Geoscience Centre, Dartmouth

### A GRAPHICAL QUERY SYSTEM FOR INDEX INFORMATION ON PUBLISHED GSC MAPS

J.E. Glynn<sup>1</sup>, P. Huppé<sup>1</sup>

The GSC Map Information System (GMIS) was developed to provide users with a graphical query system to access index information on over 16 000 maps published by the Geological Survey of Canada. The system allows the user to point to any location in Canada and retrieve information on maps covering that point. The user may select the data based on map series, title, authors, and scale. The system is completely mouse driven and menu-based to provide easy access to members of the public as well as to GSC staff.

The software runs in an X Windows environment on SUN Sparcstations and in a VMS environment on the GSC VAX 8800, and it makes use of the Geographic Information System Arc/Info. The Arc/Info database is also being used to produce high quality index maps for publication. The digital base maps of Canada were provided by the National Atlas Information System of the Surveys, Mapping, and Remote Sensing Sector of EMR, and the attribute data for the GSC maps were provided by GEOSCAN.

<sup>1</sup> Geoscience Information Division, Ottawa

### IMAGES OF THE GEOLOGICAL SURVEY OF CANADA: ACCESSING OUR PHOTOGRAPHIC HERITAGE

R. Hamilton<sup>1</sup>, C. Green<sup>1</sup>, D. Tedford<sup>1</sup>

The GSC Photo Library has undertaken a long term project to provide an on-line catalogue to supplement the other on-line catalogues available to patrons of the GSC Library System. When completed, this catalogue will provide improved access to a collection which holds photographic images dating back to 1862. Images encompassing a wide range of themes are available for research by members of the GSC, as well as the public.

The GSC Photo Library invites you take a look at the images captured by your fellow GSC colleagues, past and present. Our traditional card catalogue and on-line catalogue provide access to the collection's approximately 500,000 images. Also, the GSC Photo Library provides reference service to photographic collections held elsewhere in Canada.

The GSC photographs covering 129 years include:

- \* Peoples of Canada and the GSC
- \* The work of the GSC
- \* Geographic locations across Canada
- \* Technological advancement
- \* Canada's varied and changing environment

<sup>1</sup> Geoscience Information Division, Ottawa

### GEOSCIENCE COLLECTIONS IN CANADA

I.A. Hardy<sup>1</sup>, T. Forbes<sup>2</sup>, R.K. Herd<sup>3</sup>, E. Snow<sup>4</sup>

As we commence celebrations of the 150th anniversary of Canada's oldest scientific government organization, the Geological Survey, we begin to remember the significant role this organization has played in the growth of science since 1842. It is through the work of Dawson, Tyrrell, Logan, Ogilvie, Bell, Alcock, Belyea and many others that the Survey has accumulated a tremendous wealth of

geoscientific information, data and sample collections which together provide a comprehensive inventory and understanding of the geological framework and processes nationwide. This poster is a consolidated effort by the GSC divisions across Canada to demonstrate the diversity of the national, regional and local geoscientific databases, and associated sample collections, curated on behalf of the scientific community in Canada.

<sup>1</sup> Atlantic Geoscience Centre, Dartmouth

<sup>2</sup> Pacific Geoscience Centre, Sidney

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

<sup>4</sup> Institute of Sedimentary and Petroleum Geology, Calgary

#### **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> Geoscience Information Division, Ottawa

#### **GEOLOGICAL MAP PRODUCTION WITH A GEOGRAPHIC INFORMATION SYSTEM**

G. Labelle<sup>1</sup>, V. Dohar<sup>1</sup>, M. Méthot<sup>1</sup>, P. Huppé<sup>1</sup>

The Computer Technology Section together with the Cartography Section of GID have been continuing their evaluation of the GIS package ARC/INFO for its suitability in the production of geological maps. The primary goal of this year's project will be to demonstrate the software's ability to produce film separates from CMYK and Compugraphic encoded PostScript files, and to produce colour proofs and final printed products.

