Geological Association of Canada

ABSTRACTS

Newfoundland Section 2009 Spring Technical Meeting
February 23–24, 2009

JOHNSON GEOCENTRE, SIGNAL HILL, ST. JOHN'S NEWFOUNDLAND

Following our long-standing tradition, and in keeping with our sense of the absurd, the 2009 Spring Technical Meeting was held once again in the depths of the Newfoundland winter at the remarkable Johnson GEOCENTRE on scenic Signal Hill in St. John's.

The 2009 meeting featured a thematic session entitled Exploring the Oceans: Geology, Technology, and Politics. In an era of global warming, melting ice-caps and diminishing energy supplies, attention is increasingly directed to the exploration of the ocean basins and distant continental shelves. The definition and mapping of the latter have become important issues for many nations, including Canada, with its incredibly long coastlines. This thematic symposium looked at the efforts underway to explore and define these regions, assess their resources, and potentially develop them. In addition to geological aspects, we were interested in the technological innovations needed to accomplish these goals, and the political ramifications of pursuing them.

In addition, the 2009 meeting featured a thematic session entitled "The Central Mineral Belt of Labrador at Fifty". About 50 years ago, the Central Mineral Belt of Labrador was defined as a "uranium metallogenic province" by A. P. Beavan. It is now the second most important area of uranium exploration in Canada, and potentially the site of several economic deposits. This session looked at what we now know about the geology and mineral resources of this region, and what we still need to discover and understand.

There was also a general session with presentations of papers on an eclectic range of topics, as is normally the case at our meetings.

GAC Newfoundland and Labrador is pleased to have once again hosted an interesting and diverse meeting, and we are equally pleased to see the abstracts published in Atlantic Geology. Our thanks to all of the speakers and the editorial staff of the journal.

ANDREW KERR
TECHNICAL PROGRAM CHAIR
GAC NEWFOUNDLAND AND LABRADOR SECTION

ATLANTIC GEOLOGY 45, 81–94 (2009)
0843-5561|08|010081–14$3.10|0

Mapping marine benthic habitats in coastal Newfoundland – the issues of spatial scales and acoustic footprint

JOHN T. ANDERSON
Northwest Atlantic Fisheries Centre, Department of Fisheries and Oceans, PO Box 5667, St. John's, NL, Canada A1C 5X1

Seabed habitat mapping involves three primary components: bathymetry, geology, and biology. Combined these attributes describe the geomorphology of the seabed and the biological communities that reside there. The issue of natural variability within a hierarchy of nested spatial scales and our ability to resolve these scales using acoustic techniques remains a high research priority. The issue of the acoustic footprint is inextricably linked to our ability to detect and map seabed habitats, where most surveys are done from surface ships. Greater depths result in larger footprints and a reduced ability to discriminate small-scale features while introducing a disparity in observation sizes that complicates data processing and confuses interpretation. A practical solution is to reduce and standardize the sampling range using autonomous underwater vehicles (AUV).

An acoustic seabed classification (ASC) survey was carried out in the rugged coastal terrain of Newfoundland using the ocean class MUN Explorer AUV and compared to a previous survey done from the surface. The study area ranged in depths from 19 m to > 200 m depth with areas of high bathymetric relief of 0.45 m m^{-1} (24° slope) associated with cobble substrates and low bathymetric relief of 0.14 m m^{-1} (8°) associated with gravel. Five survey lines 5 km in length and 50 m apart were sampled at a fixed range of 35 m from the seabed. Six acoustic classes of seabed were detected from the AUV survey. Surveying at a fixed range reduced the variability in the size of the acoustic footprint on the seabed by a factor of 25 times compared to sampling from the surface. There was a high degree of spatial heterogeneity in the pattern of acoustic classes compared to the surface based survey. The predominant spatial scale of spatially contiguous classes was = 10 m (99.6% of all observations). This is equivalent to the observational scale, indicating that the true spatial scale of acoustic seabed classes was smaller than could be measured from the surface-based survey.

Development of under-ice survey capabilities for autonomous underwater vehicles around the Illulisat Fjord, western Greenland

RALF BACHMAYER[1] AND BRAD DE YOUNG[2]
1. Faculty of Engineering and Applied Sciences, Memorial University, St. John's, NL, Canada A1B 3X5 ¶ 2. Department of Physics and Physical Oceanography, Memorial University, St. John's, NL, Canada A1B 3X5

Over the last decade Autonomous Underwater Vehicles (AUVs), including underwater gliders, have seen a significant increase in usage with applications ranging from seafloor mapping and imaging to mine detection and environmental monitoring. The success of these applications was based on the improvements in data quality and data collection cost. With this proven track-record, AUVs are ready to be applied into new areas that have previously been inaccessible, such as the deep sea and the Polar Regions. AUVs hold the promise to provide us with new insights into those regions. Around the world several research groups are mobilizing over the coming years to launch campaigns to further explore the Antarctic ice shelves, map parts of the Arctic Basin and eventually traverse the Arctic Basin using AUVs. For these potentially long missions, underwater navigation, communication, endurance, and reliability are the most significant hurdles to overcome.

After having successfully proven the viability of underwater gliders to operate in the harsh environment around Newfoundland, we participated in a scientific expedition to investigate the dynamic behavior of the Illulisat Glacier in Western Greenland. This particular glacier is a significant source for icebergs in the Northwest Atlantic. It is also one of the fastest flowing glaciers worldwide, with a significant acceleration over the last decade. The reasons for this increased flow rate are thought to be influenced by climate change and have sparked a debate about the importance of atmospheric and oceanographic factors on this system. In order to provide data about the oceanographic conditions the water inside the fijord has to be sampled. But since the glacier is flowing into the Illulisat Fjord and its debris keeps the fijord year around ice covered, the waters of the fjord are inaccessible by conventional sampling methods. As part of our expedition we used a glider to profile the water at the partially ice-free area at the mouth of the fjord. We also used a helicopter to dip a depth sounder and a man-handled CTD into small leads inside the fjord to obtain the first data points of this system. As part of a general exploratory phase we deployed a glider to profile an iceberg from underneath. The lessons learned from the sampling, the glider deployments, visual observations, and local knowledge are now used to design a cost-effective next step to bring an autonomous underwater vehicle into the fjord to provide better and denser oceanographic and bathymetric data of this fjord.

