FORUM 1989

Geological Survey of Canada

Current Activities Forum
January 17-18, 1989

PROGRAM WITH ABSTRACTS

Ottawa Congress Centre
Ottawa, Ontario

Canada

Geological Survey of Canada

CURRENT ACTIVITIES FORUM

17-18 January, 1989

Place:

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

Non-Technical Event:

An informal get-together with cash bar on
Tuesday, January 17th, from
1645h to 1930h in hall A

Popular Lecture:

At 1930h on the evening of Monday, 16 January,
M.J. Keen will present a talk entitled
"Troubled waters: global oceans, global change"
in hall E

Scientific displays:

Some 90 displays will be on view
after the lecture in hall A

Energy, Mines and Resources Canada

Énergie, Mines et Ressources Canada

PROGRAM

Tuesday, 17 January 1989

0900 Welcome and opening remarks
E.A. Babcock

0910 Global change and Terrain Sciences: the record of the past
B.H. Luckman

0930 Canadian ice caps and glaciers: insights into past, present, and future climates
R.M. Koerner

0950 Global change and permafrost stability
A.S. Judge, D.G. Harry, J.A. Hunter

1010 Official opening of poster sessions

1020 **COFFEE BREAK**

1040 Sea level changes on the Pacific Coast of Canada – past and future trends
J.J. Clague

1100 Disappearing shorelines: present processes and future implications
R.B. Taylor, D.L. Forbes, J. Shaw

1120 Environmental change – is the past the key to the future?
J.V. Matthews, Jr.

1140 Monitoring global environmental changes from the recent and ancient past: a dramatic deterioration of late Paleozoic climates in the Canadian Arctic
B. Beauchamp

1200 Paleoclimatic changes in the Upper Cretaceous Dinosaur beds of Western Canada and Mongolia
T. Jerzykiewicz

1220 Geodynamics and global change
J. Popelar

1240 **LUNCH**

1420 A Paleozoic/Mesozoic rift framework for earthquake hazard estimates in Eastern Canada
J.E. Adams

1440 The current potential for major earthquakes in southwest British Columbia
G.C. Rogers, H. Dragert

1500 Landslides and economic development in the Canadian Cordillera
S.G. Evans

1520 Potential for a major volcanic eruption in the Canadian Cordillera and possible environmental effects
C.J. Hickson

1540 Lacustrine geochemistry around the north shore of Lake Superior: implications for evaluation of the effects of acid precipitation
W.B. Coker, W.W. Shilts

1600 The relationship of geology to radon in homes
R.L. Grasty, P.J. Doyle, B.W. Charbonneau

1620 Impacts of geomagnetic disturbances on human activities
R.L. Coles

1645-1930 Informal get together in poster hall; cash bar

Wednesday, 18 January 1989

0900 The Archean Superior Province and its lode gold deposits
K.D. Card, K.H. Poulsen, F. Robert

0920 Lithoprobe studies of the Kapuskasing Uplift: an exposed crustal cross-section
J.A. Percival, A.G. Green

0940 Tectonic assembly of the Canadian Shield in the Alberta subsurface: integrated potential field mapping and U/Pb zircon geochronology
G.M. Ross, M.E. Villeneuve, R.R. Parrish, S.A. Bowring

1000 Western Canadian coals: a clean, safe, and secure fuel choice
F. Goodarzi, G. Smith

1020 **COFFEE BREAK**

1050 Onshore/offshore geoenvironmental studies of the Fraser River Delta
J.L. Luternauer

1110 Stability issues with artificial island drilling structures in the Canadian Beaufort Sea
D. Gillespie, S.M. Blasco

1130 Is ice scour still a constraint for offshore development?
C.F.M. Lewis, S.M. Blasco

1150 Sediment scouring around offshore structures
C.L. Amos

1210 Geochemical constraints to deep sea waste disposal
D.E. Buckley

TALKS

GLOBAL CHANGE AND TERRAIN SCIENCES: THE RECORD OF THE PAST

B.H. Luckman[1]

ICSU's Global Change Project (IGBP) is one of the most ambitious and wide-ranging projects ever undertaken. It seeks to understand and model coupled global systems on the planetary surface to predict changes on Earth over the next century. Documentation of past environmental changes is needed to evaluate the variability, response times, linkages and pattern of natural changes and to isolate superimposed human-induced effects. Terrain Sciences Division has played a significant role in reconstructing Canada's environmental history by its classic work on the Laurentide Ice Sheet, providing a stratigraphic framework for paleoenvironmental reconstruction using pollen, macrofossils, beetles, diatoms, etc. and by ice-core studies. It complements this work with studies of contemporary geomorphic processes (particularly in the Arctic), permafrost, glaciology, natural hazards (landslides, debris flows, jökulhlaups), modern climate, vegetation and pollen rain. These studies provide critical information for the formulation of sound environmental policies and a solid foundation on which Canada's Global Change Program can build.

[1] Terrain Sciences Division

CANADIAN ICE CAPS AND GLACIERS: INSIGHT INTO PAST, PRESENT AND FUTURE CLIMATES

R.M. Koerner[1]

Our high Arctic ice caps have areas in their upper regions where the snow never melts completely. Cores taken from the surface to the bedrock in these areas carry a 100 000 year record of the atmosphere and its aerosols trapped in the snow.

Ice core records can be used to put present and predicted climate change into perspective. For example, is the warming trend of the past 100 years unique? How will the warming predicted from increasing levels of greenhouse gases affect our Arctic ice caps? Will increased melting raise sea levels globally? Have CO_2 concentrations in the atmosphere changed in the past and did they affect climate? How does the level of atmospheric pollutants today compare with levels in the past? Will we be able to use our ice caps as 'climateometers' to measure future changing climate? Reasonable answers can be given to these questions thereby helping us to plan more sensibly for changes of climate in the future.

[1] Terrain Sciences Division

GLOBAL CHANGE AND PERMAFROST STABILITY

A.S. Judge[1], D.G. Harry[1], J.A. Hunter[1]

Permafrost underlies nearly 50% of Canada and is a major factor controlling landscape evolution and constraining economic development in northern regions. Because permafrost is a ground temperature condition, it is potentially sensitive to climatic warming associated with global environmental change. The southern limit of permafrost generally coincides with the -1°C annual air isotherm; climatic warming would result in the northward migration of this limit and complete degradation of permafrost throughout the present discontinuous zone. In more northerly areas, active layer deepening and partial permafrost degradation would occur. The rate and magnitude of terrain response to these thermal changes depends on several factors, including ice content, material characteristics and vegetation cover. In areas of bedrock or ice-poor sediments, permafrost loss may occur with little or no terrain impact. Conversely, areas underlain by ice-rich sediments may experience thaw settlement and slope instability, posing major geotechnical concerns for northern development projects.

[1] Terrain Sciences Division

SEA LEVEL CHANGES ON THE PACIFIC COAST OF CANADA — PAST AND FUTURE TRENDS

J.J. Clague[1]

Sea level on the Pacific coast of Canada has varied up to 5 m from its present position in the last 5000 years. During the late Holocene, sea level has fallen relative to land on the Queen Charlotte Islands and northwestern Vancouver Island, probably due to tectonic uplift. In contrast, sea level has risen relative to land on parts of eastern Vancouver Island and the British Columbia mainland; this is a consequence of isostatic or tectonic subsidence, eustatic sea-level rise, or some combination of these factors. Great earthquakes (M8+), which may occur on average once every several hundred years in this region, are capable of producing significant instantaneous changes in relative sea level. Anticipated atmospheric warming of several degrees Celsius over the next century could result in a net sea level rise of 1 m or more along all parts of the British Columbia coast. This would aggravate coastal erosion in some areas and cause intrusion of saltwater into rivers, bays, and aquifers. It also would necessitate the construction and upgrading of dykes and other protective structures to prevent flooding of low-lying areas, such as deltas and harbour margins.

[1] Terrain Sciences Division

DISAPPEARING SHORELINES: PRESENT PROCESSES AND FUTURE IMPLICATIONS

R.B. Taylor[1], D.L. Forbes[1], J. Shaw[1]

Many barrier beaches, small islands and stretches of coastal cliff have disappeared or changed dramatically in Atlantic Canada over the past 5000 years as the relative sea level has been rising at rates of 2 to 3 mm/yr (20 to 30 cm/century) along the Nova Scotia coast and at lesser rates along much of Newfoundland. This pattern of submergence continues at comparable rates today. Geological studies of recent coastal deposits provide critical information for evaluating potential local effects of an anticipated rise in global sea level between 0.5 and 1.5 m by the year 2100.

Systematic measurements and detailed monitoring of selected coastal sites over the past 10 years have indicated that mean annual recession rates for unconsolidated shore cliffs range up to 3.3 m but most commonly up to 1.0 m. Beach response can be locally variable under similar regional rates of sea level change.

Where appropriate conditions prevail, barrier beaches have been observed to migrate landward at rates as high as 8 m/year in a "rollover" process involving chronic washover sedimentation. At other sites with headland anchors, high storm ridges/dunes, and high rates of sediment supply, or various combinations of these factors, barriers show negligible retreat and in some cases seaward progradation.

[1] Atlantic Geoscience Centre, Dartmouth

ENVIRONMENTAL CHANGE — IS THE PAST THE KEY TO THE FUTURE?

J.V. Matthews, Jr.[1]

Although not all agree that we face rapid climatic warming as a result of climbing levels of atmospheric CO_2, this is the prediction generated by General Circulation models. The projected warming of the next century is greater than has occurred during recorded history; therefore, it is necessary to look to the geological past for analogues. Considerable geological-paleoenvironmental information is available for the warmest periods — the so called interglacials — of the ice ages. We now live in the cooler part of one such warm interval. However, some climatic models call for climate as warm as that which existed approximately 3 million years ago during the last "golden age" of equable world climate and before the onset of Northern Hemisphere Glaciation. This talk discusses some of the effects of past climatic warming and suggests questions about the future that might be answered by enhanced study of past environments.

[1] Terrain Sciences Division

MONITORING GLOBAL ENVIRONMENTAL CHANGES FROM THE RECENT AND ANCIENT PAST: A DRAMATIC DETERIORATION OF LATE PALEOZOIC CLIMATES IN THE CANADIAN ARCTIC

B. Beauchamp[1]

Because of human activities, we are about to witness significant short-term changes in the global environment. The most obvious changes will be to the Earth's climatic system, but equally important changes will occur in the entire atmosphere, hydrosphere, lithosphere and biosphere. A diversity of alarmist scenarios have been proposed, but no one is sure of what pattern to predict. Because similar changes have occurred repeatedly throughout the Earth's history, the geological record provides a tangible means of assessing environmental responses to climatic fluctuations.

Analysis of Carboniferous and Permian strata in the Canadian Arctic indicates that the climates evolved from tropical warm and arid to temperate cold and more humid. Four major events (including the Permian-Triassic mass extinction), characterized by the sudden disappearance of whole faunas and floras, are superimposed on the main trend. Possible lines of explanation for these events include: tectonism, volcanism, "icehouse effect", glaciation, paleoceanographic perturbation, meteoritic impact.

[1] Institute of Sedimentary and Petroleum Geology, Calgary

PALEOCLIMATIC CHANGES IN THE UPPER CRETACEOUS DINOSAUR BEDS OF WESTERN CANADA AND MONGOLIA

T. Jerzykiewicz[1]

Paleoclimatic variations in the Western Canada Sedimentary Basin are expressed by the distribution of climatically sensitive sediments, i.e. coal and caliche, and by changes in the drainage systems. The extent of the semiarid floodplain facies and ephemeral channels is limited to the southern part of the basin. No signs of caliche have been found in the central part of the basin. Instead, some of the floodplain deposits associated with meandering rivers in this part of the basin contain economic coal. Climatic differences between the humid central part and the drier southern part of the basin cannot be explained by the position of the sea shore or by orographic influences alone. There is another external factor, i.e. the pattern of atmospheric circulation, such as that responsible for the present-day climatic differences existing between the southern and central part of the basin. The climatic impact on sedimentation is recorded in the Mongolian Basin by changes of the drainage systems from an internal, semi-desert type in the Santonian-Campanian into a permanent one composed of high-sinuosity meandering rivers and lakes in the Maastrichtian. This affected dinosaur habitat (semi-desert environment supported only small to medium-sized animals while large dinosaurs inhabited the fluvio-lacustrine environment) and produced favourable coal-forming environments.

[1] Institute of Sedimentary and Petroleum Geology, Calgary

GEODYNAMICS AND GLOBAL CHANGE

J. Popelar[1]

The earth's orbital parameters such as its eccentricity, obliquity, axial precession and spin rate are changing continuously as a result of external forces and the irregular figure, structure and properties of the earth. The impact of the astronomical cycles on the earth's climate and their role in triggering the Pleistocene ice ages forms the basis of the Milankovitch theory. The application of modern space techniques (VLBI, lunar and satellite ranging) provides the measurement accuracy and long term reference frame stability for monitoring changes of the earth's orbit, its spin rate and polar motion which must reflect the globally integrated effects of any large scale mass redistribution or exchange of momentum within the earth's system including tidal effects, atmospheric and ocean circulation, sea and ground water level changes, seasonal or permanent biomass distribution, deglaciation, crustal dynamics, mantle and core interaction. If the global geodynamic parameters do not adequately reflect the observed large scale changes in physical conditions, mitigating factors must be found to account for the disparity. In physical terms the global geodynamic parameters offer one of the few means of quantitatively assessing global change.

[1] Geophysics Division

A PALEOZOIC/MESOZOIC RIFT FRAMEWORK FOR EARTHQUAKE HAZARD ESTIMATES IN EASTERN CANADA

J.E. Adams[1]

Although much of eastern Canada is substantially aseismic it contains several zones of intense seismicity, notably along the eastern continental margin and in distinct clusters within the craton.

Seismicity along the eastern margin appears to be concentrated at the ocean-continent transition, probably through reactivation of the Mesozoic rift faults created when the North Atlantic was formed. The passive Arctic Ocean margin has a comparable ocean-continent transition but appears to be seismically active mainly where it has been recently loaded by thick sediments.

Thus most large earthquakes in eastern Canada appear to have occurred near Paleozoic or younger rifts that surround or break the integrity of the craton, i.e. places where the continent has been most recently weakened. Similar conclusions come from a study of world-wide earthquakes in "stable continental interiors".

Both the Paleozoic and the Mesozoic rift systems in eastern Canada are continuous features, many thousands of kilometres long. Despite their continuity and the uniform stress field, the rift systems are only sporadically active, as at Charlevoix and the lower St. Lawrence. This leads to the classic dilemma for hazard estimates that need to be made for low levels of probability: will the next large earthquake occur in a recognized seismic zone or not?

[1] Geophysics Division

THE CURRENT POTENTIAL FOR MAJOR EARTHQUAKES IN SOUTHWEST BRITISH COLUMBIA

G.C. Rogers, H. Dragert[1]

The subduction setting of southwest coastal British Columbia is characterized by at least two distinct tectonic regions. The southernmost one involves contemporary subduction of the Juan de Fuca plate beneath the North American plate margin. In this region, a dipping zone of earthquakes demarks the descending plate. The lack of thrust events on the subduction interface and the observed horizontal and vertical surface deformations are consistent with a model of accumulating elastic strain over a locked subduction zone. There are a number of lines of evidence that suggest that major thrust earthquakes may occur at intervals of several hundreds of years. North of central Vancouver Island, few geophysical measurements have been made and it is not known whether convergence is taking place. This region may be tectonically distinct and have potential for its own major earthquakes with possible repeat times less than those for the Juan de Fuca region.

[1] Cordilleran and Pacific Geoscience Division, Vancouver

LANDSLIDES AND ECONOMIC DEVELOPMENT IN THE CANADIAN CORDILLERA

S.G. Evans[1]

A number of catastrophic landslide hazards have been documented in the Cordillera. They include highly mobile rock avalanches, rainfall-induced debris flow, large-scale landsliding in Pleistocene sediments, destructive landslide-induced waves, and outburst floods caused by the failure of natural dams.

The economic and social infrastructure of the Cordillera, which includes mining and energy production facilities as well as strategic transportation corridors, is highly vulnerable to landslides. Landslides have been responsible for 360 deaths in the Cordillera since 1856 and it is estimated that the total direct and indirect costs of landslides in the region are in excess of $100 M per annum. This figure includes the damage to the Fraser River salmon fishery which between 1951 and 1978 experienced losses of $96 M per year directly attributable to the rockfall which partially blocked the Fraser River in 1914.

An analysis of a data base of known damaging landslides events indicates that the most damaging landslide types, both in terms of deaths and economic impact are frequent small scale (less than $0.1 \times 10^6 m^3$) precipitation triggered debris flows and low magnitude rockslope movements. Together these landslide types make up 61% of known damaging landslides in the period 1856 to 1983. This is despite the fact large scale rock avalanches and other major rockslope movements are comparatively common in the sparsely peopled Cordillera.