<sup>1</sup> Geoscience Information Division, Ottawa

#### **THE DEVELOPMENT OF MARINE GEOSCIENCE ATLAS PRODUCTS**

P. Moir<sup>1</sup>

Abstract not submitted

<sup>1</sup> Atlantic Geoscience Centre, Dartmouth

#### **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>, P. Corrigan<sup>1</sup>

As part of its 150th 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, Ottawa

#### **COMPARISON OF VARIOUS METHODS OF INTERPOLATION AND GRIDDING**

D. Nagy<sup>1</sup>, D.R. Franke<sup>2</sup>, L. Battha<sup>3</sup>, J. Kalmár<sup>3</sup>, T. Szabó<sup>3</sup>, J. Závoti<sup>3</sup>

The purpose of this presentation is to report on the critical comparison and testing of various methods of interpolation and prediction frequently used in the field of geosciences, based upon accuracy, efficiency, ease of implementation and user friendliness. Some of the most commonly available gridding methods are included, such as kriging, linear interpolation along the shortest chord, least squares approximation, surface fitting under tension, Franke's local thin plate spline, least squares collocation, collocation with empirical covariance function and interpolation by Franke's weights.

For the comparisons, a model is used for which exact values from an analytical expression can be calculated anywhere in the domain of interest. This model was obtained by Gibb and van Boeckel (1970) as a result of three-dimensional gravity interpretation, which approximates well the gravity anomaly over a geological feature, known as the Round Lake batholith, in northeastern Ontario. The results are in the form of maps.

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

<sup>2</sup> Naval Postgraduate School, Monterey, CA

<sup>3</sup> Geotechnical and Geophysical Research Institute, Sopron, Hungary

#### **DESKTOP – COMPUTER MAP PUBLISHING FOR THE 1:1 000 000 GEOLOGICAL ATLAS OF CANADA**

A.V. Okulich<sup>1</sup>

1:1,000,000 scale Geological Atlas maps have been compiled, produced and published using a 386, 25 MHz PC with 8 Mb of RAM, running AutoCAD and Autospript.

Maps are compiled by:

1) scanning author-drafted and base map materials using a Scitex scanner, followed by vectorizing and editing into AutoCAD,

- 2) tablet digitizing new and revised material, and
- 3) drafting map elements and text in AutoCAD.

During production, text fonts and line widths are specified and polygons defining colour fill are placed on appropriate AutoCAD layers. The autscript program converts the AutoCAD file into Postscript, generating Adobe text fonts and colour fill.

During publication, the Postscript file is translated for a Scitex plotter which creates negatives of each colour. Some base map material and large blocks of text from Compugraphics typesetters may be added as negatives at this stage. Combined negatives are used to make printers' plates.

This process permits most of the work to be done on versatile and powerful, but affordable PC's using widely accepted programs. It can accept data from numerous sources and converts data to digital form for GISs. It places graphics production in the hands of scientists, technical support staff and local cartographic units, thereby enhancing the use of graphic materials as scientific tools and facilitating dissemination of geological data and hypotheses to our clients.

<sup>1</sup> Institute of Sedimentary and Petroleum Geology, Calgary

#### **GEOPHYSICAL MAPS ON DEMAND**

J. Rupert<sup>1</sup>, R.A.F. Grieve<sup>1</sup>, R.K. McConnell<sup>1</sup>, J. Tod<sup>1</sup>

The Geological Survey of Canada produces a large variety of potential field maps. The compilation, printing, storage and distribution of these maps is an expensive and time consuming task. Although conventional printing of these maps presently includes the computerized production of colour separations on a laser film printer, the cartographic compilation is labour intensive. The system currently under development allows maps and accompanying explanatory notes to be produced directly from an on-line data base on a colour electrostatic plotter. In addition to creating production map series at standard scales, the Maps on Demand system has sufficient flexibility to permit individual users to generate maps to their own specifications. Cartography, printing and storage costs are reduced, especially for those map sheets in low demand. In addition, the time lag between field data acquisition and map production is significantly reduced.