We plan to take advantage of two ice-free side arms, one on each side of the fjord, for launch and recovery. In order to recover the vehicle and the data, the glider has to autonomously navigate its way across the fjord in the presence of a number of unknowns, such as currents, bathymetry and icebergs, and find the ice-free side-arm. The initial concept is to use a modified 1000 m depth-capable glider that is assisted by an acoustic navigation system, to provide conductivity, temperature, depth and current information of a cross-section of the fjord. In the case of a successful mission this survey will be repeated and eventually expanded away from a purely cross-sectional survey to a mission penetrating further into the fjord, potentially using other types of AUVs with complementary capabilities.

A three-dimensional investigation of an aff. *Phycosiphon* ichnofabric from the Cretaceous Rosario Formation, Cajiloa, Baja California, Mexico (poster presentation)

MALGORZATA BEDNARZ AND DUNCAN MCILROY
Department of Earth Sciences, Memorial University, St. John's, NL, Canada A1B3X5

This study investigates the three-dimensional nature of the ichnofabric produced by a large (1 cm diameter) Phycosiphon-like trace fossil in a turbiditic siltstone. The fossil material comes from a succession of well exposed slide blocks in a slope channel complex from coastal exposures of the Cretaceous Rosario Formation at Cajiloa, close to the town of El Rosario, Mexico. The present material has been investigated by thin sectioning, serial slicing and CT scanning in order to gain a thorough understanding of the ichnofabric produced by the trace-maker. The material is also studied using mini-permeametry to investigate the effect that the aff. Phycosiphon have on the permeability of the siltstone. The 3D morphology of the trace is also compared to pre-existing models for the geometry of Phycosiphon.

Tree ring studies in Labrador: investigating spatial and temporal patterns in climatic and ecological factors affecting tree growth

TREVOR BELL[1], C. KENNEDY[1], A.D. DUMERESQ[1], P.H. NISHIMURA[1], P. TRINDADE[1], C.P. LAROQUE[1], AND A.B. YOUNG[2]
1. Department of Geography, Memorial University, St. John's, NL, Canada A1B 3X9 ¶ 2. Mount Allison Dendrochronology Laboratory, Mount Allison University, Sackville, NB, Canada E4L 1A7

Dendrochronology is the study of annual tree rings. By examining tree ring characteristics it is possible to elucidate environmental factors important for tree growth in a given region. The most common environmental factors affecting tree growth include temperature, precipitation, fire, and insect infestations.

The forests of Labrador represent the easternmost edge of the boreal forest and have been termed the "forest of disturbance", describing their reliance on fire, insect infestations, and other disturbance events to maintain arboreal diversity. Furthermore, the forests of Labrador, being adjacent to the Labrador Sea and their relatively high latitude in northern regions, make it ideal to investigate questions of marine influence, continentality, and potential climate change on the growth of boreal forest trees.

Our research approach varies from intensive, multi-species, single-site studies that illuminate species-specific disturbances (e.g., fire and insect infestations), to regional, multi-species networks that illustrate the spatially complex radial growth/climate relationship across Labrador. These regional networks divide Labrador into three regions: Eastern , Western and Northern.

In the Eastern Region the marine influence of the cold, foggy Labrador Sea is being investigated with a focus on differential growth responses of trees to various climatic factors. In the Western Region continental effects are being evaluated against the marine influence of the Labrador Sea in order to determine the extent and magnitude of that influence. Lastly, in the Northern Region latitudinal treeline sites have been sampled to investigate the climate-growth relationship of trees growing at the edge of their limit. As these trees are persisting at the edge of their limit they will be the first to feel the effect of any natural or anthropogenically forced climatic change. Therefore, once established this relationship will help us better understand how the boreal forest will respond to changing climatic conditions.

In addition to the regional networks of living trees spanning across Labrador, sub-fossil logs preserved in shallow ponds on upland tundra sites and abandoned terrace sediments of main river systems offer an opportunity to extend the paleoclimatic record of Labrador climate to approximately 3000–4000 years before present. Together, the tree ring data from these various studies will improve our understanding of boreal ecosystems in Labrador, with particular emphasis on their sensitivity to local climates, their evolution under past climates, and their predicted response to future, perhaps very different, climatic conditions.

Application of multibeam sonar technology for benthic habitat mapping in Newfoundland and Labrador

TREVOR BELL, RODOLPHE DEVILLERS, AND EVAN EDINGER
Marine Habitat Mapping Group, Department of Geography, Memorial University, St. John's, NL, Canada A1B 3X9

In this paper we describe an approach to benthic habitat mapping by supervised classification of multibeam sonar-derived data, with examples from coastal Labrador. Benthic habitat is a combination of seabed substrate and its associated biotic components. In our habitat mapping approach we assume that substrate controls the distribution of benthic biota, a relationship which has been established for nearshore and continental shelf environments elsewhere, and that substrate can be accurately mapped using acoustic seabed data acquired from multibeam sonar surveys. Multibeam data comprise both bathymetric and backscatter intensity values; the former provides information on water depth, slope angle, and general basin physiography, while the latter largely depends on seabed properties, such as texture and roughness and the occurrence of structure-forming biota. Multibeam data are ground-truthed using drop-video camera transects and benthic grab samples, with both video and grab sample data for each ground-truth point.

Once multibeam sonar and ground-truth data have been acquired and processed, our classification procedure involves the following steps: (1) identify unique substrate classes from grab-samples and video images; (2) use Exploratory Data Analysis (EDA) to examine the distribution of multibeam sonar-derived depth, slope and backscatter values for sampled stations in each substrate class; (3) from the EDA results, generate supervised classification rules for substrate mapping of multibeam coverage; (4) define habitats by determining which substrate classes have statistically unique biological assemblages; (5) establish statistically determined characteristic taxa for each habitat class; and (6) use a Geographic Information System (GIS) to execute the classification rules for each pixel in the gridded multibeam dataset and run accuracy and ambiguity tests on the mapped substrate and habitat classes. Accuracy maps are based on ground-truth data withheld from the initial classification procedure, while ambiguity maps determine the extent to which pixels were assigned multiple classes and the class associations. Parts of this procedure have been automated in a software tool developed as an extension to ArcGIS 9.2 to allow faster production of the substrate maps and the assessment of their accuracy.