[1] Terrain Sciences Division

POTENTIAL FOR A MAJOR VOLCANIC ERUPTION IN THE CANADIAN CORDILLERA AND POSSIBLE ENVIRONMENTAL EFFECTS

C.J. Hickson[1]

The tectonically active Canadian Cordillera has been the scene of post-glacial volcanic activity, mostly in the form of mafic flows and ash eruptions limited in extent. An exception was a major rhyodacite eruption in the Mount Meager Volcanic Complex, 150 km north of the city of Vancouver. Although the likelihood of renewed volcanic activity within the next century somewhere in the Cordillera is fairly high, the record of past events suggests it will be a non-explosive, mafic eruption in an uninhabited area. The immediate surroundings of most volcanoes are sparsely populated, and the environmental impact will probably be local, but if the eruption disrupts drainage there may be profound effects on any downstream engineering structures. A major eruption at Mount Baker (50 km south of Vancouver) would pose the greatest risk to populated areas, but its effect on Canadians would be limited to inconveniences associated with the accumulation of ash.

[1] Cordilleran and Pacific Geoscience Division, Vancouver

LACUSTRINE GEOCHEMISTRY AROUND THE NORTH SHORE OF LAKE SUPERIOR: IMPLICATIONS FOR EVALUATION OF THE EFFECTS OF ACID PRECIPITATION

W.B. Coker[1], W.W. Shilts[2]

Geochemical data from the north shore of Lake Superior illustrate how natural variations in the environment, caused by differing bedrock lithologies, mineralization, and/or glacial sediment compositions, can be used to predict or evaluate anthropogenic changes in geochemical patterns, particularly as they relate to acid precipitation. Patterns of pH variations in lake waters show lakes of the northeastern part of the study area to be buffered by a sheet of calcareous till and glaciolacustrine sediment transported southward and southwestward from the carbonate bedrock of the Hudson Bay Lowland. In the remaining parts of the area, pH is more closely related to underlying bedrock types. Trace metal levels in lake waters and sediments vary significantly with changing bedrock types; patterns of variations can be used to predict areas most susceptible to metal mobilization as a result of terrain acidification.

[1] Mineral Resources Division
[2] Terrain Sciences Division

THE RELATIONSHIP OF GEOLOGY TO RADON IN HOMES

R.L. Grasty[1], P.J. Doyle[1], B.W. Charbonneau[1]

Radon is a naturally occurring radioactive gas produced by the decay of uranium. Exposed to enhanced levels of radioactive decay products of radon over long periods of time increases the risk of developing lung cancer. The GSC recently supported a project to investigate the potential of airborne gamma-ray data to predict areas where indoor randon levels were likely to be elevated. Two communities in Quebec were selected for study on the basis of their geology and ground levels of radioactivity obtained from airborne gamma-ray survey data. These were the towns of Maniwaki, situated in an area of radioactive granites and Ste-Agathe, located in an anorthosite complex of low radioactivity. The radon levels in many of the homes in Maniwaki were found to be significantly higher than those in Ste-Agathe demonstrating that airborne gamma-ray surveys can be useful for identifying areas with potential radon problems. These conclusions support recent studies in the United States and Scandinavia.

[1] Mineral Resources Division

IMPACTS OF GEOMAGNETIC DISTURBANCES ON HUMAN ACTIVITIES

R.L. Coles[1]

Temporal disturbances in the Earth's magnetic field cause problems in a variety of human activities. One common difficulty is that experienced by magnetic surveyors, who ideally require a time-invariant geomagnetic field, so that their recordings can be associated solely with crustal, or deeper, spatial anomalies. Electromagnetic and electrical survey equipment can be affected by spurious geomagnetically induced signals. However, natural source EM techniques require some degree of disturbance to function. Electrical power utility companies recognize that geomagnetic disturbances generate unwanted, potentially damaging, currents in transmission grids. Geomagnetically induced potentials in pipelines can give rise to corrosion effects. Often, however, geomagnetic activity does not directly 'cause' effects with which it correlates, but rather it simply characterizes a more complex set of phenomena. For example, high levels of geomagnetic disturbance are associated with unreliable shortwave radio communication, radars, satellite-based navigation systems, communications satellite malfunctions or failures, to name but a few.

[1] Geophysics Division

THE ARCHEAN SUPERIOR PROVINCE AND ITS LODE GOLD DEPOSITS

K.D. Card[1], K.H. Poulsen[2], F. Robert[2]

Superior Province Archean craton of the Canadian Shield was formed during Middle and Late Archean tectonomagmatic events by subduction-driven accretionary processes in convergent tectonic settings. It consists of northern and southern high-grade gneiss terranes and a central region of alternating greenstone-rich and metasediment-rich subprovinces. Terrane boundaries are complex zones of facies, metamorphic, and structural transition, commonly telescoped by crustal-scale faults. Volcanism, plutonism, and sedimentation was followed by polyphase deformation, metamorphism, and plutonism. Ductile deformation and granulite facies metamorphism at deep crustal levels represented by the high grade terranes accompanied and outlasted ductile-brittle deformation and low-grade metamorphism at high crustal levels represented by the greenstone-granite terranes. Lode gold deposits formed in the late stages of deformation are related to major faults and zones of rock alteration within greenstone-granite terranes. Models involving granulite metamorphism at depth, with formation of H^2O- and CO^2-rich fluids which were channeled upward along major faults to deposit gold at high crustal levels, probably best account for all aspects of the Superior Province deposits except their confinement to greenstone-granite terranes.

[1] Lithosphere and Canadian Shield Division
[2] Mineral Resources Division

LITHOPROBE STUDIES OF THE KAPUSKASING UPLIFT: AN EXPOSED CRUSTAL CROSS-SECTION

J.A. Percival[1], A.G. Green[1]

The intracratonic Kapuskasing uplift, characterized by prominent gravity and aeromagnetic highs, exposes about 15 vertical km of Archean crust of the Superior Province in oblique cross-section from greenschist to granulite facies. In order to understand the crustal structure and uplift mechanisms, 350 km of reflection line were recorded, over and west of the Kapuskasing structural zone (KSZ), in conjunction with refraction studies which show thick crust (53 km) and high velocities beneath the KSZ.

In the southern part of the uplift, high-resolution data image the bounding Ivanhoe Lake thrust as a network of reflectors dipping ~35°W below 1.5s TWTT; above this level, steep truncations of reflectors suggests overall listric geometry. Reflections dipping 15°W within the KSZ correspond to lithological layering near the basal contact of the Shawmere anorthosite. Regional data track reflectors down to the west where they flatten and appear to sole at about 4s TWTT. Together with refraction information which shows velocity anomalies above 20 km, the reflection data indicate a mid-crustal delamination horizon separating upper crust moving upward and eroding the lower crust flowing into a 10-15 km thick crustal 'root'.

[1] Lithosphere and Canadian Shield Division

TECTONIC ASSEMBLY OF THE CANADIAN SHIELD IN THE ALBERTA SUBSURFACE: INTEGRATED POTENTIAL FIELD MAPPING AND U/Pb ZIRCON GEOCHRONOLOGY

G.M. Ross[1], M.E. Villeneuve[2], R.R. Parrish[3], S.A. Bowring[4]

An integrated geochronological and geophysical study sheds new light on the crustal structure and timing of assembly of the Canadian Shield buried in the Alberta subsurface. The picture which emerges is one in which the assembly of dated tectonic elements (2.6-2.1 Ga) was brought about by apparent plate consumption along zones now marked by 2.0-1.8 Ga magmatic arcs and transcurrent shear zones. Arcuate north-trending anomalies of northern Alberta are interpreted as a composite magmatic arc developed west of the Archean Rae Province. Ca.2.0 Ga arcs flank an older arc/microcontinent that ranges from 2.3-2.1 Ga. These anomalies are truncated to the south by the Snowbird Tectonic Zone, a pronounced crustal break postulated to have formed during Proterozoic oblique collision between the Rae and Hearne Provinces that was associated with tectonic escape blocks and a narrow magmatic arc. Southern Alberta is dominated by Archean age rocks including the Southern Alberta Aulacogen which is a likely collision zone representing part of a

broader zone of northward convergence between the Hearne and Wyoming Provinces. The results of this work place geometric constraints on crustal lineaments that appear to have influenced sedimentation and resource accumulation in the Western Canada Sedimentary Basin.

1 Institute of Sedimentary and Petroleum Geology, Calgary
2 Mineral Resources Division
3 Lithosphere and Canadian Shield Division
4 Earth and Planetary Sciences, Washington University, St. Louis, Missouri

WESTERN CANADIAN COALS; A CLEAN, SAFE AND SECURE FUEL CHOICE

F. Goodarzi[1], G.G. Smith[1]

Coal-fired plants produce the vast majority of electricity generated in Alberta (90%) and Saskatchewan (75%). These generating stations and associated mines are located near some of Canada's prime agricultural lands. Environments surrounding these major coal developments are, apparently, not adversely affected by the coal production and utilization activities. The expanded use of Western Canadian coals in Canada and around the world can help coal users to meet increasingly stricter environmental standards. As technological advances widen the scope of acceptable users of coal in the coming decades, the diverse inventory of coals in Western Canada will continue to provide a broad basis of choice in selecting a safe, environmentally acceptable and economical fuel.

The term "coal" is applied to rocks having significantly different properties. Variation in chemical composition and physical properties of coal relates, fundamentally, to environment of deposition, original type of peat-forming vegetal debris, degree of organic maturation, structural deformation, mineralization and extent of weathering. The concentration of various minor and trace elements in coals is becoming an increasingly important factor in the selection of an optimum coal for a particular use.

1 Institute of Sedimentary and Petroleum Geology, Calgary

ONSHORE/OFFSHORE GEOENVIRONMENTAL STUDIES OF THE FRASER RIVER DELTA

J.L. Luternauer[1]

Studies have involved several GSC agencies, universities and private contractors. Investigative techniques used on the diked part of the delta have included shallow seismic reflection profiling, coring, and a range of state of the art geophysical and geotechnical measurements. As of last summer the municipality of Richmond on the delta contributed financially to the studies because they included an assessment of the earthquake vulnerability of a part of the municipality's diking system. Preliminary results suggest that the site could undergo some liquefaction during earthquakes of magnitude $M_s \geq 6.5$ causing peak accelerations of a = 0.17g or greater.

In offshore areas of the delta studies by Geological Survey of Canada have guided placement of a major submarine sewer pipeline for the City of Vancouver, identified a site of submarine landslides that is a potential threat to a lighthouse at the mouth of the Fraser River and helped mitigate the impact of major port construction on an important intertidal habitat.

1 Cordilleran and Pacific Geoscience Division, Vancouver

STABILITY ISSUES WITH ARTIFICIAL ISLAND DRILLING STRUCTURES IN THE CANADIAN BEAUFORT SEA

D. Gillespie[1], S.M. Blasco[1]

In the shallow waters of the Beaufort Sea the presence of drifting sea-ice throughout much of the year results in a unique environment for hydrocarbon drilling activities. To resist high ice loads massive gravity based drilling structures have been designed. Large volumes of sand and gravel are dredged from the seabed to form sacrificial beach islands on which modified land rigs are placed. Alternately, in deeper water, the dredged sediments are used to construct berms on the seafloor on which concrete or steel caisson retained hybrid drilling platforms are emplaced. Stability issues associated with the use of such technologies include: the potential for slope failure; the ability to resist static and dynamic ice loads, and the potential for differential settlement of the foundation. A more recent requirement to extend drilling activities into the short open water summer season has meant the artificial islands, berms and drilling platforms must also withstand the loading and erosive action of storm waves and currents.

1 Atlantic Geoscience Centre, Dartmouth

IS ICE SCOUR STILL A CONSTRAINT FOR OFFSHORE DEVELOPMENT?

C.F.M. Lewis[1], S.M. Blasco[1]

Ice scouring, the action of bottom-dragging icebergs and sea-ice ridges, incises, reworks and alters the properties of seabed sediments, and may damage engineering structures such as cables, pipelines and wellheads. Sea-ice ridges scour the Beaufort Sea shelf while icebergs from Greenland and eastern arctic Canada incise the seabed off the east coast of Canada as far south as the Grand Banks of Newfoundland. Large pressure ridges and icebergs create distinctive pits and long linear furrows as deep as 8 m in the Beaufort Sea area and 10 m on the Grand Banks. The nature of ice scouring is assessed by interpreting the seabed record of preserved scour events, and by analyzing the characteristics of the drifting ice. The risk of damage by ice scouring is determined by predicting the return period of deep events. Predictions differ between the Beaufort Sea and Grand Banks.

1 Atlantic Geoscience Centre, Dartmouth

SEDIMENT SCOURING AROUND OFFSHORE STRUCTURES

C.L. Amos[1]

Sufficient evidence exists to demonstrate that sediment mobility on mid-latitude, storm-influenced continental margins is periodically great. The consequence of this mobility to offshore development is demonstrated in a number of review documents on scouring and exposure of pipelines, flow lines, gravity-based structures and jack-up rig spud cans. Its magnitude and the potential risks to development are sufficiently large in most cases to warrant prediction of these effects which should also be taken into consideration when dealing with any subsequent engineering design. Unfortunately, knowledge of sediment transport is limited, predictions are at best, order -of-

magnitude, and understanding of near-bed boundary layer flow subject to influences of waves, currents and seabed roughness is extremely controversial. The problem will be resolved only if a team approach is taken to the study of seabed stability. This is because the problem is complex and controlled by processes which fall into geotechnical, oceanographic, biological, sedimentological and geophysical disciplines.

We cannot provide accurate answers on questions pertaining to risks to the environment of pipeline exposure on Sable Island Bank, dispersal of drilling tailings on Georges Banks, scouring of caissons in the Beaufort Sea, the effect of causeways on the lobster industry at Barrington Passage, the effect of tidal power development in the Annapolis Basin on the clam industry, the potential for scouring of the Prince Edward Island fixed link butments, and many other similar questions that have been presented to the GSC in the last few years.

[1] Atlantic Geoscience Centre, Dartmouth

GEOCHEMICAL CONSTRAINTS TO DEEP SEA WASTE DISPOSAL

D.E. Buckley[1]

Geochemical analyses of deep sea and associated pore water have been carried out to determine the feasibility of disposing of high level nuclear waste in remote ocean basins.

Turbiditic sediments in three of the largest abyssal plains in the North Atlantic have preserved paleo-oxidation zones in which redox-sensitive metals have been remobilized. These diagenetic zones represent both steady state and non-steady state processes that have resulted in the removal of as much as 80% of the original organic carbon and carbonate.

The identification of compaction faults at relatively shallow burial depths in these abyssal plains has raised serious questions about the effective barrier properties of these sediments. Recent studies have demonstrated that apparent advection along faults may be effective in the transport of radionuclides at rates much greater than the calculated diffusion rates.

The methods and results of the investigations of deep sea nuclear waste disposal provide guidelines and indicate potential constraints for the feasibility of disposal of other hazardous wastes in marine sediments, such as other toxic chemicals and sewage sludge.

[1] Atlantic Geoscience Centre, Dartmouth

POSTERS

MAPPING THE CHANGING VEGETATION PATTERNS OF EASTERN ONTARIO AND ADJACENT AREAS SINCE 12 000 YEARS B.P.

T.W. Anderson[1]

The vegetation history is depicted by 12 time series maps. The earliest inferred vegetation resembled herb-shrub tundra intermixed with woodlands of spruce, poplar, juniper, shrub birch and alder. Tundra woodland gave way to spruce-poplar woodland south of the Champlain Sea and to poplar woodland to the north. Spruce became abundant south of the Sea by 11 000 yr., expanded northward and replaced poplar in the Ottawa Valley by 10 200 yr.

Spruce dominated for about 1000 yr. until it was replaced by a mixed conifer-hardwood forest commencing with birch, then jack pine and fir, followed by white pine at 8000 to 7500 yr.

Hemlock and the hardwoods increased as early as 7600 yr. in the south and not until 6400 yr. in the Ottawa Valley. However, at about 4800 yr. the hemlock populations were drastically reduced. Beech, maple, birch and oak expanded at this time probably by occupying openings left by hemlock. Elm, ash, hickory and basswood (shade-intolerant hardwoods) were also prevalent. Hemlock became prominent again at 3000 to 3500 yr. The inferred vegetation since 3000 yr. consisted largely of a hemlock-white pine-mixed hardwoods association.