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

#### **COMPUTERS FOR GEOLOGICAL FIELD NOTES AND FIELD GIS APPLICATIONS, SOUTHWEST PINE PASS MAP AREA, BRITISH COLUMBIA**

L.C. Struik<sup>1</sup>, A. Atrens<sup>1</sup>, A. Haynes<sup>1</sup>

Geological field notes for the 1:250 000 scale Pine Pass southwest (930) mapping project were successfully taken for the past two field seasons on the ASCII editor of the 0.5kg Atari Portfolio (registered trademark of Atari Corporation) handheld computer. Drawings were made with pencil and paper. The notes

were entered with position and tag control. A computer program (GEOF), presently on the DOS platform, assists in editing the note format and generates comma-delimited data files from the ASCII notes. The comma-delimited data have been imported into dBase IV (trademark of Ashton-Tate Corporation), FIELDLOG (Ontario Geological Survey), and Arc/Info (trademark of Environmental Systems Research Institute) databases, and are sufficiently generic to import into any database. For the Pine Pass project the data were translated from the Atari in the field and entered into FIELDLOG, which was used for database queries and the plotting of geological data to AutoCAD (registered trademark of AutoDesk Inc.) diagrams. With this method digital data collected at the outcrop can be searched, plotted on maps, and statistically and graphically manipulated completely by computer on the same day it is collected. Direct field entry of data eliminates transcribing handwritten notes into GIS databases.

<sup>1</sup> Cordillera Division, Vancouver

#### **CD-ROM AT THE GSC: THE FUTURE TO ACCESSING GEOSCIENCE INFORMATION**

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

The GSC Library is developing a collection of databases on CD ROM. This technology enables millions of bytes of data to be stored on a single compact disc. Users are able to have large databases or numerous smaller databases literally in the palms of their hands.

CD ROMs have many advantages over traditional storage media: they are fast, user-friendly, incorporate powerful search and retrieval software, can include graphics, and are a fraction of the cost.

The GSC Library invites you to discover the wealth of data available on our CD ROM products. Here are some of the databases in our CD ROM collection:

- \* GeoRef - the world's geoscience literature
- \* Arctic and Antarctic Regions - an international and multidisciplinary collection of polar databases
- \* GSC Library Catalogue - holdings of the GSC libraries
- \* GEOSCAN - GSC publications and Open Files
- \* Canadian Geoscience Data Directory - digital data sets in federal and provincial geological surveys
- \* Date Locator File - database of the GSC's radiocarbon dates
- \* Deep Sea Drilling Project - index and reference files to the Deep Sea Drilling Project

Discover what the future has in store for you.  
Discover CD ROM.