Two case studies illustrate our mapping approach and highlight a range of applications in varied coastal settings. Nunatsiavut Nuluak is a research network that addresses Inuit concerns about the effects of climate change, modernization ,and contaminants on fiord-based marine ecosystems in northern Labrador. Our marine mapping component involved a baseline inventory and comparative assessment of benthic habitats in Nachvak and Saglek fiords; the former represents a pristine ecosystem adjacent to the Torngat Mountains National Park, whereas the latter has been exposed to a historical source of PCB contamination. Gilbert Bay is a Marine Protected Area (MPA) in southeastern Labrador, designated to protect a genetically unique population of Atlantic cod. The ecosystem-based management plan for the MPA requires information on benthic habitats for cod and other species to make scientifically defensible management decisions and establish monitoring protocols.

Marine record of sediment flux from glaciated and unglaciated catchments, Torngat Mountains, Canada (poster presentation)

Samuel J. Bentley and Elisbeth Kahlmeyer
Department of Earth Sciences, Memorial University, St. John's, NL, Canada A1B 3X5

Records of environmental processes and conditions (over decadal to millennial timescales) are very sparse for the Torngat Mountains National Park Reserve (Canada's newest National Park, in Northern Labrador/Nunatsiavut, Canada), although recent evidence indicates that the Labrador Peninsula is undergoing rapid environmental changes. In order to evaluate marine sedimentary records of river discharge (of sediment, a proxy for water discharge), a program of sonar seabed mapping, sediment coring, water-column measurements, and stream measurements was initiated in 2008 for the McCornick River (a presently glaciated catchment of 80 km² area), Nachvak Brook (presently unglaciated, 170 km² area), and associated marine basins in Nachvak Fjord and Saglek Fjord, respectively. In the summer of 2008, approximately 180 km of sidescan and subbottom survey lines were collected from deep, muddy marine basins closest to the two river mouths, to augment data collected during previous ArcticNet cruises. Boxcores were collected to sample specific acoustic facies identified in sonar, and cores were subsampled for analysis of sedimentary structures (X-radiography), radioisotope geochemistry (Th^{234}, Be^{7}, Pb^{210}, and Cs^{137}, to evaluate sediment depositional processes), and granulometry.

Preliminary analysis of sonar results suggest that the thickness of postglacial sediments in the marine basin for the McCornick River (16 km² area, 150–170 m deep) is 5–10 m, and 10–20 m in the basin off Nachvak Brook (20 km², 250 m deep), implying that sediment volumes are proportional to catchment area. In both basins, sediments have been deposited in wedges that thicken towards the river mouth. X-radiographs of sediment cores show very faint stratification in mostly bioturbated clay-rich sediments. The presence of stratification in bioturbated sediment, however faint, is suggestive of rapid episodic sediment delivery (such as by gravity-driven mechanisms), rather than from water-column plumes. This possibility is being evaluated in more detail at present through radiometric and granulometric analyses of cores. Rapid transfer via gravity-driven flows from river mouth to a deep, proximal marine basin would enhance the preservation potential of such episodic deposits, improving the utility of such sediment records as proxies for fluvial discharge in the recent past.

Be^{7} inventories as tracer for sediment movements on the inner shelf: western Atchafalaya River Delta, Louisiana, USA (poster presentation)

Susanne Brandstätter[1], Samuel J. Bentley[1], Stephanie Johnson[2], Gail C. Kineke[3], and Michelle Lermon[3]
1. Department of Earth Sciences, Memorial University, St. John's, NL, Canada A1B 3X5 ¶ 2. Newfoundland Labrador Offshore Petroleum Board, St. John's NL, Canada A1B 3X5 ¶ 3. Department of Geology and Geophysics, Boston College, Chestnut Hill, MA, USA 02467

Recent studies of many major fluvial-marine dispersal systems have identified the importance of high-density sediment suspensions (fluid muds) in cross-shelf transport of sediment, and resulting lithofacies distributions. We have undertaken seabed studies on the inner shelf west of the Atchafalaya River Delta to elucidate controls of cold-front passages and seasonal supply of river sediment on formation, deposition, and physical properties of muddy seabed. Sediment boxcores were collected during cruises in February, March, and April 2007 and

2008, coordinated with time-series hydrodynamic observations and coinciding with peak river discharge and the occurrence of ~weekly cold fronts that occur in winter and spring. Cores were taken along repeat transects perpendicular to the shoreline and subsampled for X-radiography, and measurements of grain size, water content, and Be^7 (half life 53.3d), a cosmogenic particle reactive radioisotope that can be used as a tracer of fluvially derived sediments in coastal-marine settings.

Measurable Be^7 activities were generally confined to physically stratified surficial sediments (the upper ~2–6 cm of the seabed) with high water content (porosity > 80%), indicating that these sediments were recently deposited and/or remobilized by waves and currents. Changes in spatial distributions of Be^7 inventories between cruises demonstrate that this high-porosity sediment layer (representing 7–20 kg of dry sediment per square meter of seabed) is highly mobile over monthly timescales, in response to wind-wave re-suspension and transport associated with cold fronts. Patterns of Be^7 inventories suggest that sediment is first delivered from fluvial sources to the east following peak river flow in early spring, and then deposited across a wide region extending 10–15 km from the shore. Subsequent sediment re-suspension and shoreward transport in the bottom boundary layer (associated with cold front passage) results in occurrence of high Be^7 inventories within 5–10 km of shore, landward of the 10 m isobath.

Hydrothermal dolomitization in the St. George Group, western Newfoundland

James Conliffe[1], Karem Azmy[1], Ian Knight[2], Denis Lavoie[3], and Sarah Gleeson[4]
1. Department of Earth Sciences, Memorial University, St John's, NL, Canada A1B 3X5 ¶ 2. Geological Survey of Newfoundland and Labrador, Department of Natural Resources, P.O. Box 8700, St. John's, NL, Canada A1B 4J6 ¶ 3. Geological Survey of Canada, GSC-Q, Natural Resources Canada, 490 de la Couronne, Québec, QC, Canada G1K 9A9 ¶ 4. Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, AB, Canada T6G 2E3

The Lower Ordovician St. George Group in Western Newfoundland consists of a sequence of subtidal and peritidal carbonates deposited on the on the southern margin of Laurentia during the Late-Proterozoic break-up of Rodinia. These carbonates are extensively dolomitized and are potential hydrocarbon reservoirs. The St. George Group dolomites are classified, based on petrography and cathodoluminescence, into three main generations (D_1, D_2, and D_3). Early and pervasive replacement dolomicrite (D_1) is fine grained and indicates that dolomitisation began during early stages of diagenesis at almost near-surface conditions. Later stage replacement dolomites (D_2) are associated with enhancement in porosity through the development of intercrystalline pores, while latest stage saddle dolomite (D_3) and late burial calcite cements significantly occluded the pores in some horizons. Fluid-inclusion homogenization temperatures range from 60 to 130°C for D_2 dolomites and from 85 to 145°C for D_3 dolomites, and are generally higher than temperatures predicted from burial histories. This implies that D_2 and D_3 dolomites were formed from warm, saline (up to 25 eq. mass% NaCl) fluids of hydrothermal origin. Stable isotope data indicates that these fluids are basinal in origin.