[1] Terrain Sciences Division

CANADIAN SEISMICITY AND SEISMIC HAZARDS

F.M. Anglin[1], R.J. Wetmiller[1],

Canadian earthquakes are shown on a 1:10 000 000 scale coloured, shaded relief map. The earthquake information is derived from the Canadian Earthquake Database, maintained by the Geological Survey of Canada's Geophysics Division, which contains data on nearly 25 000 earthquakes known to have occurred in or near Canada since 1568. Over 6000 events are plotted in three magnitude ranges: 3.0 to 4.5, 4.6 to 6.5 and 6.6 and greater. Special care has been taken in preparing the map to minimize clutter and present a balanced view of the earthquake activity throughout the country.

The map also highlights 36 of the most significant earthquakes in Canada's history including the great Queen Charlotte Islands earthquake of 1949, damaging earthquakes in British Columbia in 1946, in eastern Ontario in 1944 and in the Atlantic Provinces in 1929, and the Arctic's largest earthquake in 1933.

[1] Geophysics Division

SOME CANADIAN CORDILLERA EXAMPLES OF EPITHERMAL PRECIOUS METAL BRECCIAS: MINERALOGY AND GEOCHEMISTRY

S.B. Ballantyne[1], D.C. Harris[1], D.A. Walker[1]

Breccias are important features of hydrothermal-epithermal precious metal systems.

This study combines lithogeochemistry, scanning electron microscope (image analysis) and electron microprobe investigations to examine:

1. Near-surface phreatic hydrothermal features including McLaughlin style hot spring siliceous sinter breccia, eruption-vent breccia and ejecta of possible Eocene age (Germaine and Hunker Creeks, Dawson, Yukon).
2. Multi-stage quartz-manganese-carbonate breccia bodies and veins in which the ore minerals include diaphorite, pyrargyrite stannite and cassiterite (Cody Ridge-Mount Mye, Faro, Yukon).
3. Quartz-adularia microbreccia associated with acanthite-native silver mineralization within the Bennett Lake cauldron subsidence complex (Bennett and Partridge Lakes, B.C.).
4. Chalcedonic-opaline breccia containing 2-10 micrometre sized sulphides, barite and lead-antimony sulfosalts (Graham Creek, west of Atlin, B.C.).
5. Structurally complex precious metal quartz-breccia systems containing argentian tetrahedrite, pyrargyrite, polybasite, electrum, acanthite, and native silver (Sulphurets Creek-Brucejack Lake, north of Stewart, B.C.).

[1] Mineral Resources Division

MONITORING GLOBAL ENVIRONMENTAL CHANGES FROM THE RECENT AND ANCIENT PAST: A DRAMATIC DETERIORATION OF LATE PALEOZOIC CLIMATES IN THE CANADIAN ARCTIC

B. Beauchamp[1]

Because of human activities, we are about to witness significant short-term changes in the global environment. The most obvious changes will be to the Earth's climatic system, but equally important changes will occur in the entire atmosphere, hydrosphere, lithosphere and biosphere. A diversity of alarmist scenarios have been proposed, but no one is sure of what pattern to predict. Because similar changes have occurred repeatedly throughout the Earth's history, the geological record provides a tangible means of assessing environmental responses to climatic fluctuations.

Analysis of Carboniferous and Permian strata in the Canadian Arctic indicates that the climates evolved from tropical warm and arid to temperate cold and more humid. Four major events (including the Permian-Triassic mass extinction), characterized by the sudden disappearance of whole faunas and floras, are superimposed on the main trend. Possible lines of explanation for these events include: tectonism, volcanism, "icehouse effect", glaciation, paleoceanographic perturbation, meteoritic impact.

[1] Institute of Sedimentary and Petroleum Geology, Calgary

LABRADOR SEA BASIN ATLAS

J.S. Bell[1]

The regional setting of the Labrador Shelf is portrayed on gravity and magnetic maps complemented by a crustal thickness map and crustal transects constructed largely from geophysical data. The gross Phanerozoic geological evolution of the region is documented in a series of seismically-derived structure and isopach maps which portray the early Cretaceous continental rifting, the late Cretaceous marine incursions, Tertiary shelf progradation, subsidence and local growth faulting and final burial beneath Quaternary glacial deposits. Paleoenvironmental

maps illustrate the changing nature and setting of the accretionary surfaces on which the Mesozoic and Tertiary sediment accumulated. There is only limited information on the Paleozoic sediments, so their geological history is less well documented. Mesozoic and Tertiary clastic facies patterns are illustrated for each isopach map. The above interpretations rely on extensive recent biostratigraphic studies and revisions of rock stratigraphic correlations. Neotectonics are documented on an earthquake distribution map which also shows focal mechanism and breakout data. The opening of the Labrador Sea is portrayed on a vivid series of maps prepared using the latest computer graphic techniques. Several significant gas discoveries have been made on the Labrador Shelf: geochemical data suggest that the source of most of the hydrocarbons was Lower Cretaceous coal beds.

[1] Atlantic Geoscience Centre, Dartmouth

NEW DIGITAL METHODS IN GSC CARTOGRAPHY

J. Bill[1], D.J. Ellwood[1], J.E. Glynn[1]

The Geological Survey has recently acquired some new computer hardware and software which greatly assists the cartographic services section in producing maps, charts and displays for GSC staff. Some of the new methodology are described and results are displayed.

[1] Geoscience Information Division

INTERACTIVE INTERROGATION OF CANADA-WIDE MINERAL DEPOSITS DATA, OVERLAIN ON DNAG GEOPHYSICAL MAPS, USING THE SPANS GEOGRAPHIC INFORMATION SYSTEM

G.F. Bonham-Carter[1], D.F. Garson[1], R.M. Laramée[1], T. Webster[2]

A microcomputer-based geographic information system (SPANS) is being evaluated for handling data from CANMINDEX, a Canada-wide mineral occurrence database. SPANS version 4.01 is being used to interactively query an ASCII-file subset of CANMINDEX, containing 18 500 records with location, commodity and status information.

Canada-wide gridded magnetic and gravity data were displayed and annotated on a high-resolution colour monitor, with digitized elevation as the base. These were stored as browse files for instant recall.

A typical point query operation might begin with the following steps: 1) window selection (e.g. Maritimes); 2) display the Bouguer map; 3) superposition of provincial boundaries; 4) selection and display of major copper occurrences; 5) enter point query mode. For any cursor location on the monitor, attributes associated with the closest point can be displayed.

[1] Mineral Resources Division
[2] TYDAC Technologies Inc., Ottawa

POLLEN IN ARCTIC ICE COVERS: A CONTRIBUTION TO PALEOCLIMATIC STUDIES

J.C. Bourgeois[1]

Long pollen records have been obtained from cores drilled at the top of Canadian Arctic ice caps where the ice has been accumulating for over 100 000 years. The pollen content of the ice is extremely low compared to peat or lake sediments but is sufficient, along with the other variables studied in the cores, to reveal information about past climates. A pollen record obtained from the Agassiz Ice Cap has thus far led to the modification of the time scale for the pre-Holocene ice in our cores.

The pollen concentration in the ice varies according to source, pollen production and wind direction. To understand the interaction between the different parameters and climate, it is essential to study present pollen distribution at the top of ice caps, both on an annual and seasonal basis. Only when these are well understood will it be possible to retrieve precise paleoclimatic information from the ice core pollen records.

[1] Terrain Sciences Division

GEODYNAMIC MODELS OF THE LITHOSPHERE: APPLICATION TO EXTENSIONAL BASINS

R. Boutilier[1], G. Bassi[1], R. Courtney[1], C.E. Keen[1], B.C. Nichols[1], G.S. Stockmal[1]

Geodynamic modelling has emerged as a powerful tool in the study of the development of both extensional and compressional lithospheric and crustal scale tectonic events. Developing a physically consistent, geologically sound, and scientifically useful numerical model for the evolution of sedimentary basins requires the integration of several key components. The central element of the studies is a sophisticated model for the deformational strength of the Earth's lithosphere which includes its elastic strength, plastic flow in high stress regions, and the relaxation of stress by viscous creep. We must also include a model for the advection and diffusion of heat in the Earth's thermal lithosphere (including any sedimentary basins) since typical lithospheric rheologies are strongly temperature dependent. In addition, transient uplift and subsidence result from any perturbation to the equilibrium thermal state in the lithosphere. Since many extensional basins are fault bounded, a model which addresses at least the first-order effects of large crustal faulting is also needed.

Simple and interesting results have been obtained for deformation of the lithosphere and current work will be presented which shows how these results are being applied.

[1] Atlantic Geoscience Centre, Dartmouth

GROUNDWATER GEOCHEMISTRY IN EPIDEMIOLOGY AND ENVIRONMENTAL STUDIES

D.R. Boyle[1]

Geochemical studies of groundwater chemistry and processes of water/rock interaction can lead to the recognition of areas which display chronic 'water factors' giving rise to long term health deterioration (decreased longevity). Many of the geological/geochemical environments which may predispose man to various diseases can be detected by the use of systematic, quality controlled regional groundwater and surface water surveys. Regional geochemical surveys carried out by the Geological Survey of Canada can be used to outline areas which may be endemic for certain diseases. Follow-up studies by a geochemist/epidemiologist/medical team will be required to determine cause, effect and remediation.

Groundwater recharge into Canadian lakes may vary from as little as 5% to as much as 100% of the total water input. Groundwater sampling equipment developed at the GSC, together with mass transfer studies, will permit a more holistic assessment of the role acid precipitation plays in a variety of lake environments.

[1] Mineral Resources Division

HIGH RESOLUTION BOREHOLE TEMPERATURE GRADIENT LOGS: A POSSIBLE APPLICATION IN EARTHQUAKE PREDICTION

Q. Bristow[1]

A high sensitivity, high resolution temperature probe for use in borehole measurements has been developed at the Geological Survey of Canada. Experience to date has indicated that detailed temperature gradient logs from boreholes in a normally stable geological environment are highly reproducible from month to month.

It seems probable that the accumulated stresses which culminate in the sudden release of energy giving rise to an earthquake, also produce small strains or movements before the event. Such movements might well cause subtle deviations in the normal pattern of temperature gradients measured in boreholes in the vicinity, thereby providing advance warning of an imminent earthquake.

In order to test the hypothesis a data base of temperature gradient logs, taken at regular intervals in boreholes in the Eastern Ontario region, is being compiled. This will help to establish the normal variations which can be expected due to "Earth tides", seasonal variations and other phenomena unrelated to abnormal stress build-up.

[1] Mineral Resources Division

ROLE OF GAS-CHROMATOGRAPHY-MASS SPECTROMETRY (GC-MS) IN OIL EXPLORATION AND ENVIRONMENTAL STUDIES, ANCIENT AND MODERN

P.W. Brooks[1], M.G. Fowler[1], R.W. Macqueen[1], L.R. Snowdon

GC-MS is used in organic geochemistry to study the distribution and abundance of organic compounds known as biological markers, present in oils and rock extracts. These compounds can be related through their chemical structures to compounds which are abundant in present day living organisms.

Hence, the distribution of biological markers in oils and ancient rock extracts provides evidence for the type of organic matter originally present in the paleoenvironment of deposition, and maturation and migration attributes. Many biological markers, once present, are resistant to microbial alteration and thus important information may be obtained on oils which have been extensively altered by biodegradation. Biomarkers provide evidence of source rock organic matter type, and source rock lithology. Biomarkers also may be used in maturation studies to predict source rock and oil maturities.

Although the focus of gc-ms based research at the Institute of Sedimentary and Petroleum Geology is on oil-oil and oil-source correlations, the gc-ms and gc-ms-ms instrumentation involved is equally suitable for a wide range of studies of organic compounds, including the distribution of man-made organic compounds which may occur as contaminants in the natural environment.

[1] Institute of Sedimentary and Petroleum Geology, Calgary

STRATIGRAPHY OF THE ALBERTA FORELAND BASIN: AN INTERPRETATION IN TERMS OF CORDILLERAN TECTONICS

D. Cant[1], G.S. Stockmal[1]

An idealized foreland basin sequence resulting from tectonic accretion of a terrane onto a continental margin is 1) unconformity-bounded, 2) a shallowing-upward wedge of mainly clastic sediments. Analysis of the Jurassic to Tertiary stratigraphy of the Alberta Basin using this model has lead to the recognition of 6 clastic wedges which show a good correlation in time to the accretion of 6 documented terranes in the Cordillera. The unconformity-bounded sequences in the basin are therefore primarily tectonically generated.

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APPLICATION OF MULTIPARAMETER AIRBORNE GEOPHYSICS TO MINERAL DEPOSIT STUDIES: LUPIN AND THOR LAKE, N.W.T.

B.W. Charbonneau[1], P.B. Holman[1], K.L. Ford[1], R. Hétu[1]

Two detailed multiparameter airborne geophysical surveys were flown by the GSC Skyvan system in 1988, as part of a Canada-NWT MDA project in the vicinity of the Lupin (Au) and the Thor Lake (Be – rare metal) deposits. Results of this work complement ongoing geoscientific studies directed at understanding deposit genesis and thus assist exploration. The publication consists of eleven geophysical maps (ternary radioelement, exposure rate, K, U, Th, U/Th, U/K, Th/K, total field magnetic, VLF-EM total field and quadrature), stacked profiles and a geological map.

The geophysical surveys effectively map many aspects of the geology in the two areas. At Lupin, high U and U/Th ratio and low Th/K ratio and aeromagnetic response over the adjacent granite may indicate a high degree of magmatic differentiation. At Thor Lake (originally discovered by reconnaissance gamma ray spectrometry) the mineralized zones are characterized by high Th and U. In both areas the airborne data indicate many features which remain unexplained when compared with available geology. An example of these is the anomalous thorium zone which parallels the East Arm of Great Slave Lake.

[1] Mineral Resources Division

EVIDENCE OF PALEOSEISMICITY OBTAINED BY SUBBOTTOM ACOUSTIC PROFILING OF LAKES

J.J. Clague[1], W.W. Shilts[1]

A portable, high-resolution subbottom profiling system, operating at a frequency of 7kHz, has been deployed from small boats on lakes in eastern and western Canada for the purpose of defining types of sediment disturbance (slumping, erosion, liquefaction) caused by seismic events, first by surveying lakes with recorded disturbance from historic earthquakes, then by surveying lakes where disturbance could be anticipated on geological grounds.

Lake floors near the major 1946 Vancouver Island and 1935 Lake Temiskaming earthquakes were found to be covered by hummocky deposits offshore from known areas of shoreline disruption or where significant amounts of suspended sediment had been observed. In Lac Témiscouata, Quebec, similar hummocky deposits were observed to cover much of the bottom. In the subbottom of Temiscouata, at least two older hummocky surfaces were recorded, indicating that this historically seismically quiet Appalachian valley may have been subjected to more than one major prehistoric seismic event. Studies are continuing in these areas to improve discrimination among processes that can cause sediment disturbance – seismic shocks, hydrologically induced slope failures, anthropogenic modifications, and normal shoreline erosion and sedimentation.

[1] Terrain Sciences Division

FORECASTING GEOMAGNETIC ACTIVITY

R.L. Coles[1], J. Hruska[1], H.-L. Lam[1]

Forecasting of geomagnetic activity is in demand by a variety of user groups, including the exploration industry, telecommunications agencies, electric power utilities, the

military, pipeline operators, geodetic surveyors, and scientific researchers. Long and medium term forecasts can be issued, based on recurrent features in solar and geomagnetic activity. Short term forecasts, up to a few days, depend on prompt observations of the latest solar phenomena and on continuous monitoring of the geomagnetic field.

[1] Geophysics Division

EFFECTS OF RECENT SEA LEVEL CHANGE AND EROSION ON COASTAL ZONE GEOTECHNICS

S.R. Dallimore[1], P.J. Kurfurst[1], B.R. Pelletier[1]

The Beaufort Sea has undergone a rise in mean sea level of over 100 m during the last 20 000 to 30 000 years. Historical records and aerial photographs confirm that substantial changes in coastal position have continued during the past 100 years. Rates of coastal retreat of over 5 m/a have been recorded at locations on the Yukon coast, Mackenzie Delta and Tuktoyaktuk Peninsula. Studies of the nearshore zone indicate a high degree of spatial and temporal variability in geological and permafrost conditions. In water depth over 2 m, submerged terrestrial sediments are in a state of thermal dis-equilibrium which causes their rapid thaw. Ice-rich sediments or sediments containing massive ground ice are prone to development of thermokarst, leading to substantial thaw settlement. Additional geotechnical concerns in onshore areas include landslides and frost heave.