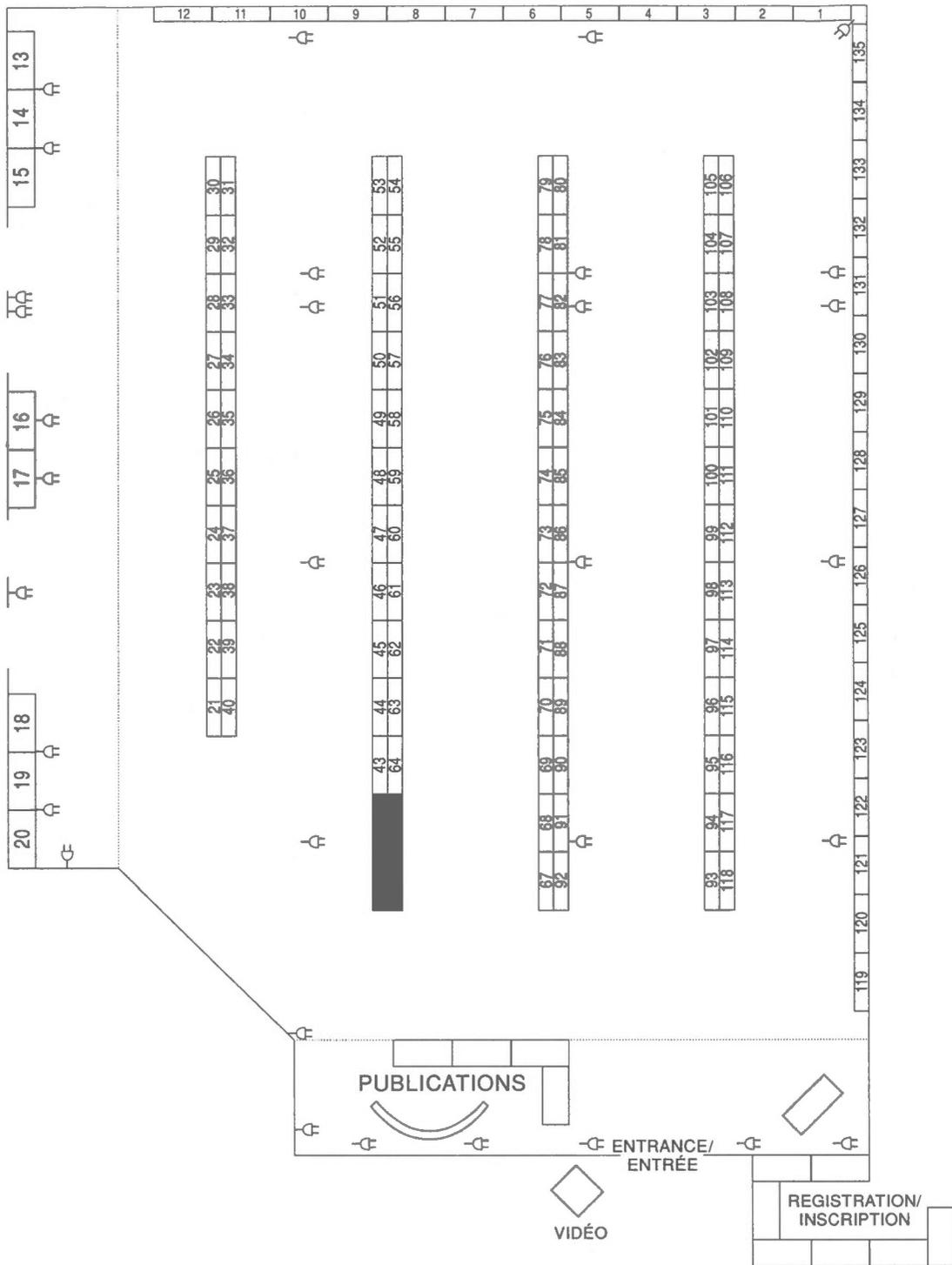
<sup>1</sup> Geoscience Information Division, Ottawa

## AUTHOR INDEX

Adam, E.	7	Charbonneau, B.W.	5
Allard, R.	28	Chen, B.	29
Ames, D.E.	22	Cherry, M.E.	5
Anderson, R.G.	7	Chouteau, M.	13
Anderson, T.W.	24	Christian, H.	16
Armitage, A.E.	18	Ciesielski, A.	10
Aspler, L.B.	5,7,9	Cinq-Mars, A.	22
Aylsworth, J.M.	24	Cochonat, P.	16
Bailes, A.H.	14	Coflin, K.	10
Bailey, R.C.	13	Coles, R.L.	25
Ballantyne, S.B.	3,18,20,21,22,23	Cooper, R.V.	10,18
Baril, D.	5,9	Corrigan, D.	15
Balma, R.	23	Corrigan, P.	29
Barnes, A.	7,15	Corriveau, L.	19
Battha, L.	29	Daigneault, R.A.	25
Beach, R.J.	9	Dallimore, S.R.	24
Beaudoin, G.	23	Darch, W.	23
Beaudry, C.	7	De Silva, N.	20
Beaumont-Smith, C.	13	DiLabio, R.N.W.	6
Bégin, C.	4	Dohar, V.	29
Bell, R.T.	8	Doig, R.	23
Bent, A.L.	26	Dostaler, F.	17
Berman, R.G.	8	Dredge, L.A.	25
Bernius, G.	19	Dressler, B.O.	14
Bertrand, R.	8	Duk-Rodkin, A.	24
Bevier, M.L.	7	Dunn, C.E.	20,27
Birkett, T.C.	11	Dunphy, J.M.	16
Blair, B.	29,30	Dyke, A.S.	4
Boerner, D.	8,13	Egginton, P.A.	24
Bolduc, A.M.	8	Elliott, B.E.	19
Bossé, J.	19	Evans, S.G.	26
Boteler, D.H.	25	Forbes, D.L.	28
Bowie, C.	11	Forbes, T.	28
Bowman, W.S.	21	Ford, K.L.	10,11,18,24
Boyle, D.R.	25	Forsyth, D.A.	11
Brodaric, B.	5,8,9	Fowler, M.G.	4
Brooks, P.W.	4	Franke, D.R.	29
Broome, J.	5,9	Frobel, D.	28
Brouillette, P.	15	Gagnon, S.	15
Burns, R.A.	25,28	Gandhi, S.S.	20
Bursey, T.L.	5,7,9	Garneau, M.	4
Butt, I.	9	Gauthier, E.	15
Card, K.D.	2,16	Gauthier, M.	19
Caron, J.	29	Gibb, R.A.	10,15,17
Carrière, J.J.	19	Giles, P.S.	11
Carson, J.M.	10	Girard, R.	11
Chagnon, A.	19	Glynn, J.E.	28