The occurrence of high porosity associated with D_2, combined with tight limestone beds, presence of favourable source rocks, and thermal maturation, indicates that hydrothermal dolomite plays in the St. George Group carbonates are possible potential hydrocarbon reservoirs and suitable targets for future hydrocarbon exploration in western Newfoundland.

Provenance of ophiolite to arc transition in the peri-Laurentian realm, central Newfoundland Appalachians (poster presentation)

April Coombs
Department of Earth Sciences, Memorial University, St. John's, NL, Canada A1B 3X5

The study area is a complex and economically important area in Newfoundland and is located west of the Red Indian Line in the peri-Laurentian realm of the central Newfoundland Appalachians. The area consists of various island arc and back-arc basin complexes that were juxtaposed following the Middle Ordovician closure of the Iapetus Ocean along the Red Indian Line. The region hosts many prospects and showings and is a focus for active exploration for base and precious metals. Volcanogenic massive sulphide (VMS) deposits occur on both sides of the Red Indian Line, including the Buchans mine which hosted a world class VMS deposit. Since the VMS deposits are hosted in a variety of volcanic terranes at different structural and stratigraphic levels, the understanding of local stratigraphy is paramount for terrane interpretation and VMS exploration.

The subject of this study is a polymictic volcanogenic breccia-conglomerate unit that is located to the southwest of the town of Buchans within the Red Indian Lake Group of the Annieopsquotch accretionary tract. Samples of the unit for this study were collected in the Wiley's Brook area by the Geological Survey of Canada as part of the Targeted Geosciences Initiative (TGI-3) program in order to detail the provenance and significance of the breccia-conglomerate unit. This is accomplished by SHRIMP U-Pb dating of detrital zircons and lithogeochemistry of constituent clasts and proximal volcanic rocks. Constraining the provenance of the clasts may help to reconstruct the nature of the basin, local source rocks, and depth of exposure of the basin-flanking structures. An understanding of the contribution of the well-dated source terranes and detrital geochronology will help to constrain the age of the unit. Together they may allow an evaluation of whether the breccia-conglomerate unit has more affinities to the Buchans or Red Indian Lake group, or forms a geological link between the two.

The breccia-conglomerate horizon studied herein has been

interpreted to stratigraphically overlie the Skidder Formation, which is host to the Skidder VMS prospect. The unit is relatively thin and spatially restricted. However, similar breccia-conglomerate horizons occur throughout the Buchans-Roberts Arm Belt at approximately the same time interval. Widespread occurrence of this time marker may tectonically link the various terranes. Association of breccia-conglomerate units with the Buchans Group VMS ore bodies may suggest an extensional setting, and hence a large-scale fragmentation of a peri-Laurentian arc; however, their origin is poorly understood. This current project offers an opportunity to contribute to the stratigraphic and structural framework of VMS-prospective terranes by deciphering the local history of volcanism, sedimentation and tectonism. An understanding of these processes has direct implications for active exploration for volcanogenic massive sulphides in the area.

Towards mapping eastern Canada's shallow marine habitats using optical remote sensing

PATRICK GAGNON
Ocean Sciences Centre, Memorial University, 1 Marine Lab Road, St. John's, NL, Canada A1C 5S7

Optical remote sensing is increasingly used to map shallow, marine benthic habitats for investigation of coastal community changes associated with broad scale phenomena such as climate change and biological invasions. A few factors, including the attenuation of light by the water column and inaccuracies of positional devices used to acquire the imagery and associated ground truth data, can reduce our ability to discriminate bottom features, and hence create accurate classification maps of shallow marine habitats. In this paper, I discuss recent research along the coast of Nova Scotia to map the extent of the invasive green alga, Codium fragile, and native kelp species using airborne hyperspectral remote sensing. Specifically, I compare the accuracy of classified map products created with low- (soundings by the Canadian Hydrographic Service [CHS]), intermediate- (soundings with a fish finder), and high- (radiative transfer algorithm) resolution bathymetric grids as core data input to conventional image classifiers. Contrary to our prediction, the use of a low-resolution bathymetric grid interpolated from soundings by the CHS provides the highest classification accuracy of both kelp and carbon fragile habitat classes. Inescapable positional mismatch between the imagery and ground data likely accounted for the observed differences in the classification accuracies. Future research directions that include the use of hyperspectral remote sensing are presented briefly.

Depositional processes on a rapidly prograding muddy intertidal flat complex, Firth of Thames, North Island, New Zealand (poster presentation)

TRISANDHI GOSINE[1], SAM BENTLEY[1], AND ANDREW SWALES[2]
1. Department of Earth Sciences, Memorial University, St. John's, NL, Canada A1B 3X5 ¶ 2. National Institute of Water and Atmospheric Research, Hamilton, New Zealand 3219

In this study, we analyse the depositional processes on a muddy intertidal flat complex in New Zealand, in the Firth of Thames estuary, 70 km southeast of Auckland on the North Island, using a combination of radiochemical and granulometric analyses and X-radiography of sediment cores. The mangrove habitat in this area has been expanding rapidly over the last 50 years and is attributed to the impact of development on the surrounding areas. Changes in land use and deforestation have contributed to increased sediment yields to the estuary. This build-up of sediment is rapidly altering coastal ecosystems in the area. Along the seaward edge of the mangrove forest seedlings are colonizing open mud flats allowing forests to expand. Our study aims to increase the understanding of sediment deposition in the open mud flat areas and to understand the processes involved in sediment mixing along the fringe of the mangrove. Five cores were collected in March 2006 on a transect extending 1 km seaward of the mangrove fringe on the open unvegetated intertidal flat. Cores collected have been analysed for sediment-bound radioisotopes (^{7}Be, ^{210}Pb, ^{137}Cs), as well as grain size and sedimentary fabric, through X-radiography.