[1] Terrain Sciences Division

SEA ICE PALEOCLIMATE DERIVED FROM BOWHEAD WHALES AND DRIFTWOOD, CENTRAL AND EASTERN CANADIAN ARCTIC

A.S. Dyke[1], T.F. Morris[2], J. Hooper[3]

Raised beaches in the central and eastern Arctic contain records of extensions and retractions in the range of whales over the last 10 000 years. In the central Arctic, whales were abundant between 10 500 and 8500 BP, including the interval of deglaciation, were nearly absent 8500 to 5000 BP, due to summer sea ice conditions, reoccupied the area 5000 to 3000 BP, and were again excluded during the last 3000 years, the Neoglacial. Penetration of driftwood to the same area was at a maximum during the Neoglacial; hence driftwood penetration is not a reliable paleoclimate indicator.

In the eastern Arctic, Bowhead fossils occur in unprecedented abundance, but the region is devoid of driftwood. On emerging coasts, whale bones are moderately abundant in high level beaches (early Holocene), absent in the middle range, and very abundant at lower levels, diminishing in beaches of Neoglacial age. The record is truncated on submerging coasts.

[1] Terrain Sciences Division
[2] Ontario Geological Survey, Toronto
[3] Memorial University of Newfoundland, St. John's

PLANT DISTRIBUTION INDICATORS OF POTENTIAL TERRAIN INSTABILITY, ELLESMERE ISLAND, N.W.T.

S.A. Edlund[1], B.T. Alt[1], D.G. Harry[1], B.H. Luckman

In late July and August, 1988 numerous active-layer detachment slides occurred along a 5 km stretch of Hot Weather Creek, Fosheim Peninsula, Ellesmere Island. Activation relates to meltwater generated by summer melting of subsurface ground ice; no precipitation events are associated with these features. Vegetation indicators such as small wetland communities and denser shrub communities are the only surface manifestation of thaw sensitive terrain underlain by massive ground ice. In 1988, the magnitude of late-summer ground ice melt may have been exceptional. Dried-up creeks and tundra ponds were recharged and a large number of active-layer detachment slides were triggered. However, seemingly anomalous vegetation patterns suggest that subsurface water is regularly available in late summer. These vegetation patterns provide a potential means to identify such areas of thaw sensitive terrain.

[1] Terrain Sciences Division

MARINE GEOLOGICAL CONSTRAINTS TO THE NORTHUMBERLAND STRAIT FIXED CROSSING

G.B.J. Fader[1]

Recent surveys of the marine geology of the central part of Northumberland Strait in the area of the proposed fixed link crossing between New Brunswick and Prince Edward Island have identified the presence of dynamic seabed conditions and other seabed features not previously known. Earlier marine surveys identified the major surficial formations but did not address the dynamics of seabed sediments. This recent study was undertaken with high resolution seismic reflection profilers together with a 100khz sidescan sonar system and seabed samplers. These data indicate the presence of sand ribbons, sand waves, 2- and 3-dimensional megaripples, comet marks, and areas of boulders and outcropping bedrock. In the nearshore, linear depressions occur which may represent present day ice scouring of the seabed. The presence of the bedforms suggests that the seabed of the Strait is much more dynamic than previously thought. The amount of sediment transport and the direction will impact on the foundation design of the proposed crossing structure. Seismic reflection information clearly defines the unconformity at the bedrock surface and provides thicknesses for the overlying surficial formations. The regional distribution of bedforms and other seabed features including examples of sidescan sonograms is presented.

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AERIAL OBLIQUE VIDEO: A TOOL FOR MULTI-DISCIPLINARY COASTAL ENVIRONMENTAL STUDIES

D. Frobel[1], R.B. Taylor[1], D.L. Forbes[1]

At the Atlantic Geoscience Centre (AGC), video tape recording equipment has been used to obtain continuous, aerial oblique video coverage of more than 7300 km (61h) of Canada's Arctic and Atlantic coastlines. The tapes include commentary that adds navigational control, and provides detailed field observations that supplement the visual information. Geological Survey of Canada open files of a portion of this material cover parts of the Arctic Archipelago, the Beaufort Sea, western Newfoundland and the New Brunswick coast.

The tapes include a wide variety of coastal environments ranging from the ice-affected shores of the Arctic to aquaculture sites in Passamaquoddy Bay, N.B. For our purposes, as coastal geologists, the tapes are considered a type of audio/visual field note that provide baseline reconnaissance information. They form reference material for a variety of concerns including oil spill contingency planning, engineering evaluations for harbour development and pipeline landfall sites, coastal hazard assessment, national parks resource planning, monitoring of aquaculture operations, coastal mapping and educational and public relations purposes. The major users of these open files, outside of our own group, have been universities, oil companies and other government agencies.

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WESTERN CANADIAN COALS: A CLEAN, SAFE AND SECURE FUEL CHOICE

F. Goodarzi[1], G.G. Smith[1]

Coal-fired plants produce the vast majority of electricity generated in Alberta (90%) and Saskatchewan (75%). These generating stations and associated mines are located near some of Canada's prime agricultural lands. Environments surrounding these major coal developments are, apparently, not adversely affected by the coal production and utilization activities. The expanded use of Western Canadian coals in Canada and around the world can help coal users to meet increasingly stricter environmental standards. As technological advances widen the scope of acceptable uses of coal in the coming decades, the diverse inventory of coals in Western Canada will continue to provide a broad basis of choice in selecting a safe, environmentally acceptable and economical fuel.

The term "coal" is applied to rocks having significantly different properties. Variation in chemical composition and physical properties of coal relates, fundamentally, to environment of deposition, original type of peat-forming vegetal debris, degree of organic maturation, structural deformation, mineralization and extent of weathering. The concentration of various minor and trace elements in coals is becoming an increasingly important factor in the selection of an optimum coal for a particular use.

1 Institute of Sedimentary and Petroleum Geology, Calgary

FORMATION OF MASSIVE SULPHIDES IN A SEDIMENTED RIFT, MIDDLE VALLEY, NORTHERN JUAN DE FUCA RIDGE: IMPLICATIONS FOR ANCIENT EXHALATIVE SULPHIDE DEPOSITS

W.D. Goodfellow[1], K. Grapes[1], G.M. LeCheminant

Middle Valley is a sedimented rift valley at the northern end of the Juan de Fuca Ridge. Within the valley, two areas with anomalously high heat flow are actively venting hydrothermal fluids from sulphide chimneys. In one area, a sulphide mound 60 m high and 300 m across has formed by prolonged hydrothermal discharge; the second area is represented by clusters of chimneys that are rooted in hydrothermally altered sediment. The top 10 m of the mound is represented by collapsed sulphide chimneys and sedimentary breccias that have been replaced and infilled by mostly sulphides, and hydrothermally altered sediment. Compared to sulphides that occur at sediment-bare ridges, Middle Valley deposits are fewer in number, larger and have probably formed over a longer time-span. The low thermal conductivity of the sedimentary pile reduces conductive heat loss thereby prolonging hydrothermal activity; the low permeability focusses discharge at long-lived vents. These observations of deposits now forming in Middle Valley may explain why ancient exhalative sulphide deposits associated with sediments are on average an order of magnitude larger than deposits hosted entirely within volcanic sequences.

1 Mineral Resources Division

LARGE-SCALE SAGGING ROCK SLOPES IN WESTERN NEWFOUNDLAND AS A CAUSE OF LANDSLIDES, WITH PARTICULAR REFERENCE TO GROS MORNE NATIONAL PARK

D.R. Grant[1]

Surficial mapping reveals that 100 huge segments of 300-700 m cliffs are failing by slow deep-seated gravitational creep. Called sags or sagging slopes, groups of megablocks or slices on 30°-90° slopes in all rock types are slumping along orthogonal sets of listric normal faults, producing crestal scarps up to 200 m high and tension fissures that tilt trees and tear peat cover. The outer edges fail as landslides; those adjacent to water bodies in public areas require risk management. Sags are correcting oversteepening caused by glacial, marine and fluvial erosion. A few are preglacial; most began as glacier support withdrew. Volumes average about 10^7 m^3 (dimensions: more than 1 km long, 100-500 m wide, 100-300 m deep; the largest is 6x2x0.6 km = 10^9 m^3). There is no apparent preferred lithology, rock fabric, or slope type and age. As most are in thin thrust sheets, structural geometry may have focused regional compressive stress.

1 Terrain Sciences Division

REFLECTION PROFILES OVER HIGH GRADE METAMORPHIC TERRANES: KAPUSKASING STRUCTURE, GRENVILLE FRONT AND VALHALLA COMPLEX

A.G. Green[1], B. Milkereit[1], A. Davidson[1], J.A. Percival[1], R.R. Parrish[1], F.A. Cook[2], W.T. Geiss[2], W. Cannon[3], D. Hutchinson[3], G.F. West[4], R. Clowes[5]

The westernmost line of the Cordillera transect crossed the Valhalla Dome, a metamorphic core complex buried by easterly transported exotic terranes in Jurassic-Cretaceous times and brought to shallow depths during an extensional event in the Tertiary. A GLIMPCE profile in 1986 across the Grenville Front and Orogen recorded structures buried and exhumed during various phases of Middle Proterozoic thrust tectonism. Finally, several profiles in 1987-88 crossed the Kapuskasing Structure, which exposes middle to lower crustal rocks affected by widespread extension in the Archean and a major intra-plate thrust event sometime in the Early to Middle Proterozoic. In all three data sets, layered reflections have a variety of origins, but are most often associated with velocity discontinuities at highly strained contacts between gneissic rocks of varying lithologies. Particularly strong reflections originate from zones of mylonite and cataclasis. Rocks are so deformed in parts of these three diverse terranes that "layering" created by extreme attenuation and plastic flow has yielded seismic images resembling stratified sedimentary units. We suggest that certain types of gneissic rock may be a common source of layered reflections from the deep crust, with reflections originating from lithological boundaries and mylonite zones within the gneiss.

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INTEGRATED GEOPHYSICAL LITHOPROBE STUDIES OF THE KAPUSKASING STRUCTURE

A.G. Green[1], B. Milkereit[1], J.A. Percival[1], R.D. Kurtz[1], H.J. Broome[1], G.F. West[2], F.A. Cook[3], R.M. Ellis[4], A.V. Boland[4]

Preliminary results of studies across the Kapuskasing Structural Zone (KSZ) include:

(a) No major electrical conductivity anomalies are associated with the lower crustal rocks exposed within the KSZ. Instead, the high grade rocks of the KSZ seem to be particularly resistive and are underlain by a mid-crustal conductivity anomaly. The zone of high electrical conductivity, at a depth of about 25 km, extends uninterrupted from the Abitibi granite/greenstone belt beneath the KSZ to the Wawa gneiss dome.

(b) The crust under the KSZ is thickened relative to adjacent regions by 5 to 10 km.

(c) High velocity material (>6.6 km/s) can be traced dipping westwards from surface outcrop within the KSZ to depths of approximately 15 km. The velocity structure is relatively flat at depths greater than about 25 km.

(d) Strong seismic reflections, recorded from the Ivanhoe Lake Cataclastic zone, seem to flatten at a depth of 12 to 15 km, where they merge with a thick zone of reflections that extend to the eastern limit of the survey.

(e) The reflectivity of the middle to lower crust is highly variable throughout the KSZ and adjacent regions. In particular, there seems to be no simple unifying seismic response associated with the transition from the Abitibi granite/greenstone belt to the KSZ.

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THE CANADIAN GEOPHYSICAL ATLAS

R.A.F. Grieve[1], J. Adams[1], A.K. Goodacre[1], L. Newitt[1], D.J. Teskey[1]

The Canadian Geophysical Atlas is intended to display data from national databases containing outputs of the geophysical mapping programs of the Survey. The maps are of value in synoptic studies of the crustal structure of Canada. To date, five Canada-wide gravity maps at a scale of 1:10 000 000 have been published. These maps: observed gravity, free air anomaly, Bouguer anomaly, horizontal gradient of Bouguer anomaly and isostatic anomaly represent increasing complexity of data processing and emphasize different aspects of the Canadian gravity field. The derivation and some indication of the utility of each map is summarized by marginal notes. Other maps: vertical gradient of Bouguer gravity anomaly, gravimetric geoid, total field magnetic anomaly, vertical gradient, shaded relief, and upward continued magnetic field are currently at the plot or proof stage and will be printed soon. Other maps, emphasizing various aspects of the geomagnetic and seismic nature of Canada, are planned.

1 Geophysics Division

GLOBAL CHANGE IMPLICATIONS OF GROUND ICE DISTRIBUTION IN THE TUKTOYAKTUK COASTLANDS, N.W.T.

D.G. Harry[1], S.R. Dallimore[1], P.J. Kurfurst[1]

Ground ice forms a major component of the unconsolidated Quaternary deposits which underlie the Tuktoyaktuk Coastlands. It occurs in the form of pore ice, wedge ice, segregation/intrusion ice and bodies of buried glacier ice. Discrete bodies of massive ice up to 30 m in thickness and greater than 1 km^2 in area have been identified by stratigraphic and geophysical investigations. The distribution of ground ice will form a primary control on terrain process during the climatic warming predicted to occur in association with global environmental change. Thaw of ice-bearing sediments will lead to surface settlement and slope instability, forming extensive thermokarst terrain similar to that developed during earlier Holocene warm intervals. In the coastal zone, a combination of permafrost degradation and rising sea level may lead to accelerated rates of coastal erosion. These processes will have a major impact upon both present and planned resource development in the Beaufort Sea region of northern Canada.

1 Terrain Sciences Division

TECTONIC HISTORY OF THE FOXE-RINKIAN BELT IN CENTRAL BAFFIN ISLAND, N.W.T.

J.R. Henderson[1], J. Grocott[2], M.N. Henderson[3], S. Perreault[4]

The stratigraphy throughout the belt comprises a lower platformal facies (carbonate, quartzite, pelite) overlain by a basinal turbiditic flysch facies. An assemblage of mafic-ultramafic flows, sills, epiclastic and chemical rocks is locally abundant at the bottom of the basinal facies in Baffin Island and west Greenland. Rocks of biotite grade are exposed in the Dewar Lakes area of central Baffin Island, where two episodes of low P-high T metamorphism, and three periods of regional deformation are defined. The first metamorphism (M_1), uniformly sillimanite-grade and recognized only in the lower metapelite-quartzite assemblage, occurs over hundreds of km^2. The second metamorphism (M_2) affects the entire supracrustal sequence, and increases progressively southward from biotite to migmatite grade. The first deformation and metamorphism were contemporaneous; D_1 recumbent-fold axes trend E-W, but the kinematics are unclear. D_2 north-directed transport accompanied M_2. Elliptical Archean-basement-cored domes characterizing D_3 are compressional features.

1 Lithosphere and Canadian Shield Division
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ACTION OF SEA ICE ON THE SUBLITTORAL BOTTOM SEDIMENTS OF THE CANADIAN BEAUFORT SEA

A. Héquette[1]

The Canadian Beaufort Sea is covered by pack ice for almost nine months of the year. Ice pressure ridges come in contact with the unconsolidated sediments of the continental shelf, cutting trenches (some several metres long) and reworking the sediments. The study of offshore bathymetric variations at a site in the southeast Beaufort Sea has revealed substantial erosion since 1971 (as much as 1 m in places) at depths between 12 and 15 m, caused essentially by marine ice, as indicated by sidescan sonar recordings. Ice pressure processes also contribute to accretion measured between depths of 5 and 9 m.

1 Atlantic Geoscience Centre, Dartmouth

AEROMAGNETIC SURVEY OF THE GREAT LAKES, 1981-87

P.J. Hood[1], D.J. Teskey[1], D.G. Olson[1], K.W. Anderson[1], I. Butt[1], A.J. Dicaire[1], S.D. Dods[1], T.R. Flint[1], H.W.C. Knapp[1], L.D.H. Lawley[1], P. Sawatzky[1]

In 1981, an aeromagnetic survey of the lakes Ontario, Erie and Huron was commenced as a Canadian contribution to the Magnetic Anomaly Map of North America and this included the US portion of the lakes by arrangement with the US Geological Survey. The GSC Queenair aeromagnetic survey aircraft, was utilized and the basic specifications were a 1 km flight line spacing and a 305 m flying height commensurate with those for the rest of the country. The prime navigation aid was Loran C. With the setting up of the Great Lakes International Multidisciplinary Program on Crustal Evolution (GLIMPCE), the program was extended in 1987 to Lake Superior. Thus over 160 000 line km were flown in the 7 field seasons of 1981-87 by the GSC Queenair survey team consisting of D.G. Olson, P. Sawatzky, A. Dicaire, T.R. Flint, H. Knapp and L. Lawley and the results were compiled by the Aeromagnetic Data Processing Section consisting of K. Anderson, S.D. Dods, I. Butt and L. Lawley.

It is clear from the maps presented that a number of interesting geological features have been delineated. These include the locus of the Grenville Front that crosses Georgian Bay and the southern part of Lake Huron. The Isle Royale fault in Lake Superior is sharply defined indicative of the fact that it is a marginal thrust fault that forms the boundary fault for the rifted Lake Superior Basin.