Goodacre, A.K.	10,11	Kiss, F.	17
Goodarzi, F.	8	Kjarsgaard, B.A.	6,20
Goodfellow, W.D.	21	Kopf-Johnson, A.G.	29,30
Graham, D.F.	11	Kornik, L.J.	13,18
Grant, A.C.	12	Kouba, J.	27
Grant, J.A.	10	Kurfurst, P.J.	25
Grasty, R.L.	5	Kurtz, R.D.	13
Green, A.G.	14	Labelle, G.	29
Green, C.	28	Lambert, A.	27
Grieve, R.A.F.	30	Lambert, M.B.	13
Guevremont, R.	20	Lavoie, D.	2,8
Gunning, M.J.	7	Lawley, L.	9
Hall, G.E.M.	21,26	Leaver, M.E.	21
Halliday, D.W.	9,10,14,27	LeCheminant, A.N.	5,7
Halpenny, J.F.	10	Leclair, A.	14
Hamilton, R.	28	Legault, M.I.	5
Hanmer, S.	12	Lemkow, D.	18
Hardwick, D.	11	Lemmen, D.S.	26
Hardy, I.A.	28	Lenton, P.	14
Harris, D.C.	18,20	Lentz, D.R.	21
Hearst, R.	9	Lévesque, S.	15
Hearty, D.B.	10,15,18	Lewis, C.F.M.	24
Henderson, J.R.	12	LITHOPROBE	13
Herd, R.K.	28	Loncarevic, B.D.	4
Héroux, Y.	19	Lucas, S.B.	3,5,9,14,16
Hétu, R.	10	Lustwerk, R.	23
Hickson, C.J.	12	Lynch, G.	2,14
Hinton, R.W.	17	Lynch, J.J.	21
Holman, P.B.	10,18,24	Ma, J.	3,21
Hood, P.J.	9	MacLean, B.	13
Hulbert, L.	21	Macnab, R.F.	11
Hunter, J.A.M.	25	Macqueen, R.W.	4
Huppé, P.	28,29	Mader, U.K.	8
Hyndman, R.D.	3	Malo, M.	2
Inglis, O.E.	29	Marchildon, N.	11
Janveau, J.	9	Marcotte, D.	11
Jefferson, C.W.	8,23	Marcoux, E.	23
Jetté, H.	26	Mareschal, M.	8,13
Jones, A.G.	3	McClelland, B.M.	7
Jones, T.	23	McConnell, R.K.	10,15,30
Josenhans, H.	13	McGrath, P.H.	9,14
Jourdain, V.	19	Mengel, F.	18
Judge, A.S.	18,22,25	Méhot, M.	29
Kalmár, J.	29	Michaud, Y.	4
Keen, C.E.	3	Miles, W.	9
Kellett, R.	8,13	Milkereit, B.	3,7,14,15
Killeen, P.G.	19,22	Miller, A.R.	18
King, J.E.	5,9	Moir, P.	29
Kirkwood, D.	2	Monday, P.	16