X-radiographs and ^{7}Be profiles indicate intense and rapid mixing (by waves) of the uppermost 3–7 cm of sediment on unvegetated flats. Sediment accumulation rates of 2–3 cm/y (from ^{210}Pb analysis of cores) are occurring on the unvegetated flats, much slower accumulation than the 5–10 cm/y accumulation rates observed landward in the outer edges of mangrove forest. Our observations suggest that the wave-swept unvegetated mudflats accrete relatively slowly until an elevation threshold is reached that allows mangrove recruitment. Sediment accretion in the mangrove fringe remains low until vegetation is sufficiently dense to reduce wave exposure, whereupon more rapid sediment accumulation ensues, as the young trees mature.

This depositional setting is similar to that of the many other tropical to subtropical muddy coasts worldwide, where muds accumulate on energetic open coastlines. Mechanisms of sediment transport and deposition are not well understood in these widespread environments, and we hope that our study will allow us to better understand the processes and rates of change governing morphodynamics in these important coastal settings.

Palaeoenvironments and fabrics of fine-grained sediments: the Lower Ordovician Beach Formation, Bell Island, Newfoundland, Canada (poster presentation)

DARIO HARAZIM, DUNCAN MCILROY, AND JOE MACQUAKER
Department of Earth Sciences, Memorial University, St. John's, NL, Canada A1B 3X5

The Lower Ordovician Bell Island Group (Bell Island, Newfoundland), represents stacked shallow marine cycles deposited on a storm-dominated shelf. The lower part of the Tremadocian Beach Formation was developed in a lower shoreface environment with dark-grey to black clay-bearing, silt-rich mudstone interbedded with cross-stratified, fine-grained sandstone. The studied interval (5 m) is heavily bioturbated by trace fossils of the proximal Cruziana Ichnofacies. Previous studies of the Bell Island Group have outlined the importance of storm-wave reworking in a shallow shelfal setting by investigating the physical sedimentary structures and facies architecture of sandstone beds, including consideration of their lateral extent. Those studies, however, neglected the associated mudstone facies, and their implications for sedimentary facies interpretation. The approach we present in this study combines the outcrop study with hand specimen and low-power examination of thin sections. Our findings support the previousinterpretation that the Beach Formation was deposited as a heterolithic lower shoreface succession, but also show that sedimentary processes operating through sandstone intervals also act to produce the interbedded mudstone layers. Scour marks, erosional surfaces, and other transport-related structures identified in thin section show that previous interpretations, which would conventionally place siderite-enriched intervals and a layer lacking bioturbation in a low-energy, low-oxygen environment, are erroneous. The process-sedimentological study of mudstone/siltstone presented herein demonstrates that the same strong wave/storm generated currents that deposited the sandstone also controlled rapid mudstone deposition. We suggest that study of mudstone fabric and ichnofabric is an essential component of rigorous facies analysis and the basis for fully integrated palaeoenvironmental reconstructions.

New insights into the evolution of the Paleoproterozoic rocks of the Aillik Group and implications for the tectonic evolution of the Makkovik Province

ALANA M. HINCHEY
Geological Survey of Newfoundland and Labrador, Department of Natural Resources, P.O. Box 8700, St. John's, NL, Canada A1B 4J6

Regional bedrock mapping in the Aillik domain of the Makkovik Province, Labrador, has further defined the lithological units that occur within this domain. The Aillik domain largely comprises the Paleoproterozoic Aillik Group (previously termed the Upper Aillik Group), a supracrustal assemblage consisting of metasedimentary and metavolcanic rocks, which were intruded by abundant, syn- and post-deformation Paleoproterozoic intrusive suites.

Detailed bedrock mapping has further constrained the tectonostratigraphy of the Aillik Group. The Aillik Group comprises polydeformed, upper-greenschist to lower-amphibolite facies, bimodal volcanic rocks and sedimentary lithologies and hosts abundant base-metal and uraniferous showings. Aillik Group stratigraphy is complicated by lithological units that are not laterally continuous and locally complex structures causing stratigraphic repetition .

New geochronological data from this project indicates that felsic volcanism in the Aillik Group was longer lived than previously recognized. New U-Pb zircon data indicate that felsic volcanism occurred as early as ca. 1883 Ma. This suggests that the Aillik Group records felsic volcanism for at least 18 Ma to possibly as long as 35 Ma (incorporating the errors). New geochemical data for the Aillik Group illustrate a continuum from active-arc to back-arc/arc rift volcanic settings. These new data need to be accommodated in a refined tectonic model for the formation of the Aillik domain and Makkovik Province as a whole.

A multi-proxy study on decadal to centennial time-scale variations in freshwater discharge recorded in the marine sedimentary record of the Nelson River estuary (Manitoba) and offshore of the Great Whale River mouth (Quebec) in Hudson Bay (poster presentation)

PETER HÜLSE AND SAMUEL J. BENTLEY
Department of Earth Sciences, Memorial University, St. John's, NL, Canada A1B 3X5

This study aims to bring recent variations in river water discharge into the Hudson Bay Basin into an appropriate centennial to millennial climatic context by studying the marine sedimentary record. This will help to distinguish between natural variability and possible anthropogenic impacts due to global warming.

The marine sedimentary record of two field localities, the Nelson River estuary (western coast of Hudson Bay) and a sedimentary basin offshore of the Great Whale River mouth (eastern coast of Hudson Bay), will be used to study river water and sediment discharge, marine sediment dispersal and accumulation processes and the history of river runoff variations in Hudson Bay. Recent observations in river discharge from the Canadian Shield to the Canadian sub-Arctic/ Arctic show large variations during the past forty years. These variations have a substantial influence on the marine ecosystem and on sea-surface conditions and deep water formation in the Labrador Sea and thus on the global thermohaline circulation. There is a critical need to increase our understanding of paleo-river-discharge variations to place our current knowledge in a longer climatological context and to prepare for possible future changes. The study applies a multi-proxy approach to

relate freshwater discharge to sediment discharge and to delineate variations in freshwater discharge within the sedimentary record on decadal to centennial timescales. Hydrographic modeling programs help to estimate river discharge variations under varying climatic conditions. Further, variations in river discharge are used to estimate sediment discharge. High-resolution short-lived radioisotopes (^{7}Be, ^{234}Th, ^{210}Pb, ^{137}Cs) help to elucidate sediment accumulation rates and post-depositional alteration processes to evaluate the potential for preservation and the temporal resolution of the sedimentary record. Because short-lived radioisotopes cannot be applied in the study of the long-term record, granulometry and different imaging techniques (X-radiography, thin-sections) are used to recognize sedimentary structures. Further, stable isotopes (^{18}O, ^{13}C) will be used to delineate variations in terrestrial influence in the sedimentary record, in addition to major element chemistry and the mineralogical composition of the sediment. A multi-sensor core logger will supply additional information on sediment properties, such as grain size, lithology, and color, to study variations in terrestrial input. The geochronological framework will be established by ^{14}C dating.