1 Geophysics Division

SOME APPLICATIONS OF REGIONAL GEOCHEMICAL DRAINAGE SURVEYS TO ENVIRONMENTAL AND PUBLIC HEALTH CONCERNS

E.H.W. Hornbrook[1], P.W.B. Friske[1], M. McCurdy[1]

Nationally systematic regional stream and lake sediment and water surveys carried out under the National Geochemical Reconnaissance (NGR) program are undertaken using an established methodology with well defined specifications for the collection, preparation, analysis and publication of data to provide a systematic, coast to coast geochemical data base. Areal coverage to 1988, represented by 170 000 sites, amounts to approximately 2 million km^2.

With these data, examples will be shown of the extent of natural variation in pH and selected elements related to various bedrock and surficial environments across Canada. Alkalinity, pH and related data will also be used to demonstrate a given area's response to the impact of acidic deposition. The occurrence of elevated levels of toxic elements in lake sediments southwest of Thunder Bay, Ontario, will be related to the bedrock geology and the physico-chemical conditions of the drainage regime. Comparison of data from selected areas throughout Canada will be made to demonstrate that "natural" concentrations of some elements in the surficial environment can be of the same order of magnitude as levels related to pollution.

[1] Mineral Resources Division

ROLE OF NATURAL GEOCHEMISTRY OF LAKES AND GLACIAL SEDIMENTS IN INDICATING SENSITIVITY OF CANADIAN SHIELD TERRAIN TO ACID RAIN

E.H.W. Hornbrook[1], I.M. Kettles[2], W.W. Shilts[2]

Lake water and sediment samples from approximately 2200 lakes and glacial (sub-solum) samples from about 1800 sites were collected throughout a 38 000 km^2 rectangular area extending from Georgian Bay east to the Ottawa and St. Lawrence rivers in Ontario. Lake water alkalinity and pH patterns are similar to the distribution of carbonate components in glacial drift. Carbonate-rich drift derived from Paleozoic limestone has been dispersed across a variety of non-calcareous metasedimentary and igneous rocks of the Canadian Shield, providing buffering capacity to lakes situated in granitic terrain. Although composition of the drift is generally reflected by lake geochemistry, post depositional processes can cause significant variations between patterns derived from the two sample types. Anions and cations such as SO_4, Cl^-, Na^+, and F^- exhibit concentration patterns thought to reflect both anthropogenic inputs and natural variations due to differences in the geology.

[1] Mineral Resources Division
[2] Terrain Sciences Division

UPPER PALEOZOIC EVAPORITES OF SOUTHEASTERN CANADA

R.D. Howie[1]

The Paleozoic fold belt in Atlantic Canada forms the northeastern part of the Appalachian region of North America. During the waning stages of the Middle Paleozoic Acadian orogeny, folding, faulting, uplift and granitic intrusion occurred. The highly fractured basement subsided forming a complex series of northeast-trending horst and graben structures. In this area of regional downwarp, evaporite deposits of two ages were deposited. Minor salt deposits containing glauberite accumulated locally and are preserved as part of continental sequences in local playa like deposits known as the Horton Group rocks (late Tournaisian to early Visean) while the overlying Windsor Group (middle to late Visean) contains thick deposits of salt.

Temporary tectonic stability, abnormally high temperatures, a nearly land-locked marine setting and semiarid conditions resulted in the rhythmic deposition of Windsor Group evaporites over a wide area. The salt occurs as bedded deposits or within flow structures that vary in thickness from a few centimetres to over 4573 m in structurally thickened sections. The variation in local thickness of these rocks is a function of both environment of deposition and tectonism. In some areas the salt is pure enough to be mined and, locally, contains significant amounts of potash. Some of these mines have the potential for development of underground storage sites for hydrocarbons and industrial waste.

[1] Atlantic Geoscience Centre, Dartmouth

PLATINUM GROUP ELEMENT MINERALIZATION IN THE MUSKOX INTRUSION, N.W.T.

L.J. Hulbert[1]

Platinum-group element enrichments are found in the marginal zone and the main chromitite reef of the Muskox Intrusion.

The main chromitite reef superficially resembles chromitites from the upper critical zone of the Bushveld Complex; especially the UG2 chromitite. However, the platinum-group element grade and ratios, the concentration of base metals, and the isotopic signature of the sulphur differ significantly.

Numerous areas of Cu-Ni sulphide mineralization have been examined in the marginal zone of the intrusion. Platinum-group element assays in excess of 100 ppm have been recorded within this zone. Preliminary geochemical and isotopic analyses suggest that the highest PGE grades and degree of crustal sulphur contamination occur in the eastern portion of the intrusion. A pronounced As, Sb and Se geochemical signature distinguishes the platinum-group element enriched Cu-Ni sulphides.

[1] Mineral Resources Division

DEVELOPMENT OF GEOPHYSICAL INSTRUMENTATION AND TECHNIQUES FOR TERRAIN SCIENCES APPLICATIONS

J.A. Hunter[1], A.S. Judge[1], S.E. Pullan[1], M.M. Burgess[1], J.A. Pilon[1], V.S. Allen[1], R.A. Burns[1], R.L. Good[1] and R.M. Gagné[1]

Geophysicists from the Terrain Dynamics Subdivision are involved in applied research to delineate physical properties of earth materials in the third dimension as an aid to geotechnical engineering, groundwater and stratigraphic mapping problems. Many developments are northern oriented. Instrumentation and techniques under development for permafrost and related problems include:

1. dataloggers for remote temperature data acquisition;
2. down-hole, light-weight, helicopter transported, continuous high-pressure temperature logging tool;
3. deep-sounding, ground-probing radar for mapping ground-ice configuration;
4. deep-towed, marine refraction seismic system for mapping sub-seabottom ice-bearing permafrost;
5. under-ice vertical refraction seismic array for seabottom gas hydrate studies;
6. under-ice, seabottom 3-component geophone for measuring shear wave properties of seabottom permafrost;

Other applied geophysics developments include:

1. assistance in the development of a commercial Canadian engineering seismograph;

2. development of a shallow seismic reflection technique for overburden mapping;

3. development of ground-probing radar field techniques for shallow stratigraphic mapping.

[1] Terrain Sciences Division

VANCOUVER ISLAND ACCRETIONARY SEDIMENTARY PRISM

R.D. Hyndman[1], C.J. Yorath[1], E.E. Davis[1], K.M. Rohr[1], L.K. Law

Along the margin of Vancouver Island the Juan de Fuca plate has been underthrusting the continent since the Eocene. A large accretionary wedge has been formed from the scraping off of the thick incoming clastic sequence. On the continental shelf the less deformed Tofino Basin sediments have been deposited on the seaward accreting wedge. Study of this margin has three objectives:

1. To provide a modern framework within which the petroleum potential of this region may be assessed. Exploration conducted in the 1960's was based on stabilist concepts that limited the interpretation of exploration data.

2. To provide data from an actively deforming sedimentary wedge that has applicability in understanding the formation processes and structures of ancient fold and thrust belts such as the Alberta foothills.

3. To provide deep pore pressure and temperature estimates that will constrain the occurrence and size of major ('megathrust') earthquakes on the subduction thrust zone.

A proposal has been submitted to the International Ocean Drilling Program (ODP) for drilling a series of deep sea holes across this margin, to address sediment accretion processes in subduction zones.

[1] Cordilleran and Pacific Geoscience Centre, Vancouver

QUATERNARY VULCANISM AND FAULTING, FORT SELKIRK AREA, YUKON

L.E. Jackson, Jr.[1]

A volcanic edifice near Fort Selkirk, Yukon is almost entirely composed of hyaloclastite tuffs, breccias, and pillow breccias. Pillow basalt is found near the summit of the mountain. All of these lithologies contain rounded and faceted erratic pebbles. These observations, plus the gentle slopes of the mountain, indicate that it erupted beneath an ice sheet. Since deposits of the Reid Glaciation only reach the base of the mountain, the eruption must have occurred during a pre-Reid glaciation. Faulting may have occurred beneath the north end of the mountain during the Pleistocene

[1] Terrain Sciences Division

PALEOCLIMATIC CHANGES IN THE UPPER CRETACEOUS DINOSAUR BEDS OF WESTERN CANADA AND MONGOLIA

T. Jerzykiewicz[1]

Paleoclimatic variations in the Western Canada Sedimentary Basin are expressed by the distribution of climatically sensitive sediments, i.e. coal and caliche, and by changes in the drainage systems. The extent of the semiarid floodplain facies and ephemeral channels is limited to the southern part of the basin. No signs of caliche have been found in the central part of the basin. Instead, some of the floodplain deposits associated with meandering rivers in this part of the basin contain economic coal. Climatic differences between the humid central part and the drier southern part of the basin cannot be explained by the position of the sea shore or by orographic influences alone. There was another external factor, i.e. the pattern of atmospheric circulation, such as that responsible for the present-day climatic differences existing between the southern and central part of the basin. The climatic impact on sedimentation is recorded in the Mongolian Basin by changes of the drainage systems from an internal, semi-desert type in the Santonian-Campanian into a permanent one composed of high-sinuosity meandering rivers and lakes in the Maastrichtian. This affected dinosaur habitat (semi-desert environment supported only small to medium-sized animals while large dinosaurs inhabited the fluvio-lacustrine environment) and produced favourable coal-forming environments.

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ELECTROMAGNETIC INVESTIGATIONS OVER THE SOUTHEASTERN BRITISH COLUMBIA LITHOPROBE TRANSECT

A.G. Jones[1], R.D. Kurtz[1], D.E. Boerner[1]

As part of the LITHOPROBE Southern Cordilleran Transect investigations, a novel combination of Controlled Source Audio Magneto Telluric (CSAMT) and natural-source ElectroMagnetic Array Profiling (EMAP) surveys were performed successfully during October 1988. The EM profiles cover the western half of the Nelson Batholith and were designed to answer questions raised by the interpretation of 1987 magneto telluric (MT) data. As this is the only location known to the authors where the lower crust is seismically transparent but electrically conductive, these detailed surveys have major significance to our understanding of the lower crust's composition and state. Combining the CSAMT and EMAP surveys should also provide a clearer understanding of static shift effects as well as a more precise "image" of the geoelectric structure by possibly mapping the base of the batholith and the Slocan Lake Fault, a major Eocene extensional fault interpreted from seismic data to cut through the whole crust and offset the Moho. Preliminary results of both surveys will be presented.

[1] Lithosphere and Canadian Shield Division

GROUND TEMPERATURE AND CLIMATE CHANGE: EXAMPLES FROM NORTHWEST CANADA

A.S. Judge[1], A.E. Taylor[1], D. Allen[2]

The thermal regime of the Earth is a delicate balance between the incoming solar radiation and the Earth's internal heat. Climate essentially determines the surface temperature, whereas the subsurface rise in temperature with depth, the geothermal gradient, is determined by the geologic materials and the internal heat flux. Temporal changes in surface temperature, whether due to climate change, sea-level variation or glacial/interglacial surface conditions are reflected in subsurface temperatures. The geothermal gradient contains a "recollection" of the surface temperature history which can be unravelled from precise temperature measurements in wells as shown in two examples. Deep wells in the Mackenzie Delta are used to reconstruct the glacial history of the past 75 000 years and to reveal early and late Wisconsinan episodes of surface temperature 10°K lower than present. In contrast, shorter wells in the Mackenzie Valley indicate 2°K increases of surface temperature in the past 80 years.

[1] Terrain Sciences Division
[2] Department of Earth Sciences, Carleton University, Ottawa

CONTAMINANT MIGRATION AND CONTAINMENT CHARACTERISTICS OF ROCKS

T.J. Katsube[1]

Contaminants will migrate through rocks even though they appear to be very tight and impermeable. The distance of migration in 30 years can vary from a few centimetres to hundreds of metres, depending on the rock type and transport mechanism involved.

Pores in rocks consist of connecting pores that contribute to the migration, and pocket pores that retard migration and contribute to storage of the contaminants. The magnitude of pore space or the relationship between connecting and pocket pores vary with rock type and other geological conditions.

Petrophysical data on sandstones is abundant, due to its significance in the petroleum industry. Therefore, there is no problem in characterizing these rocks in terms of their contaminant migration and containment characteristics. There exists some petrophysical data for crystalline rocks, mainly granites. Petrophysical data on other rock types is almost non-existent. In addition, the public knowledge on fluid or ionic migration and containment characteristics is extremely poor. Therefore, the GSC has at its disposal petrophysical data on a wide range of Canadian rocks which could be made available to the public.

[1] Mineral Resources Division

MODERN CONTINENTAL MARGINS OF EASTERN CANADA: DEEP SEISMIC REFLECTION PROFILING

C.E. Keen[1], W.A. Kay[1]

Recent deep seismic reflection profiling has established the diverse tectonic character of the modern continental margin of Eastern Canada. Southeast of Newfoundland, deep reflection data show a highly reflective lower continental crust thinning towards the margin. To the north on the eastern Grand Banks, the deep crust is again characterized by high reflectivity and rapid crustal thinning near the margin. Unlike the transform margin to the south however, the transition from continental to oceanic crust is more gradual.

The deep structure of the conjugate margins of the Goban Spur and northeast Flemish Cap regions have been delineated, and the pre-Atlantic rift system restored along a crustal cross-section based on deep seismic data from both margins. This shows that the rift was symmetric, and later broke on the western side to create the present asymmetric margins.

Seismic data reveals the presence of an extremely broad sedimentary basin northeast of Newfoundland which appears to have formed by lithospheric stretching, and a décollement zone between the upper brittle crust and the lower ductile lithosphere. In contrast the Mesozoic basins on the Grand Banks are narrow, half graben which are bounded by deep, single (?) basin bounding master faults.

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DEFORMATION AND PLUTONISM IN THE CENTRAL SLAVE PROVINCE, N.W.T.: IMPLICATIONS FOR GOLD EXPLORATION

J.E. King[1], C. Relf[2], W.J. Davis[3], O. van Breemen[1]

Earliest magmatism (2670-2650 Ma) preserved in the Contwoyto Lake area includes mafic to intermediate volcanism, hornblende gabbro, porphyritic granodiorite (locally associated with Cu-Mo mineralization) and biotite tonalite. A second major magmatic episode (2615-2585 Ma) comprises biotite-hornblende-diorite, biotite tonalite, leucotonalite, and biotite (+/- muscovite) granodiorite to syenogranite. In the 35 Ma between major magmatic episodes, extensive turbiditic (Itchen and Contwoyto Formations) and minor volcaniclastic rocks were deposited and D_1 folding and cleavage formation occurred. Intense refolding, cleavage formation and faulting (D_2) occurred concurrently with the onset of the second major magmatic episode. Low-P / high-T regional contact metamorphism accompanied the second magmatic episode. NE-trending cross folding (D_3) postdates the youngest Archean intrusions and is late-synmetamorphic. NW-trending cross folds (D_4) postdate D_2 but otherwise are not well constrained in time. Gold-mineralized iron formations are involved in the complex fold interference patterns that result from F_1, F_2, F_3 superposition. Quartz veins associated with gold-arsenopyrite mineralization developed late-syn-D_2.

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ARCTIC ICE AND SNOW CHEMISTRY: A RECORD OF NATURAL AND ANTHROPOGENIC POLLUTANTS

R.M. Koerner[1], R.J. Dubey[1], M. Parnandi[1]

Because the snow never melts completely in the upper regions of Arctic ice caps it preserves a record of the gases and aerosols that are trapped as the snow accumulates. In the Canadian Arctic the record is 100 000 years long.

The glaciology section of Terrain Sciences Division is measuring the concentration of ions, micro-particles and volcanic deposits in Arctic ice cores. These measurements show unusually high levels of micro-particles and certain ions in late glacial snows. However, they also show that the levels of certain ions (and acidity) have been increasing since at least the early 1930's. The levels vary seasonally with high 'pollutant' levels each spring. It is these spring peaks that have shown the most marked increase this century.

[1] Terrain Sciences Division

GEOSCAN: YOUR WINDOW ON CANADIAN GEO-SCIENCE INFORMATION

A.G. Kopf-Johnson[1], B. Blair[1], J. Caron[1]

GEOSCAN is a data base which provides bibliographic, geographic and subject access to publicly available geoscience literature concerning the Canadian landmass and offshore regions. This bibliographic data system is cooperatively produced from the indexing contributions of fifteen federal, provincial, academic and professional geoscience organizations located throughout Canada. The Geological Survey of Canada coordinates these indexing activities and provides computer resources in support of this project.

GEOSCAN presently contains over 120 000 bibliographic records and approximately 7500 new records are added to the data base each year. Subject analysis and indexing is performed by geologists and a standardized methodology is maintained through use of a thesaurus, controlled authority files and detailed indexing documentation. Document types covered in GEOSCAN include published serials, periodicals, theses, published and unpublished maps, open files and mineral assessment reports. Coverage is strongest for government produced literature and mineral assessment reports and overlap with other geoscience data bases is minimal.