Monger, J.W.H.	3	Schau, M.	8,18
Moorhead, J.	11	Schrijver, K.	23
Morgan, W.C.	29	Scoates, R.F.J.	13
Morris, W.A.	9	Scott, D.	18
Morrison, G.G.	14	Seemayer, B.E.	18
Morrison, M.L.	16	Shaw, J.	28
Mudroch, A.	27	Shilts, W.W.	6
Murphy, D.M.	3	Shives, R.B.K.	5,18,24
Mortensen, J.K.	2	Sinha, A.K.	17,22
Mwenifumbo, C.J.	21,22	Slimmon, W.	14
Nadaradju, G.	7	Smith, P.L.	7
Nadeau, L.	15	Snajdr, P.	14
Nagy, D.	15,29	Snow, E.	28
Naldrett, A.J.	14	Spencer, C.	15
Nelson, B.	11	Srivastava, S.P.	11
Newitt, L.R.	15	Stephens, L.E.	27
North, R.G.	26	Stern, R.A.	2,14
Okulitch, A.V.	11,29	Stevens, A.E.	27
Palacky, G.J.	22,27	Stockmal, G.S.	17
Paradis, S.J.	15,19	Stone, P.	17
Parent, M.	16	Syme, E.C.	14
Parrish, R.R.	12,16	Szabó, T.	29
Paul, D.	13	Tanczyk, E.I.	9
Percival, J.A.	2,16	Taylor, R.B.	28
Percival, J.B.	22,27	Tedford, D.	28
Peterson, T.D.	16	Tella, S.	18
Petrachenko, W.	27	Telmer, K.	23
Pilon, J.A.	18,22	Templeman-Kluit, D.J.	3
Pineault, R.	7	Teskey, D.J.	9,11,17
Piper, D.J.W.	16	Thomas, D.	14
Plouffe, A.	18,22	Thomas, M.D.	9,18
Prasad, N.	20	Thompson, R.I.	3
Radburn, L.K.	24	Tod, J.	9,17,30
Rainbird, R.H.	23	Todd, B.J.	25
Reed, L.	15	Tremblay, A.	2
Rees, M.	23	Tushingam, M.	27
Reilley, B.	14	Van Kranendonk, M.	18
Rencz, A.	23	Veizer, J.	17
Rhéaume, P.	23	Veys, C.	6
Richard, F.	13	Viljoen, D.	5,9
Roots, C.F.	3	Waldron, J.	17
Ross, D.I.	4	Walker, D.A.	24
Ross, G.M.	3,4	Wardle, R.	18
Rousseau, R.M.	6	Weber, J.R.	10
Rupert, J.	30	Wilks, J.	30
Ruzicka, V.R.	23	Williams-Jones, A.E.	23
St-Onge, M.R.	3,16	Williamson, M.A.	4
Sangster, D.F.	19,23	Závoti, J.	29
Savard, M.	17	Zevenhuizen, J.	13
		Zhang, P.	13



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**GSC FORUM POSTER DISPLAYS**  
**FORUM DE LA CGC EXPOSITIONS VISUELLES**