First results from the Nelson River estuary show that sedimentation occurs due to fluvio-tidal re-suspension on topset beds, and possibly also as gravity-driven fluid muds in the foreset and bottomset region. Offshore of the Great Whale River a large sedimentary basin was discovered, which will provide several thousand years of river runoff history with an estimated temporal resolution of approximately 20 years.

The search for uranium in the Great White North — similarities and differences amongst four Canadian Proterozoic settings

C.W. Jefferson, W. Davis, P. Ramaekers, R. Rainbird, S. Bosman, K. Chamberlain, T. Peterson, and W. Bleeker
Geological Survey of Canada, 601 Booth Street, Ottawa, ON, Canada K1A 0E8

Prospective intracontinental basins developed 100 to > 400 million years before local tectonic adjustments mobilized and precipitated uranium during the Proterozoic. Low-temperature hydrothermal alteration pervaded these basins, and regional layer-parallel flow has been modeled between hypothetical diagenetic aquitards, supported by some diagenetic features. Nevertheless, deposit-specific alteration is most obviously associated with fault systems that were active before, during, and after deposition of multiple, unconformity-bound, fluvial sequences. Reactivated steep faults, lateral thickness and facies changes, and basement uplifts clearly enhanced the vertical components of fluid flow, redox, and alteration. Telltale uraniferous phosphate cements formed at a range of sites just before uraninite deposition was focused where certain reactivated structures intersected geochemically favourable basement rocks, mafic dykes with contact metasomatic effects in sandstone, or stratigraphic facies changes. Such structural and temporal coincidences provide unique vectors and events for exploring each basin.

The largest, highest-grade deposits and potential are unchallenged in the Athabasca Basin, but at least three other basins offer viable potential. The Athabasca Basin was initiated ~1750 Ma with its fourth sequence still accumulating after 1541 ± 13 Ma (Re-Os isochron on oil shale). Local tectonic rejuvenation generated a regional angular unconformity between sequences 2 and 3 that is constrained by basin-transecting uranium-bearing fluorapatite cement (U-Pb ~1640 to 1610 Ma), and felsic tuff (U-Pb 1644 ± 13 Ma) above that unconformity. Pre-ore hydrothermal minerals near the basal unconformity were formed ~1670–1620 Ma. The principal uraninite ore deposits have so far yielded U-Pb ages as old as 1600–1500 Ma. Newly dated uraniferous fluorapatite in Thelon Basin (U-Pb 1667 ± 6 Ma) formed about 80 million years after basin initiation (< 1750 Ma) and prior to similar Athabasca cements. Thelon apatite has yet to be linked temporally to regional unconformities or uraninite, but is found in at least the lower two sequences, predates the Kuungmi shoshonite flows (U-Pb 1540 ± 30 Ma), and occupies a range of sites including altered basement, basal silicified breccia and higher soft-sediment faults. Brittle fault arrays are associated with basin margins, and with unconformity uranium deposits hosted by Archean or Paleoproterozoic strata and/or 1750 Ma granitic complexes. In Otish Basin > 440 million years separated basin initiation (U-Pb > 2170 Ma) from alteration (K-Ar and Sm-Nd 1730 Ma) associated with uranium deposits along fault offsets of the basal unconformity and northerly trending mafic dykes. In "Hornby Bay Basin" more than 450 Ma, dramatic basin reorganization, and volcanism at 1667 ± 8 Ma separated initiation of detrital sedimentation (< 1750 Ma) from deposition of the uranium host sandstone that contains local xenotime cement (U-Pb 1284 ± 11 Ma) in corrosive contact with detrital quartz and early quartz cement. Fluorapatite then cemented lower strata (U-Pb 1160 ± 80 Ma), not long before uraninite was disseminated in sandstone (U-Pb 1050 ± 50 Ma). Here the ore trap was an overlying carbonaceous unit within a graben superimposed on an older horst. In summary, each basin has its own structural, lithologic, and temporal coincidences to better quantify for exploration.

Recent sediment delivery and accumulation in three subarctic fjords (poster presentation)

Elisabeth Kahlmeyer and Sam Bentley
Department of Earth Sciences, Memorial University, St. John's, NL, Canada A1B 3X5

Sediment cores from three subarctic fjords on the Nunatsiavut/Labrador coast (Canada) have been studied to evaluate patterns of sediment delivery and accumulation over the past century. The fjords span a gradient of human impact, from Nachvak Fjord (a pristine fjord within the Torngat

Mountains National Park), to Saglek Fjord (on the southern edge of the Torngat Mountains, undeveloped except for a small military installation), to Anaktalak Fjord, the site of significant mining and associated activities over the past two decades. Onboard the CCGS Amundsen in 2007, boxcores were collected from deep muddy basins (depth 100–250 m) in each fjord. Basin floor coring targets were selected in sonar data collected during and before the Amundsen 2007 cruise. Cores were sub-sampled and analyzed for grain size, sedimentary fabric and structures (via X-radiography), and Pb^{210}/Cs^{137} radioisotope geochronology.

X-radiographs show that sediments in each core have been bioturbated moderately to intensely, bioturbation imparting relatively homogeneous fabric to each core, with no obvious physical stratification. Radioisotope analyses suggest that sediment accumulation rates vary among fjords over the range of 0.18–0.26 cm/y with results from Pb^{210} and Cs^{137} being broadly consistent. Using the landward reaches of Nachvak Fjord as a specific example, seabed bathymetry appears to tightly constrain the location of depocenters for fluvial sediment. Accumulation rates estimated for one basin with an area of ~10 km^2 suggest that annual total sediment accumulation is on the order of 16 × 106 kg/y. This equates to relatively modest sediment yields from adjacent river catchments of < 105 kg/y, despite the steep topography and mostly unvegetated landscape. Thus, the bathymetry in fjord basins appears to focus modest sediment supply and creates a relatively high resolution stratigraphic record of fluvial sediment supply over the past 100–200 y.

Single beam acoustic classification technologies: a method for fisheries habitat identification

Chris Keats
School of Ocean Technology, Marine Institute, P.O. Box 4920, St. John's, NL, Canada A1C 5R3

The use of acoustic technologies for seabed classification is continuously evolving to provide an efficient means of habitat mapping for scientists and managers. Understanding the nature and distribution of habitat and the relationship between biomass and habitat is essential for the effective management of the marine environment and fisheries, especially as the exploitation of marine biological resources increases. The present rate of habitat degradation in marine ecosystems is alarming, and conservation of marine biological diversity is critical.