[1] Geoscience Information Division

STRUCTURAL ELEMENTS OF THE TRANS- HUDSON OROGEN: A GRAVITY AND MAGNETIC INTERPRETATION

L.J. Kornik[1], M.D. Thomas[1]

The Proterozoic Trans-Hudson orogen extends 2800 km from South Dakota to northern Hudson Bay, but is exposed for only 500 km in the Canadian Shield. Various gravity and magnetic maps are used, therefore, to delineate the boundaries and internal structures of the orogen; subdivision into 5 first order structural domains is proposed. The northernmost, characterized by N to NE trends, occupies most of Hudson Bay. It is dextrally offset several 100 km from the three southernmost domains along a narrow WNW-trending domain (WNW trends), which probably originated as a transform fault in the spreading Trans-Hudson ocean. The next 2 domains to the south are subparallel, N-trending, dominated by N trends and share a boundary near the Tabberror fault. They are separated from the southernmost domain by an interpreted major fault. In Hudson Bay, E-W symmetry of Bouguer gravity anomalies in the northernmost domain suggests a picture of collisional sutures along the western and eastern boundaries of the orogen. Late faulting crossing domain boundaries is suggested by patterns of magnetic anomalies in Hudson Bay.

[1] Lithosphere and Canadian Shield Division

CRUSTAL DEFORMATION MEASUREMENTS BY SATELLITE TECHNIQUES ON CANADA'S WEST COAST

J. Kouba[1], H. Dragert[2]

Global Positioning System (GPS) is being used to study crustal deformations on central Vancouver Island in conjunction with conventional electronic distance measurements (EDM). The initial GPS survey in the Port Alberni region was conducted by the Geodetic Survey of Canada between August 20, 1986 and August 29, 1986. A network of 11 stations was observed with four TI4100 receivers in 10 daily sessions. The observed baselines varied from 18 km to 116 km in length with a maximum height difference of 1700 m. The GPS phase observations have been used in a multiparameter solution which includes meticulous modelling of GPS atmospheric, orbital and instrumental errors. A comparison with simultaneous EDM baseline determinations shows agreement at the 0.5 ppm precision level which is consistent with the formal relative accuracy of the EDM survey. Given that current strain accumulation at the west coast of Vancouver Island has been estimated at 0.15 to 0.3 ppm per year, these results indicate that the GPS satellite technique has the potential to observe crustal strain on Vancouver Island over a decade with observations repeated at three to five year intervals.

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THE MOREL SILLS OF EASTERN WOPMAY OROGEN, N.W.T.: AN EXAMPLE OF IN SITU FRACTIONATION

A.E. Lalonde[1]

The Morel sills comprise a regional swarm of gabbroic sills intruded within both autochthonous and allochthonous sedimentary rocks of the early Proterozoic Coronation Supergroup in Wopmay orogen. They are bedding-concordant sheets of pigeonite gabbro, 150 to 200 m thick, with glassy margins at both roof and floor. Evidence of incipient fractionation comes from the localized occurrence of miarolitic cavities and granophyric gabbro near the roof. Detailed compositional sections of one sill reveal decreasing abundances of MgO, Ni and Cr upwards with concomitant increase in total Fe. Slight differences in the REE abundances of the chilled margins and the centre of the sills reflect minor in situ fractionation easily modeled by pigeonite and plagioclase crystallization. Chilled margins from widely separated localities have identical bulk compositions and REE distributions characterized by strong LREE-enrichment. The unusual LREE-enrichment suggests contamination of the magmas by crustal material during uprise.

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MEASUREMENT OF POSTGLACIAL MOVEMENTS BY GRAVITY AND SPACE TECHNIQUES

A. Lambert[1]

Post-glacial vertical movement of the land with respect to sea-level in the region formerly covered by the Laurentide Ice Sheet has been traditionally derived from the results of field research and radiocarbon dating of material in littoral sediments carried out by the GSC and other institutions over the last few decades. New gravimetric and space-based positioning techniques are now being used to improve the estimates of present day rates of vertical movement and to distinguish global sea-level effects from regional effects. The technique of absolute gravimetry can detect a relative change of 2-3 microgals which is the change in gravity expected to occur annually in the Hudson Bay area as a result of post-glacial movement. This technique will be combined with measurements of position using a combination of techniques involving Very Long Baseline Interferometry (VLBI), the Global Positioning System (GPS) and the Geodynamics Laser Ranging System (GLRS). A network of twelve stations is being established in eastern and arctic Canada to monitor the post-glacial rebound effects. It is expected that annual measurements over a period of five to ten years will be required to delineate the pattern of gravity and height change associated with the adjustment of the Earth to glacial unloading.

[1] Geophysics Division

MAFIC DYKE SWARMS OF THE CAMERON AND BEAULIEU RIVER VOLCANIC BELTS, SLAVE PROVINCE, N.W.T.

M.B. Lambert[1], R.E. Ernst[2]

Dense swarms of Archean mafic dykes and sills intrude and relate to the volcanism that formed these greenstone belts. Swarms of density up to 80% in adjacent granitoid basement do not cross the complex shear zones that separate the volcanic and granitoid terranes.

The densest of these swarms is the NNW trending, 3 by 20+ km Step'nduck dyke complex which comprises mainly meta-diabasic to – gabbroic dykes separated by screens of granitic gneiss and minor volcanic flows. It contains about 350 mainly parallel dykes, forming solitary units (0.05-35 m wide) and multiple intrusions (clusters of 100% dykes consisting of up to 15 members that range up to 200 m wide). The dykes represent a 1800 m extension of a granitic gneiss that was originally 1200 m wide.

The Step'nduck Lake dyke swarm, which records profuse penecontemporaneous injections of mafic magmas into extended granitoid crust, is not analogous to a sheeted dyke complex of an ophiolite.

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SEISMICITY AND GEOPHYSICAL CHARACTERISTICS OF THE LOWER ST. LAWRENCE REGION

M. Lamontagne[1], J.E. Adams[1], T. Feininger[2], B.D. Loncarevic[3], D. Lefebvre[4]

The Lower St. Lawrence region is the site of continuous, seismic activity, but historically of low level (maximum

magnitude of approximately 5). Relocations of old earthquakes agree with the present distribution, i.e. that the earthquakes are occurring principally under the St. Lawrence river, within the Forestville-Sept-Îles-Matane triangle. Focal mechanisms suggest that the earthquakes are occurring on the faults of the St. Lawrence paleorift system.

The gravity and magnetic fields emphasize some geological characteristics of this seismic zone. The total magnetic field emphasizes some lithological and structural features that correspond in some cases to topographic lineaments. The gravity field was used to model the Sept-Îles layered mafic intrusion, at the east end of the zone, as a funnel-shaped body 80 km in diameter and 8.5 km thick.

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2 Lithosphere and Canadian Shield Division
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4 Ministère de l'Énergie et des Ressources du Québec

HEAT FLUX IN THE CANADIAN CORDILLERA: RESULTS AND INTERPRETATIONS

T.J. Lewis[1]

The heat flux, defined by 230 measurements, is related to the tectonic history within most of the Canadian Cordillera and in nearby offshore areas. In southwestern British Columbia the heat flux above the subducting Juan de Fuca plate varies from 25 to several hundred mW m^{-2}. Heat is absorbed in the warming of the descending lithosphere and in the dehydration of the oceanic crust, producing a low heat flux above the descending oceanic crust and a very deep, cool continental crust. An abrupt transition from low values above the subducting plate to 70-80 mW m^{2} occurs 30 km seaward of the Garibaldi Volcanic Belt. The very large, local variations in heat flux within this belt are the result of advective cooling of intruded magmas. East of the Coast Plutonic Complex there is a heat-flow province with a high reduced heat flow of 58 mW m^{2} that crosses both terrain and physiographic boundaries. The extensive heat generation measurements within this province can be used to estimate the heat flux at locations where it has not yet been measured. To the north of this heat-flow province the data are sparse, but the heat flux from the lower crust and mantle is smaller. Marine measurements define the large transitions in heat flux both above the subducting Juan de Fuca plate and in areas that border the young oceanic crust near the Queen Charlotte Islands.

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RESULTS FROM THE LITHOPROBE ABITIBI PROJECT

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Many recent models for the evolution of Archean greenstone belts invoke horizontal transport as a result of thrust and/or strike-slip motion. However, the deformation zones associated with such movements are poorly understood and defined. Two areas, the Rouyn-Noranda base metal mining camp (RNL) and the Kirkland Lake Au district (KLL), are characterized by extensive piles of mafic and felsic volcanic rocks of about 2700 Ma. At the southern limit of the RNL the Cadillac fault juxtaposes volcanic assemblages with granite, gneiss and metasediment of the Pontiac subprovince. The seismic signature of the granite-gneiss terrane and that of the southern extremity of the KLL is characterized by a remarkable series of shallow, north-dipping reflectors for at least the top 15 km of the crust. These reflectors steepen dramatically under the surface expression of the Cadillac break. The volcanic dominated terrane displays a distinct seismic signature to that of the granite-gneiss terrane. Once again the dominant fabric indicates shallow north-dipping structures, which appear rooted in a zone at approximately 10 km. The new results contradict any model involving "vertical" tectonics in the Abitibi and possibly other greenstone belts.

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PRECIOUS METAL MINERALIZATION OF BETTS COVE OPHIOLITE, NEWFOUNDLAND

J.W. Lydon[1], J. Lavigne[1]

In addition to its base metal sulphide deposits (Tilt Cove and Betts Cove mines), the Betts Cove ophiolite also appears to have potential for precious metal mineralization of economic significance. Gold occurrences are preferentially distributed along the northwesterly tectonized contact of the ophiolite in association with zones of ductile deformation and carbonate alteration. Towards the southwestern portion of the ophiolite belt, deformation is increasingly of a brittle nature and gold tends to be most commonly concentrated in quartz-carbonate-sulphide veins. Anomalous concentrations of platinum and palladium are associated with carbonatization and serpentinization fronts in ultramafic rocks, particularly in the zone of transition between ductile and brittle deformation styles. The platinum group element concentration has similarities to the hydrothermal platinum-palladium mineralization of the Unst Ophiolite, Shetland Islands.

1 Mineral Resources Division

BEDROCK AND SURFICIAL GEOLOGY OF ARCTIC MARINE CHANNELS

B. MacLean[1], G. Vilks[1], G. Sonnichsen[1], K. Moran[1], D. Praeg[1], D. Hodgson[2], A. Jennings[3]

Information on the seabed geology of interisland channels of the Canadian Arctic Archipelago was gathered using shallow single channel and Huntec high resolution seismic reflection profiling and sampling systems. Data were also obtained in some regions by small boats in leads in the permanent and semi-permanent sea ice.

The data show that glacial drift is the thickest and most widespread surficial sediment unit. Apparent morainal and multiple drift deposits are represented.

Glaciomarine and postglacial sediments up to a few metres thick locally mantle the drift in bathymetric depressions.

Samples reveal that distinctive texture, geotechnical properties, and foraminiferal assemblages are associated with each of the sediment units recognized from seismic reflection profiles.

High magnetic susceptibility of the glacial drift and glaciomarine sediments in some channels suggest that these deposits were in part derived from Archean rocks bordering the Gulf of Boothia, whereas sediments in the other channels surveyed came from source areas of low magnetic susceptibility.

Bedrock underlying Norwegian Bay consists of sedimentary rocks which are considered correlatives of those that occur on adjacent islands.

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CRUSTAL THICKNESS UNDER THE GULF OF ST. LAWRENCE, NORTHERN APPALACHIANS, FROM GRAVITY AND DEEP SEISMIC DATA

F. Marillier[1], J. Verhoef[1]

The Gulf of St. Lawrence is underlain by two major Paleozoic basins, the Anticosti and the Magdalen basins. In this area a major offset of the Northern Appalachians units occurs. To obtain the crustal thickness we first calculated a complete Bouguer anomaly map from the free air gravity. In the complete Bouguer anomaly the water and sediments are replaced by material of standard crustal density. The depth to Moho was then obtained from the Bouguer anomaly by inversion, assuming that this anomaly is due to the crust-mantle density contrast.

In the Anticosti basin, the calculated Moho depth corresponds to the depth observed on deep seismic reflection profiles. In the Magdalen basin seismic data indicate a much deeper Moho than calculated. Gravity modelling in the Magdalen basin suggests that this basin is underlain by a lower crustal layer of high density ($3.1\ g/cm^{-3}$). We suggest that this layer is due to mantle underplating of the crust beneath the Magdalen basin.

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PRE ICE-AGE ENVIRONMENTS OF THE ARCTIC: A VISION OF THE FUTURE?

J.V. Matthews, Jr.[1]

Fossils from the Beaufort Formation and related Neogene deposits in the Arctic provide baseline information on the late Tertiary environment of that region. For example, 5 million years ago Meighen Island at 80°N was characterized by treeline vegetation consisting of plants such as five-needle pine, spruce, eastern white cedar and larch. Forest-tundra also existed as far north as northern Alaska, Ellesmere Island and northern Greenland in late Pliocene time after which the climate cooled and has not since been as warm. Such information is essential for understanding the effect of future climate change in Canada, especially if, as predicted by some models, greenhouse warming exceeds that which has occurred over the last 10 Ma. Under such conditions the Arctic would not revert to its late Tertiary state, but the ranges of some plants and animals may well approach that seen during the Tertiary.

[1] Terrain Sciences Division

THE GEOLOGICAL SURVEY OF CANADA 'DATE LOCATOR FILE': A RADIOCARBON DATA BASE

R.N. McNeely[1]

Radiocarbon dates are essential to the development of a chronologic framework for many of the natural sciences including Quaternary and environmental geology, as well as the recent Global Change Initiative. Until now there was no central source to consult when conducting geochronometric investigations. Terrain Sciences (GSC) has developed a computerized data base, 'Date Locator File, of all GSC ^{14}C dates. This data base provides the research community with immediate access to the relevant information produced by the GSC Radiocarbon Dating Laboratory. The data base allows dates to be selected on "key" parameters such as Locality, Latitude/Longitude, Submitter, Material, as well as individual Lab. Codes.

A committee of Canadian laboratories and users of ^{14}C dates recently proposed that Canada develop a Canadian data base to insure the availability of radiocarbon dates to Canadian researchers. The GSC has been nominated as the most logical institution to house this 'National' data base.

[1] Terrain Sciences Division

MODELLING FLUID PRESSURE EVOLUTION AND HYDROCARBON GENERATION IN THE VENTURE GAS FIELD OFF NOVA SCOTIA

S. Mudford[1], E. Best[2]

The Venture gas field is a deep overpressured gas reservoir on the Scotian Shelf off eastern Canada. The overpressuring occurs at depths below 4.5 km and is associated with significant quantities of gaseous hydrocarbons. The overpressured zone has a sandstone to shale ratio close to one. The shales have low permeabilities ($< 10^{-20} m^2$) and nearly normal levels of compaction. The sandstone units in the field have high permeabilities ($\geq 10^{-13} m^2$) and porosities ($\simeq 30\%$). Corrected sedimentation rates, calculated by backstripping the sediments, have averaged around 20 m/Ma over the last 95 Ma. One dimensional modelling of fluid pressure evolution indicates that, even with a low sedimentation rate, compaction disequilibrium can lead to significant levels of overpressuring if there are low permeability shale beds within the sediment column. Hydrocarbon generation is modelled using simple kinetic reaction theory. The results of modelling two phase flow in the Venture gas field indicate that compaction disequilibrium is responsible for a large proportion of the overpressuring. The geochemical data we have available at present implies that hydrocarbon generation has the effect of slightly increasing overpressures which are primarily the result of compaction effects.

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THE USE OF BOREHOLE GEOPHYSICS IN HYDROGEOLOGICAL STUDIES OF THE FREDERICTON AQUIFER, NEW BRUNSWICK

C.J. Mwenifumbo[1]

Five observation wells were drilled for hydrogeological studies of the Fredericton aquifer, the city's primary groundwater supply. Borehole geophysical measurements were carried out by the GSC in cooperation with the Groundwater Studies Group at the University of New Brunswick. Logging included natural gamma ray, density and temperature. The gamma ray and density data were successful in defining the stratigraphic sequence intersected by these boreholes and these data were useful in checking depths and thicknesses of the lithologic units determined from chip sampling data. Temperature logging data showed that these data may be helpful in understanding the water flow in these boreholes. Resistivity and induced polarization (IP) measurements carried out in the uncased portion of one of the boreholes provided some useful information on the bedrock characteristics. Water-bearing fracture zones were characterized by low resistivity and high IP effects. High IP observed within the fractured zones suggests the presence of iron oxides.