**POSTER SITE PLAN  
GUIDE DE LOCALISATION DES EXPOSANTS**

<b>150th MAPPING PROJECT</b>	<b>119-122</b>	Chen, B.	119-122	Hall, G.E.M.	10,108
Adam, E.	40	Cherry, M.E.	123-125	Hall, G.E.M.	51-52
Allard, R.	16	Chouteau, M.	36	Halliday, D.W.	35,75,95
Ames, D.E.	134	Christian, H.	69	Halpenny, J.F.	95
Anderson, R.G.	97-98	Ciesielski, A.	91-92	Hamilton, R.	15
Anderson, T.W.	43	Cinq-Mars, A.	129	Hanmer, S.	103
Armitage, A.E.	58	Cochonat, P.	69	Hardwick, D.	96
Aspler, L.B.	89	Coffin, K.	6-7	Hardy, I.A.	21-24
Aspler, L.B.	88	Coles, R.L.	48	Harris, D.C.	80
Atrens, A.	13	Cooper, R.V.	57	Harris, D.C.	81
Aylsworth, J.M.	44	Cooper, R.V.	95	Haynes, A.	13
Bailes, A.H.	126	Corrigan, D.	73	Hearst, R.	35
Bailey, R.C.	36	Corrigan, P.	119-122	Hearty, D.B.	57,73,95
Ballantyne, S.B.	80	Corriveau, L.	114	Henderson, J.R.	104
Ballantyne, S.B.	81,83,106,109	Daigneault, R.A.	54	Herd, R.K.	21-24
Baril, D.	127	Dallimore, S.R.		Héroux, Y.	116
Balma, R.	109	Darch, W.	133	Héту, R.	4-5
Barnes, A.	40,74	De Silva, N.	113	Hickson, C.J.	105
Battha, L.	12	Dohar, V.	18	Hinton, R.W.	64
Beach, R.J.	35	Doig, R.	110	Holman, P.B.	4-5,80,82
Beaudoin, G.	110	Dostaler, F.	59	Hood, P.J.	94
Beaudry, C.	40	Dredge, L.A.	49	Hulbert, L.	108
Beaumont-Smith, C.	90	Dressler, B.O.	39	Hunter, J.A.M.	47
Bell, R.T.	93	Dunn, C.E.	10	Huppé, P.	18,19
Bent, A.L.	8	Dunn, C.E.	112	Inglis, O.E.	119-122
Berman, R.G.	86-87	Dunphy, J.M.	55	Janveau, J.	94
Bernius, G.	118	Elliott, B.E.	118	Jefferson, C.W.	93,133
Bertrand, R.	85	Evans, S.G.	50	Jetté, H.	53
Bevier, M.L.	97-98	Forbes, D.L.	20	Jones, T.	133
Birkett, T.C.	2-3	Forbes, T.	21-24	Josenhans, H.	76
Blair, B.	14,67	Ford, K.L.	4-5	Jourdain, V.	114
Boerner, D.	36	Ford, K.L.	78,80,82	Judge, A.S.	47,80,83
Boerner, D.	38	Forsyth, D.A.	96	Kalmár, J.	12
Bolduc, A.M.	100	Franke, D.R.	12	Kellett, R.	36,38
Bossé, J.	117	Frobel, D.	20	Killeen, P.G.	118,129
Boteler, D.H.	48	Gagnon, S.	61	King, J.E.	123-125,127
Bowie, C.	78	Gandhi, S.S.	111	Kiss, F.	59
Bowman, W.S.	108	Gauthier, E.	73	Kjarsgaard, B.A.	131-132
Boyle, D.R.	45-46	Gauthier, M.	117	Kopf-Johnson, A.G.	14
Brodaric, B.	86-87,127	Gibb, R.A.	59,73,95	Kopf-Johnson, A.G.	67
Broome, J.	35	Giles, P.S.	99	Kornik, L.J.	57
Broome, J.	127	Girard, R.	2-3	Kornik, L.J.	72
Brouillette, P.	73	Glynn, J.E.	19	Kouba, J.	32
Burns, R.A.	16	Goodacre, A.K.	95	Kurfurst, P.J.	47
Burns, R.A.	17	Goodacre, A.K.	101	Kurtz, R.D.	36
Burns, R.A.	47	Goodarzi, F.	85	Labelle, G.	18
Burse, T.L.	88	Goodfellow, W.D.	107	Lambert, A.	32
Burse, T.L.	89	Graham, D.F.	78	Lambert, M.B.	90
Butt, L.	94	Grant, A.C.	102	Lavoie, D.	85
Card, K.D.	70	Grant, J.A.	4-5	Lawley, L.	94
Caron, J.	67	Green, A.G.	39	Leaver, M.E.	108
Carrière, J.J.	115	Green, C.	15	LeCheminant, A.N.	89
Carson, J.M.	4-5	Grieve, R.A.F.	11	Leclair, A.	126
Chagnon, A.	116	Guevremont, R.	113	Lemkow, D.	58
		Gunning, M.J.	97-98	Lemmen, D.S.	34