Recent advances in acoustic remote sensing technologies are providing researchers with the capability to describe and map marine environments effectively and efficiently. Many different acoustic remote sensing systems have been used to map seabed character, including sidescan sonar, multi-beam echosounder and single-beam echosounder. However, this paper focuses specifically on the utility and limitations of single beam echosounders.

Single beam echosounder data from fisheries acoustic surveys in Smith Sound, Trinity Bay, were analyzed. Categorization of the data was performed using acoustic seabed classification software, QTC Impact™, and interpreted using a geographic information system (GIS). An unsupervised classification was utilized on two acoustic data sets (2006 and 2007), which revealed virtually identical classification results. Generally, the data presented different acoustic classes along on the periphery (slope) and bottom of the study area. However, without ground truth data, no definite seabed identification or assessment of accuracy could be ascertained. Nevertheless, several logical assumptions were made in an attempt to justify differences in acoustic response.

Good vibrations in the infra-red: some pilot studies from Newfoundland illustrating the potential of reflectance spectroscopy in economic geology research

Andrew Kerr, Heather Rafuse, Greg Sparkes, John Hinchey, and Hamish Sandeman
Geological Survey of Newfoundland and Labrador, Department of Natural Resources, PO Box 8700, St. John's, NL, Canada A1B 4J6

Many common minerals exhibit characteristic absorption spectra for visible and infra-red electromagnetic radiation, and VIRS techniques can identify them and place general constraints on their compositions and relative abundances in natural samples. VIRS is ideally suited to the study of alteration assemblages, in which minerals are commonly very fine-grained or entirely cryptic, and may be difficult to identify from petrography. Portable VIRS instruments are now used extensively in mineral exploration and mining for varied applications, but are not yet standard tools in research-oriented studies. The Geological Survey of Newfoundland and Labrador acquired an ASD Terraspec Pro^{R} VIRS instrument in 2008, and is now applying it to a variety of problems.

The acquisition of VIRS data is extremely easy and rapid, to the point where proper organization of results and retention of their exact geological/locational context becomes a significant consideration. There are automated computer programs that can quickly identify the most abundant responsive mineral species in samples, but our experience suggests that a more systematic assessment of spectra, using human reasoning, is very important to extract the maximum possible amount of data and understand the significance of results. This is particularly true where samples contain more than one responsive mineral, which is commonly the case. As the method is to a large extent empirical, careful use of reference spectra is very important to ensure that minerals are not inadvertently confused. As in conventional petrographic analysis, the first step in systematic assessment of results are knowing what to look for, partly on the basis of known geological associations between mineral species.

To date, several pilot studies have been completed in association with metallogenic studies projects. These include assessment of epithermal-like alteration assemblages in epi-

genetic gold and syngenetic VMS systems, superimposed propylitic and potassic alteration facies in a Mo-Cu porphyry system, skarn-like alteration associated with uranium mineralization, and distinctive "spotty" alteration in sedimentary country rocks near mesothermal gold veins. Each investigation produced interesting results that illustrate the utility of the method, but each also raised some unexpected complications in interpretation of data. In short, these pilot studies provided a valuable and illustrative learning experience that allowed us to improve our systematic procedures for acquisition and interpretation of VIRS data. This rapid and easy technique clearly has great potential as a research tool in economic geology but, like any analytical method, it will always be most useful where it is constrained by other independent types of data such as petrography and lithogeochemistry.

"CAGE": a new uranium province, Nunavik, Quebec

J. Neto[1], C. Caillat[2], S. Genest[3], M. Cuney[1], C. Marignac[1], L. Lescuyer[1], J.L. Feybesse[1], N. Goulet[4], J. Bonhoure[1], and F. Castorina[5]
1. Nancy Université, CNRS, CREGU, BP239, F54506, Vandoeuvre les Nancy, France ¶ 2. AREVA, Paris La Défense, France ¶ 3. Omégalpha, Québec, Canada J6E 7Y8 ¶ 4. University de Quebec Montreal, Montreal, Québec, Canada H3C 3P8 ¶ 5. Rome University, La Sapienza, Rome, Italy

The CAGE district was discovered during an exploration survey made in 2005 in Northern Québec, by Claude Caillat (AREVA) and Serge Genest (Omegalpha). The district is located in the northeastern Canadian Shield, at the eastern margin of Ungava Bay. The U showings are located in Paleoproterozoic metasedimentary rocks (Lake Harbour Group) that were deposited on a passive margin epicontinental platform setting. High-grade metamorphism with partial melting occurred during the Torngat collision (1.86–1.74 Ga). Several pegmatoid generations were injected into the metasedimentary rocks. The strongly differing structural, mineralogical and geochemical characteristics of each generation reflect derivation by partial melting from a variety of protoliths. The pegmatoid bodies are generally poorly mineralized in U, except for some located outside the CAGE district (e.g., Amaujaq). Two types of mineralization have been distinguished according to their geological setting, mineralogical, and geochemical characteristics, but both give the same age on uraninite (1790 ± 10 Ma).

The first type is hosted by impure dolomitic marble (with phlogopite – olivine – K-feldspar) and skarnoids (diopside – tremolite – phlogopite – K-feldspar – scapolite), resulting from nearly isochemical metamorphism of impure dolomitic limestone or marl. The ore mineral is pure uraninite with REE patterns characterized by a decreasing fractionation from the LREE to HREE, with neutral or a slightly positive Eu anomaly and a low total REE. The uraninite is consistently associated with enriched Ba (Ba-rich K-feldspar and phlogopite, celsiane, kampfite, baryte), V (coulsonite $Fe^{++}V^{+++}{}_2O_4$, V-pyroxene), Zn (sphalerite), Pb (non-radiogenic galena), S-Cu (pyrite, pyrrhotite, chalcopyrite, chalcosite), As (arsenopyrite), Sb (ullmanite NiSSb) and Mo (molybdenite). The scapolite composition (40 < marialite % < 60) and kampfite $[Ba_{12}(Si_{11}Al_5)O_{31}(CO_3)_8Cl_5]$ suggest the influence of evaporitic fluids. Graphite is locally observed in the marble. Organic matter and/or sulphide minerals may have represented the initial U traps. The uraninite could have been present in the marble prior to metamorphism or it may have been introduced during metamorphism.