[1] Mineral Resources Division

THE EFFECT OF CLIMATE ON PEAT ACCUMULATION IN CANADIAN WETLANDS

L. Ovenden[1]

Peat covers 12% of Canada's land surface and represents a large mass of carbon (184 Gigatons), equal to about 10% of global soil carbon or 33% of terrestrial plant carbon. Most peat in Canada has accumulated under cool Holocene climates of our boreal and subarctic regions. With the prospect of major climatic change, two questions arise: (1) how has climate affected peat (ie. carbon) accumulation in the past, and (2) how will peatlands respond to climatic change.

This presentation discusses three ways of estimating climate/peat relationships: geographic patterns of peat volume and accumulation rate, past accumulation rates in comparison to climatic history, and current carbon balance under monitored environmental conditions. These data suggest that boreal climate promotes peat accumulation more than temperate or subarctic climate. Information is needed on thermokarst and carbon losses (methane emissions, organic content of outflow), to predict effects of climatic warming on the carbon balance of Canadian peatlands.

[1] Terrain Sciences Division

MAPPING OF QUATERNARY SEDIMENTS IN NORTHERN ONTARIO WITH ELECTROMAGNETIC TECHNIQUES

G.J. Palacky[1], L.E. Stephens[1]

Traditionally, seismic techniques have been used in mapping of quaternary sediments and in determination of depth to bedrock. The use of electromagnetic (EM) methods has proven faster and less expensive. The experience of the GSC research team indicates that various types of Quaternary sediments can be identified on the basis of even less expensive horizontal-loop EM (HLEM) data. Examples will be shown of HLEM responses over clay, silt, clay-sand, silt-till, till, and sand sequences. While the conductivity of clays is high (15-40 mS/m), silts and tills are more resistive and dry sand is highly resistive. In 1987-88, 113 km of HLEM surveys were carried out in the Smoky Falls, Smooth Rock Falls, Kapuskasing and Timmins areas. So far, 70 holes based on HLEM results were drilled using the reverse-circulation technique. Resistivities were determined in laboratory on a number of drill core samples. In most instances, drilling confirmed the reliability of HLEM interpretation. Sites for ground HLEM surveys were selected on the basis of interpretation of helicopter EM data which were acquired in February 1987 (total of 830 line km). The techniques for interpretation of HLEM data we developed will have significant importance in environmental and engineering studies.

[1] Mineral Resources Division

STRUCTURE AND STRATIGRAPHY OF THE KAMINAK-ENNADAI BELT, SOUTHWEST OF RANKIN INLET, DISTRICT OF KEEWATIN

A.F. Park[1], S. Ralser[1]

In this area the Archean Kaminak Group, a greenstone-metasedimentary sequence, is overlain by the (?) Lower Proterozoic Hurwitz Group, a quartz-rich sedimentary sequence. Archean volcanites, conglomerates, and turbidites contain features indicative of deposition in an extensional basin. Two phases of Archean deformation are documented. D_1 is characterized by layer-parallel high strain zones and tight, recumbent westward-facing folds. D_2 is characterized by open to tight folds and steeply dipping shear zones, both trending NE. Shear zones show a complex movement history, part of which controlled deposition of the overlying (?) Lower Proterozoic Hurwitz Group sediments. D_3 constitutes the NE trending folds and fabrics affecting the Hurwitz Group sediments. Sulphide-bearing gabbros are contemporaneous with the mafic volcanites of the Kaminak Group. Sulphide and (?auriferous) quartz-carbonate vein assemblages post-date D_2, but relate to particular phases of vein development rather than particular vein sets.

Contribution to Canada-Northwest Territories Mineral Development Agreement.

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SELECTED PRECAMBRIAN GEOCHRONOLOGICAL HIGHLIGHTS OF 1988

R.R. Parrish[1], O. van Breemen[1], E. Hegner[1], S.D. Carr[2], A. Davidson[1]

The oldest Proterozoic element of the Cape Smith belt is the Purtiniq Ophiolite, a 1999 +/-2 Ma remnant of oceanic crust. Zircons in meta-anorthositic rocks of the ophiolite also contain 1976 +/-2 Ma zircons, possibly indicative of ancient sea-floor metamorphism. This ophiolite is one of the oldest remnants of oceanic crust yet discovered.

Detrital single zircon U-Pb dating has been applied to meta-arkose in Saskatchewan to assess its provenance. Analyses indicate the age range of grains to be 1850-1863 Ma. The data and the age of a cross-cutting granite allow the age of the sediment to be determined.

Zircon and baddeleyite U-Pb dating of coronitic metagabbro within the Grenville province has revealed a clear distinction between the age of the original olivine gabbro (1170 Ma, baddelayite) and the age of corona-forming metamorphism at about 1045 Ma (zircon).

Nd isotopic studies of the Thelon tectonic zone of the northwest Canadian Shield has revealed that Archean crust is the dominant source of the 1.9-2.0 Ga rocks of the Thelon zone.

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GEOLOGY OF THE ASHUANIPI COMPLEX, SUPERIOR PROVINCE, QUEBEC-LABRADOR

J.A. Percival[1]

The Ashuanipi complex consists of early paragneiss, with concordant, <2-km-thick, tonalitic sills with rare diorite, gabbro and pyroxenite. Homogeneous intrusions, making up most of the terrane, include tonalite and diorite, cut by widespread, peraluminous Opx-granodiorite, probably derived from paragneiss, late granite and syenite. The dominant S_1 foliation defines a regional homocline with open F_2 basins and "Z" warps on the 10-20 felsic rock types; mineral thermobarometry yields 750-800°C at 5-6.5 kb. Detrital zircons in paragneiss are 3.3-2.7 Ga (U-Pb), suggesting sediment deposition after 2.7 Ga; the igneous rocks have zircons of 2.7-2.66 Ga; monazites are 2.67-2.63 and retrogressed granulite has 2.64 Ga zircon.

Based on observations in the Ashuanipi complex and higher levels exposed in belts of the same age to the west, a model of development in a >2000 km accretionary prism is proposed: immature sediments derived from adjacent volcanic arcs were accreted less than 2.70 Ga ago; thermal relaxation and/or arc magmas caused fusion and upward heat transfer through granitic magmas, crystallized as deep and higher-level peraluminous granites. The overthickened crust rebounded to an isostatically stable 35 km.

[1] Lithosphere and Canadian Shield Division

DYNAMICS AND TECTONICS OF THE MACKENZIE IGNEOUS EVENTS

T.D. Peterson[1], A.N. LeCheminant[1]

We present a tectonic model for the 1.27 Ga Mackenzie igneous events based on dynamic models of magma generation and dyke propagation, and generalize problems in continental flood basalt petrogenesis. The model proposes that PGE and Cu-rich Mackenzie magmas were derived rapidly from hot asthenosphere where a rift intersected a domal uplift supported by upwelling primitive mantle. The length of some Mackenzie dykes (1000+ km) approaches the limit allowed by heat transfer theory, indicating an abundant magma source. Some crustal

contamination occurred by ablation of wall rocks near the source, was greatest in thick, longer-lived dykes and is most evident in the centres of large dykes with chilled margins. The extensive mafic magmatism and short time-span of magmatic activity (possibly less than 5 Ma) suggest that initial high-volume Mackenzie eruptive events may have caused widespread dispersal of PGE-bearing volcanic emissions. Significant and perhaps catastrophic release of volatiles from a primitive mantly plume could occur during early stages of rapid magma production triggered by a rifting event. The large breccia bodies in the Wernicke Supergroup may represent an explosive phase of Mackenzie activity from the outer portion of the hotspot.

[1] Lithosphere and Canadian Shield Division

DERIVED POTENTIAL FIELD DATA SETS FOR NORTH AMERICA

M. Pilkington[1], R.A.F. Grieve[1], R.A. Gibb[1], J.F. Halpenny[1]

Derived potential field data sets prepared for the Decade of North American Geology are amenable to manipulation to produce derived data sets, which emphasize different features of crustal structure of North America. Gravity gradients (horizontal and vertical) enhance expression of upper crustal structure, suppessing long-wavelength features and identifying previously unrecognized major lineaments and large-scale gravity/structural domains related to continental accretion. Residual isostatic gravity removes long wavelength information associated with major topographic features and highlights upper crustal features such as the granite intrusions in the Abitibi greenstone belt in the Superior province. Pseudogravity, computed from the aeromagnetic data, suppresses much of the higher frequency magnetic anomalies and emphasizes regional changes in magnetization. Magnetization/density ratio and correlation coefficient maps have been produced by regression analysis of the aeromagnetic and vertical gravity gradient data sets. A high degree of correlation occurs over features such as the Mid-Continent Gravity high, Oklahoma Aulacogen and the Thelon Front. Differences in ratios and correlations occur between the buried and exposed shield areas and areas of younger crust.

[1] Geophysics Division

NEW BRUNSWICK MDA - AEROMAGNETIC TOTAL FIELD, GRADIOMETER, VLF SURVEY, 1986-87

E.E. Ready[1], B.M. Ellis[1], D.J. Teskey[1]

A combined aeromagnetic total field, gradiometer and airborne VLF survey of an area southwest of Bathurst, N.B. was flown under contract to the Geological Survey of Canada by Geophysical Surveys Inc. of Quebec City in the period October 1986 to April 1987.

A mean elevation clearance of 150 m was maintained with a flight line separation of 300 m. VLF total field and quadrature data have been recorded using signals from Cutler, Maine and Annapolis, Maryland.

Survey output is in the form of 1:20 000 aeromagnetic total field and gradiometer contour maps and 1:50 000 magnetic anomaly and gradiometer colour interval maps. The VLF total field and quadrature profiles are printed on the back of the magnetic anomaly and gradiometer colour maps respectively in such a way that they can be viewed jointly with the magnetics on a light table. The zero contour of the vertical gradient has been shown to outline very closely contacts between rock masses with contrasting magnetization such as volcanics and sedimentary units, whereas VLF data have proven to be useful for the delineation of near surface conductors and zones of contrasting conductivity. This survey joins up two previous gradiometer surveys completing the mapping of the northern part of the Miramichi volcanic-sedimentary belt.

Contribution to Canada-NewBrunswick Mineral Development Agreement 1984-89

[1] Geophysics Division

NOVA SCOTIA MDA - AEROMAGNETIC TOTAL FIELD, GRADIOMETER, VLF SURVEY, 1986-87

E.E. Ready[1], F.G. Kiss[1], P.E. Stone[1], D.J. Teskey[1]

A combined aeromagnetic total field, gradiometer and airborne VLF survey was flown in the Cobequid Highlands area of Nova Scotia. A comparative study of these geophysical data sets with the mapped geology demonstrates the effectiveness of an integrated aeromagnetic/ gradiometer/VLF-EM system in providing useful structural and lithological information in areas where the geology is complex and outcrop exposure is poor.

The Cobequid Fault and the major unconformity which marks the northern limit of the Cobequid complex are particularly well defined. Improved resolution of contacts between large acidic and basic intrusive bodies such as the Wyvern and the Gilbert Mountain Plutons and, on a smaller scale, accurate positioning of diabase dykes is demonstrated. The mafic volcanic units of the Fountain Lake Group are resolved on the gradiometer map and interpreted to extend beyond their present mapped limits.

[1] Geophysics Division

SEISMIC REFLECTION AND REFRACTION EXPERIMENT ON AN ACTIVE TRENCH-RIDGE-TRANSFORM MARGIN, QUEEN CHARLOTTE ISLANDS REGION

K.M.M. Rohr[1], G. Spence[1], Queen Charlotte Island Seismic Group

A coincident seismic reflection and refraction experiment was conducted in July 1988 to define sedimentary basin structure and tectonic history of the continental margin in Queen Charlotte Sound and Hecate Strait. The Juan de Fuca ridge impinges on the continental margin at Queen Charlotte Sound but its location is not well defined by magnetics. South of the triple junction the oceanic Explorer plate is being shoved under the continent and north of the triple junction the Pacific plate is moving past the Queen Charlotte Islands at a rate of 55 mm/yr. A commercial seismic boat shot the reflection data under contract using a 3600 m, 240 channel digital streamer and 6400 in^3 array of 60 airguns. Shots were spaced every 45 m for 40 fold data and were recorded to 14 s at 4 ms. Some 1135 km of reflection data were collected; brute stacks show fault bounded asymmetric sedimentary basins and deeper events between 6 and 10 seconds. Seismometers from the Geological Survey of Canada and University of British Columbia recorded the shots at 19 land stations; some profiles received data from as far away as 180 km.

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TECTONIC ASSEMBLY OF THE CANADIAN SHIELD IN THE ALBERTA SUBSURFACE: INTEGRATED POTENTIAL FIELD MAPPING AND U/PB ZIRCON GEOCHRONOLOGY

G.M. Ross[1], M.E. Villeneuve[2], R.R. Parrish[3], S.A. Bowring[4]

An integrated geochronological and geophysical study sheds new light on the crustal structure and timing of assembly of the Canadian Shield buried in the Alberta subsurface. The picture which emerges is one in which the assembly of dated tectonic elements (2.6-2.1 Ga) was brought about by apparent plate consumption along zones now marked by 2.0-1.8 Ga magmatic arcs and transcurrent shear zones. Arcuate north-trending anomalies of northern Alberta are interpreted as a composite magmatic arc developed west of the Archean Rae Province. Ca.2.0 Ga arcs flank an older arc/microcontinent that ranges from 2.3 to 2.1 Ga. These anomalies are truncated to the south by the Snowbird Tectonic

Zone, a pronounced crustal break postulated to have formed during Proterozoic oblique collision between the Rae and Hearne Provinces that was associated with tectonic escape blocks and a narrow magmatic arc. Southern Alberta is dominated by Archean age rocks including the Southern Alberta Aulacogen which is a likely collision zone representing part of a broader zone of northward convergence between the Hearne and Wyoming Provinces. The results of this work place geometric constraints on crustal lineaments that appear to have influenced sedimentation and resource accumulation in the Western Canada Sedimentary Basin.

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STRUCTURE AND TECTONOSTRATIGRAPHY OF THE EASTERN CAPE SMITH THRUST-FOLD BELT: A SET OF FIFTEEN NEW COLOUR MAPS AT 1:50 000 SCALE

M.R. St-Onge[1], S.B. Lucas[1]

Fifteen 1:50 000 scale colour maps document the tectonostratigraphy, structural geometry and regional metamorphism of the eastern Cape Smith Belt. Major tectonostratigraphic units are: (1) Povungnituk Group continental rift sediments and basalts (1960 Ma); (2) Chukotat Group transitional crust basalts; and (3) the Purtuniq ophiolite, including mafic and ultramafic cumulates (1999 Ma), sheeted dykes, pillowed basalts and deep water sediments. Layered 1922 Ma mafic-ultramafic sills, hosting Cu-Ni-PGE mineralization, intrude the Povungnituk and Chukotat Groups. D_1 imbrication and southward translation occurred above a basal décollement, generally separating the Proterozoic allochthons from autochthonous Superior Province gneisses. Thick-skinned D_2 (east-west) and D_3 (north-south) folding deformed both the thrust belt and the gneisses. The >30 km of composite structural relief on D_3 fold limbs has been utilized to construct a down-plunge cross section. The colour maps and cross section provide a 3-D geological framework for mineral exploration in the belt.

1 Lithosphere and Canadian Shield Division

SENSITIVITY OF GLACIAL DEPOSITS TO ACID PRECIPITATION IN NORTHERN MANITOBA

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Glacial dispersal of Paleozoic carbonate in northern Manitoba extends westward from Hudson Bay, 200 km across Precambrian shield terrane. Exotic carbonate debris, coupled with extensive Lake Agassiz clay cover has influenced the sensitivity of shield terrane in the area to acid precipitation. C-horizon till samples were collected along a 100 km transect parallel to ice flow, where matrix carbonate content varies from >35% (NE) to 0% (SW). Profile sampling was also carried out within various types of sediment/soil sequences to assess in situ variability and the influence of clay cover on buffering capacity in calcareous and noncalcareous systems. The Wyatt method was used to determine acid neutralizing capacity (ANC). In general, coarse-grained noncalcareous sediment is sensitive to acidification and release of heavy metals. Calcareous sediment and fine-grained Lake Agassiz clay buffer acidification. Acid sensitivity in this area therefore, is a combined function of the distribution of calcareous till and Lake Agassiz clay.

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EFFECTS OF GEOLOGICAL PARAMETERS ON ACID RAIN STUDIES IN EASTERN ONTARIO LAKES

D.F. Sangster[1], Z.D.G. Richardson[1], J.J. Carrière[1]

Lake waters in eastern Ontario (between Ottawa and Georgian Bay) are being examined with respect to pH and sulphate content with the objective of determining to what extent bedrock geology may affect these parameters, both of which are commonly used as a measure of acid rain influence. Lakes in the eastern part of the study area are underlain by metasedimentary rocks of the Grenville Supergroup; those in the western part by granitic gneisses and intrusions.