Lenton, P.	126	NATMAP	123-125	Seemayer, B.E.	58
Lentz, D.R.	107	Nelson, B.	96	Shaw, J.	20
Lévesque, S.	73	Newitt, L.R.	71	Shives, R.B.K.	80
Lewis, C.F.M.	43	North, R.G.	8	Shives, R.B.K.	82
LITHOPROBE	37	Okulitch, A.V.	25-26	Sinha, A.K.	63
LITHOPROBE		Okulitch, A.V.	96	Sinha, A.K.	135
PROJECT	35-40	Palacky, G.J.	9	Slimmon, W.	126
Lucas, S.B.	126	Palacky, G.J.	135	Smith, P.L.	97-98
Lucas, S.B.	55,123-125,127	Paradis, S.J.	61	Snajdr, P.	39
Lustwerk, R.	133	Paradis, S.J.	116,117	Snow, E.	21-24
Lynch, G.	77	Parent, M.	60	Spencer, C.	74
Lynch, J.J.	108	Parrish, R.R.	55,103,104	Srivastava, S.P.	96
Ma, J.	106	Paul, D.	90	Stephens, L.E.	9
MacLean, B.	76	Percival, J.A.	70	Stern, R.A.	126
Macnab, R.F.	96	Percival, J.B.	10	Stevens, A.E.	33
Mader, U.K.	86-87	Percival, J.B.	134	Stockmal, G.S.	62
Marchildon, N.	2-3	Percival, T.D.	68	Stone, P.	59
Marcotte, D.	96	Petrachenko, W.	32	Struik, L.C.	13
Marcoux, E.	110	Pilon, J.A.	80	Syme, E.C.	126
Mareschal, M.	36,38	Pilon, J.A.	83	Szabó, T.	12
McClelland, B.M.	97-98	Pineault, R.	40	Tanczyk, E.I.	35
McConnell, R.K.	11,79,95	Piper, D.J.W.	69	Taylor, R.B.	20
McGrath, P.H.	35	Plouffe, A.	80,83	Tedford, D.	15
McGrath, P.H.	75	Plouffe, A.	84	Tella, S.	58
Mengel, F.	56	Prasad, N.	111	Telmer, K.	133
Méthot, M.	18	QUESNEL TROUGH	80-84	Teskey, D.J.	59,94,96
Miles, W.	94	Radburn, L.K.	1	Thomas, D.	126
Milkereit, B.	39	Rainbird, R.H.	133	Thomas, M.D.	35
Milkereit, B.	40	Reed, L.	74	Thomas, M.D.	57
Milkereit, B.	74	Rees, M.	133	Tod, J.	11,59,94
Miller, A.R.	58	Reilley, B.	126	Todd, B.J.	47
Monday, P.	55	Rencz, A.	109	Tremblay, A.	
Moorhead, J.	2-3	Rhéaume, P.	110	Turner, R.J.W.	31
Morgan, W.C.	119-122	Richard, F.	36	Tushingam, M.	32
Morris, W.A.	35	Ricketts, B.	31	Van Kranendonk, M.	56
Morrison, G.G.	39	Rupert, J.	11	Veizer, J.	64
Morrison, M.L.	69	Ruzicka, V.	130	Viljoen, D.	127
Mudroch, A.	10	St-Onge, M.R.	55	Waldron, J.	62
Mwenifumbo, C.J.	128	Sangster, D.F.	110,115	Walker, D.A.	1
Mwenifumbo, C.J.	129	Savard, M.	64	Wardle, R.	56
Nadaradju, G.	97-98	Schau, M.	58,86-87	Weber, J.R.	95
Nadeau, L.	73	Schrijver, K.	110	Wilks, J.	14
Nagy, D.	12	Scoates, R.F.J.	72	Williams-Jones, A.E.	110
Nagy, D.	79	Scott, D.	56	Závoti, J.	12
Naldrett, A.J.	39			Zevenhuizen, J.	76
				Zhang, P.	36