Probably because of the buffering effects of carbonate rocks in the Grenville Supergroup, the eastern lakes have approximately 13% higher average pH than those in the west. In addition, the eastern lakes are approximately 25% higher in sulphate content than their western counterparts in spite of the fact that the latter are closer to the presumed sources of sulphate-bearing acid rain (i.e. Sudbury and central United States). The source of the additional sulphate in the eastern lakes is not yet clear but preliminary results indicate that oxidation of pyrite in rocks of the Grenville Supergroup may be contributing the extra sulphate. Sulphur isotopic studies of both pyrite, lake waters, and a small number of rain samples are currently underway to determine the validity of this possibility.

1 Mineral Resources Division

GEOLOGY OF NORTHERN MELVILLE PENINSULA, N.W.T.

M. Schau[1]

Bedrock on the Mellville Peninsula horst is disposed in an asymmetric manner. Archaean high grade rocks typical of the deep crust occur in the northwest whereas the east coast is underlain by a high crustal level Archaean greenstone and pluton association. This asymmetry is only partially caused by differential uplift in the Phanerozoic. Proterozoic faults cut the Melville Peninsula and have been reactivated often. A particularly prominent, ESE- striking, steeply dipping, fault set traverses the peninsula at intervals of about 10 km resulting in panels which contain coherent geological structures. Offset by these faults is an earlier, anastomosing, SW-trending, ductile, high-strain zone which is especially widespread and prominent on the west side of the peninsula. Previous to a mafic dyke set, that is disrupted by the above structures, are flat structures along which granulite grade orthogneisses have moved from the WNW onto amphibolite grade Archaean granites, gneisses and Prince Albert Group supracrustals.

1 Lithosphere and Canadian Shield Division

SIZE, SCOPE, SIGNIFICANCE, AND ACCESS TO SAMPLE/RECORD HOLDINGS AT THE ATLANTIC GEOSCIENCE CENTRE

A. Sherin[1], I.A. Hardy[1]

Since the inception of the Atlantic Geoscience Centre in the early 1960's vast volumes of multichannel seismic, deep penetration seismic reflection, sonobouy refraction, gravity, magnetic, bathymetric, large area mapping sonar and Huntec data have been systematically collected on more than 350 survey programs conducted off eastern Canada and in the high Arctic. This represents an area of more than 1.6 million square kilometers from George's Bank to the Arctic Islands. Similarly, seabed dredging, coring, hydraulic piston coring and shallow borings from a minimal water depth of 7 m to depths in excess of 2 km have also been collected, and constitute one of the major, and most modern marine sediment collections for eastern North America.

These collections of the Geological Survey of Canada, regardless of type or origin, constitute a fundamental resource for the geoscientific study of the Canadian geology for use by the scientific community at large, educational institutions and/or associations as well as by industry. To access and to determine the viability of these holdings, more than 12 data base management systems have been developed utilizing the Bedford Institute of Oceanography CDC Cyber 840, Base III plus software on PC compatible microcomputers and more recently have been prepared for conversion to relational data bases using ORACLE.

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MAGNETIC ANOMALY AND TECTONIC ELEMENTS OF ATLANTIC CANADA

K.G. Shih[1], H. Williams[2], R.F. Macnab[1]

Recent compilations of aeromagnetic and marine magnetic observations over the continental margin of eastern Canada have created a digital data base that is well suited to the automated production of high quality colour maps. Portions of the new data base were used to prepare an updated and expanded version of the magnetic anomaly map published in 1984 by Williams and Haworth. The new map covers an area ranging from central Labrador to Cape Hatteras, and from the coast of the Carolinas to east of the Newfoundland Basin.

Illustrating the anomaly field over a range of 1500 to -1500 nano Tesla, the map presents a striking portrayal of magnetic signatures related to local and regional geological features. Major oceanic and continental signatures are identified by an overlay map that correlates magnetics to known tectonic elements; the latter are based on interpretations extracted from the literature and from the results of recent field work in Newfoundland, Cape Breton, and the Laurentian Channel.

The map is a major and detailed synthesis of magnetic information that spans a variety of terranes: continental craton, ancient orogenic belt, passive continental margin, and oceanic crust. It promises to be a useful adjunct to geological and tectonic investigations.

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AN ENHANCED RESIDUAL ISOSTATIC ANOMALY MAP OF CANADA: A NEW PERSPECTIVE FOR CRUSTAL INVESTIGATIONS

L.W. Sobczak[1], J.F. Halpenny [2], M.D. Thomas[1]

Free-air, Bouguer and residual isostatic gravity anomaly maps and a map of the horizontal gradient of Bouguer anomalies for Canada have been published recently in the Canadian Geophysical Atlas at a scale of 1:10 000 000. All of these maps represent valuable data bases for investigating structure of the lithosphere, but the anomaly maps contain certain deficiencies arising from isostatic anomalies and topography, and in the process create enhanced residual isostatic anomalies. Such anomalies, divested of any dependance on topography, should represent variations in gravity related strictly to geological structure. Interpretation of enhanced residual isostatic anomalies may proceed without concern that some variations may be related to continental-oceanic crust boundaries, water-rock interfaces, topography/bathymetry, isostatic roots/antiroots, crust-mantle interfaces and thermal and loading effects.

1 Lithosphere and Canadian Shield Division
2 Geophysics Division

SEISMOLOGICAL CONTRIBUTIONS TO THE QUEBEC-MAINE-GULF OF MAINE GLOBAL GEOSCIENCES TRANSECT

C.P. Spencer[1], A.G. Green[1], B. Milkereit[1], H.J. Broome[1], J. Unger[2], D.B. Stewart[2]

In 1983 and 1984 the Geological Survey of Canada participated in the acquisition of seismic reflection and refraction data along an 800 km profile across the Appalachian orogen and Atlantic margin from Quebec City to south of Georges Bank.

The principal features of our interpretation of the data for Quebec are as follows: i) In southeast Quebec and northwestern Maine, Grenville basement is overlain by an allochthon up to 24 km thick emplaced during the Taconic orogeny. In its upper part the allochthon consists of the Chai Lakes Massif and cover sequences. ii) The Baie-Verte- Brompton line which separates slope and rise deposits from oceanic material penetrates the upper crust only. iii) The Connecticut Valley-Gaspé Synclinorium is a shallow structure extending no deeper than 4 km.

We shall present a detailed interpretation of the data pertaining to Quebec and examples of seismic reflection sections along the entire line.

1 Lithosphere and Canadian Shield Division
2 U.S. Geological Survey, Reston, Virginia

OUR EARTHQUAKES - WILL HISTORY REPEAT ITSELF?

A.E. Stevens[1], J.A. Drysdale[1]

Earthquake prediction is based upon a knowledge of past earthquakes - where, when and how big. Some future earthquakes will, however, occur in unexpected places - unexpected because our present knowledge of earthquake history is limited - unexpected because seismicity patterns may change with time.

Earthquake impact on Canadian society depends upon the degree of urbanization near the earthquake centre, the quality of earthquake-resistant construction, and the extent of earthquake preparedness.

The poster depicts some of the significant Canadian earthquakes of the past and their effects. If any of these earthquakes were to re-occur, the social and economic effects could extend beyond the limits of the severely-shaken areas.

The Geological Survey of Canada continuously monitors earthquake activity in Canada, analyzes earthquake patterns and advises governments and the private sector on earthquake hazard reduction and earthquake preparedness measures.

Earthquake catastrophes are not inevitable.

1 Geophysics Division

PLATE TECTONIC EVOLUTION OF THE CANADIAN APPALACHIANS

G.S. Stockmal[1]

Our understanding of the regional tectonic framework of the Canadian Appalachians has greatly increased through acquisition of more than 1600 km of marine deep seismic reflection data.

The familiar upper crustal tectonic-stratigraphic zones of the Appalachians (Humber, Dunnage, Gander, Avalon, Meguma) are seen to be underlain by three main lower crustal blocks (LCBs): the Grenville, and Avalon LCBs. The lateral extents of the LCBs can be interpolated with confidence between seismic lines due to the consistent spatial relationships observed between the LCBs and the overlying zones. This results in a jig-saw pattern of LCBs showing: (i) the sharply irregular edge of the Grenville LCB; and

(ii) the dismembered nature of the Central and Avalon LCBs. Palinspastic reconstructions of these blocks along major strike-slip fault zones places bounds on the relative timing and geometry of accretion of the Central and Avalon blocks to North America. In turn, this bounds the plate tectonic setting of accretion, and suggests the existence of a major back-arc basin between the Taconian arc and the Central LCB.

1 Atlantic Geoscience Centre, Dartmouth

STRATIGRAPHIC AND STRUCTURAL RELATIONS, CENTRAL QUEEN CHARLOTTE ISLANDS

R.I. Thompson[1]

Two fold episodes have been identified. The first occurred prior to or during the start of Middle Jurassic Yakoun volcanism; the second occurred in Late Cretaceous or early Tertiary time, after deposition of Upper Cretaceous Honna conglomerate. Block faults were active from Middle Jurassic until late Tertiary time.

Neither the Rennell Sound fold belt nor the northern strands of the Louscoone Inlet Fault were zones of significant, right-lateral, strike-slip displacement during Tertiary time.

The southwestern side of the Rennell Sound fold belt contains slices of Triassic Karmutsen volcanics imbricated with limestone and siltstone of the Kunga Group (Upper Triassic and Lower Jurassic). The belt crosses Louise and Moresby islands and does not support a simple, west-side-up, flexural model for Tertiary evolution of Hecate Strait.

The eastern side of the Rennell Sound fold belt parallels an older block fault. It appears that the largest and tightest Lake Cretaceous and/or Tertiary folds were, in part, controlled by pre-existing block faults.

1 Pacific and Cordilleran Geoscience Division

NEWFOUNDLAND MDA — AEROMAGNETIC TOTAL FIELD, GRADIOMETER, VLF SURVEY, 1986-87

J. Tod[1], E.E. Ready[1]

An aeromagnetic total field, gradiometer and airborne VLF survey was carried out over an area in central Newfoundland. This portion of the Dunnage Zone is geologically complex, and well suited to mapping with aeromagnetics. Aerodat Limited of Toronto carried out the contract in 1986/87, using a rotary wing aircraft.

Survey results are available at two map scales: 1:25 000 aeromagnetic total field and gradiometer contour maps and 1:50 000 magnetic anomaly and gradiometer colour interval maps. The VLF total field and quadrature profiles are printed on the back of the 1:50 000 maps.

The aeromagnetics substantiate and expand on the known geology in this part of the Dunnage Zone. The gradiometer colour maps, in particular, show clearly defined intrusive features and major transcurrent faults. A series of folded sills, as well as a thrust sheet can be identified in the middle and northern regions of the survey area.

1 Geophysics Division

SURFICIAL GEOLOGY MAP OF GASPÉSIE, QUÉBEC

J.-J. Veillette[1], M. Cloutier[2]

The Geological Survey of Canada undertook, in 1985, the compilation of a surficial geology map of the Gaspésie Peninsula as a contribution to the Canada Economic Development Plan for Gaspé and Lower St. Lawrence, Mineral Program 1983-88. The map shows the distribution, the thickness and the main characteristics of the surficial deposits, and presents an overview of ice flow history, distribution of lithological indicators of glacial transport, radiocarbon ages, and elevation and age of the marine limit. This synthesis results mostly from data accumulated during the last two decades by Quaternary scientists, particularly surficial geology mappers of the Ministère de l'Énergie et des Ressources du Québec, to which we have added our own field observations.

1 Terrain Sciences Division
2 Cogéo Consultants Inc.

LATE QUATERNARY PALEOCEANOGRAPHY AND SEDIMENTARY ENVIRONMENTS IN HUDSON STRAIT

G. Vilks[1], B. MacLean[1], B. Deonarine[1], C.G. Currie[1], K.M. Moran[1]

Airgun and high resolution Huntec seismic profiles show up to 130 m of glacial, glaciomarine and post glacial sediments on top of the bedrock. Five acoustic units were identified, at least three of which were penetrated with piston cores. Foraminifera of the stratigraphically deepest core in the eastern basin indicate a proximal glaciomarine environment and a possibility of an ice shelf. A ^{14}C date of 8060±70 BP on molluscan shells gives a minimum age for the top of the acoustically laminated distal glaciomarine sediments. Extrapolated age for the ice shelf is circa 10 000 BP.

The ratio of $^{18}O/^{16}O$ in the benthic foraminifer *Cibicides lobatulus* relates to bottom salinity. Downcore measurements of δ18O on *C. lobatulus* tests indicate lower than present bottom paleosalinities by about 0.5‰ shortly before the dated horizon of 8000 BP. The lower bottom salinities indicate that tidal mixing took place between glacial meltwater leaving Hudson Bay and the offshore counterflow. Thus the salinity difference of the surface plume of Laurentide meltwater was reduced before entering the ocean. This is important information for inferences used in paleoclimatic reconstructions on a global scale: how glacial meltwater was mixed with the oceans.

1 Atlantic Geoscience Centre, Dartmouth

HEAVY MINERALS: DETECTION AND CLASSIFICATION USING AUTOMATED IMAGE AND X-RAY MICROANALYSIS

M.E. Villeneuve[1], D.A. Walker[1]

The heavy mineral suite ($\rho > 3.3 \cdot g \cdot cm^{-3}$) of a rock can fingerprint the character of its source and may include economically important gold-, silver-, and platinum-bearing minerals. Automatic characterization of such suites is possible using a Cambridge Instruments S-200 scanning electron microscope interfaced with a Link Analytical AN10/85S energy dispersive X-ray microanalyzer and image analysis software.

Heavy mineral separates are prepared as polished grain mounts. The motorized stage is driven under software control to successive fields of view, which are then scanned to detect mineral grains. Upon detection, each grain is analyzed to determine its mineral class and its geometric properties (area, diameter, etc). Data from all fields are combined, and a plot of number of minerals in each class vs. geometric property is produced.

Major benefits include unattended operation for large samples, software based statistical analysis, and the ability to pinpoint minerals making up a minute portion of the suite.

1 Mineral Resources Division

NEW EDITION OF THE TECTONIC ASSEMBLAGE MAP OF THE CANADIAN CORDILLERA AND ADJACENT UNITED STATES

J.O. Wheeler[1], P. McFeely[1]

The 1:2 000 000 scale map displays tectonic assemblages, bounded by unconformities or faults, deposited in specific tectonic settings during particular intervals of time. It shows plutonic rocks, mainly as suites defined by age, composition and other attributes, faults, major metamorphic boundaries, important carbonate-shale transitions, melanges, and volcanic rocks broadly subdivided according to composition, volcanic centres and diatremes.

New additions to the map include: age of adjacent Pacific Ocean floor; formations in the Mackenzie Delta and adjacent Beaufort Sea beneath the Pliocene and younger cover; subdivisions of the Alexander Terrane; the Paleozoic and Mesozoic clastic wedges and accretionary prisms; Upper Proterozoic and Middle Cambrian rift assemblages; Proterozoic to Triassic pericratonic terranes between the North American passive margin and the Mesozoic volcanic allochthonous terranes; and new and revised ages of plutonic rocks, especially in the Coast Plutonic Complex.

The legend shows the assemblages and suites by age, name, tectonic setting, lithologic and other attributes, and their positions in time and space in relation to the Cordilleran terranes and the five morphogeological belts. It also highlights important overlap assemblages, the position and direction of dispersal of clastic wedges, and the composition and stratigraphy of the terranes.

1 Cordilleran and Pacific Geoscience Division, Vancouver

LABRADOR OFFSHORE BASINS DEFINED BY POTENTIAL FIELD DATA

J.M. Woodside[1]

Structure of the Hopedale and Saglek Basins and the classification and delimitation of geologic domains of the Nain and Makkovik Structural Provinces are facilitated using new compilations of the gravity and magnetic anomalies across the Labrador margin. Geologic boundaries are well-defined from an analysis of the second vertical derivative of the magnetic anomaly. Inferred block faulting and the occurrences of volcanic material in the basins correspond, in the Hopedale basin, to locations where these have been observed in wells and in the seismic reflection data. Between the primary Hopedale basin depocentre and the oceanic crust of the Labrador Sea are several large east-tilted fault blocks. Similar structures are not inferred east of the Saglek basin. The Saglek and Hopedale Basins are continuous through a narrower trough across the Oak Arch. The Nain Anorthosite Complex may extend eastward from the coast about 60 km. In general, a gravity high follows the main depocentres, with flanking lows over the structural highs, suggesting some flexural response to the sedimentary load.

1 Atlantic Geoscience Centre, Dartmouth

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