The second type of U mineralization is hosted by calc-silicate rocks (skarnoids or primary skarns) located in the vicinity of pegmatoid injections in transtensional settings. The endoskarns are dominated by scapolite and the exoskarns by Fe-rich diopside. Newly formed tremolite, scapolite (20 < Marialite % < 70), phlogopite, and calcite in veins and vugs are spatially associated. The ore minerals are Th-rich uraninite and uranothorianite, characterized by high REE contents, a weak global fractionation, and a marked Eu anomaly. These are typical of magmatic uraninite, in particular that of the Rössing alaskite. Both uranium enrichment and the late vein minerals are seemingly related to expulsion of magmatic fluid from the latest pegmatites. This event corresponds to transtension near the end of the tectonic-magmatic cycle, also typical of the Rössing setting.

U-enrichment in the CAGE province is interpreted to have started with the emplacement of U-rich high-K Archean granite in the basement. During the Paleoproterozoic, U was leached from the Archean granite and trapped in the reduced epicontinental platform sedimentary rocks. Partial melting of the metasedimentary rocks and possibly of the basement gneiss led to the formation of U-rich anatectic melts and fluids which were trapped in overlying marble, forming the second type of mineralization. The first type of mineralization may be of sedimentary or diagenetic origin with local remobilization by metamorphic fluids.

TGI 3 Deep Search Project: development and testing of new and improved methods of exploring for deeply buried base-metal deposits

Neil Rogers
Geological Survey of Canada, 601 Booth St, Ottawa, ON, Canada K1A 0E8

The TGI 3Deep Search Project is a thematic, multidisciplinary and collaborative project with the primary objective of developing, testing and applying new and innovative methods of exploring for base-metal deposits concealed at depth in the Earth's crust. The Government of Canada instigated the TGI 3 research program to conduct mapping to help sustain the base-metal reserves around existing mining communities. To this end a series of regional projects were established for some of Canada's major base-metal regions, such as the Central Mobile Belt of Newfoundland. In complement to these projects, the

Deep Search Project was instigated to develop and test new methodologies that will assist in the discovery of buried deposits, whether they are hidden beneath 200 m of bedrock or 5 m of till. The project has four primary objectives: (i) to develop and test new and innovative methods of exploring for buried base metal deposits in mature mining camps; (ii) to define potential exploration targets by applying new methodologies in major mining districts, TGI3 project areas; (iii) to transfer new methods and technologies to the exploration industry; and (iv) to mentor and train highly qualified personnel by supervising post-doctoral fellows, graduate students, and students employed during the summer in field programs. To achieve its stated objectives the Deep Search Project consist of five major themes: (1) Primary Vectors: mineralogical and geochemical vectors, and new genetic models for base metal deposits (e.g., alteration and hydrothermal sediment vectors, hyperspectral mapping); (2) Surficial Vectors: mineralogical and geochemical methods of detecting deposits buried beneath glacial sediments (e.g., indicator minerals, groundwater hydrology and geochemistry, soil geochemistry); (3) Geophysics: deeply penetrating methods of detecting buried deposits (e.g., 3D seismics, magnetotellurics (MT), EM, gravity, etc.); (4) 3D Modelling: build 3D geological models of mining camps and belts, map the subsurface distribution of ore horizons, integrate multiparameter data and define potential targets, and develop new interpretive tools; and (5) New Exploration Tools: testing and application of new technology (e.g., Innov-X portable XRF, ASD Field Spec Pro portable hyperspectral system, precision in situ micro-analysis of minerals using ICP-MS and MC-ICP-MS technology.

These research themes are being tested across Canada, some in tandem with other TGI 3 projects in well established mining areas, such as the Kidd-Monroe argillite vectors in the Abitibi Provence, and others over undeveloped mineral deposits such as in the Hackett River greenstone belt.

Fine grained sediment depositional model associated with channel-fan system in deepwater Gulf of Papua, insight from seafloor geomorphology and microfacies analysis (poster presentation)

Erlangga Septama and Sam Bentley
Department of Earth Sciences, Memorial University, St John's, NL, Canada A1B 3X5

A multi-scale investigation has been carried out in a modern deep-sea channel-fan system in the Gulf of Papua by integration of cores, bathymetric and geo-acoustic data, in order to relate sediment supply with resultant seabed morphology and facies. The major axial channel extends >800 km southeastward from the upper slope, and is interpreted to correspond with development of a fold ridge in the shelf break. Decreasing modern sediment accumulation from the proximal shelf edge (0.35–0.28 cm/y) to the basin floor (0.07–0.05 cm/y) suggests that either the underlying morphology retains sediment near the shelf edge or that the major input point is shifting landward, restricting detrital transport further basinward during the present sea level highstand.

Five microfacies units have been established based on our observations. Unit 1, distributed widely across the basin and slope, is characterized by partially mottled silt and clay with sparse biogenic structures. The morphology of large vertical burrows suggests the slow vertical sedimentation from a nepheloid layer depositing a loose particulate substrate. Unit 2 consists of upward thinning muddy beds/laminae typical of Bouma sequence Td or Te units. Facies character suggests formation via a combination of low-density turbidity currents and hemipelagic deposition. Both units 1 and 2 are associated with semi-prolonged acoustic echo. Unit 3 is composed of thinly bedded turbidites (± 25 cm), associated with continuous parallel reflector echoes. Sawtooth density profiles have sharp bed contacts that appear erosional in thin section. This unit contains woody debris, is locally intensely bioturbated by horizontal traces, and is attributed to levee facies, formed via channel spillover. Unit 4 is found at the toe of slope, and is composed of thick turbidites. Echo character includes regular overlapping hyperbolae. Density logs are consistent with amalgamated turbidites forming agradational channel fill. Unit 5 displays blocky density log profiles, and irregular hyperbolic acoustic echoes might represent slump facies from channel sidewall.

Results show the basin is still receiving active and continuous terrigenous sediment supply through the channel system during the present sea level highstand, and could be used to better understand the evolution of other deep sea systems over centennial-millennial time scales.

Altius' Kamistuatusset Project: an Iron Maiden's tour through Labrador West

Carol Seymour, Lawrence Winter, Roland Butler, and Jackie O'Driscoll
Altius Resources Inc, Bond Street, St. John's, NL, Canada A1C 5J9

The iron ore mining district of Labrador West and adjacent Quebec is Canada's largest iron ore producer with over 50 years of production. The district is located in the southern extension of the Labrador Trough within the Grenville tectonic province of the Canadian Shield. The area lies close to the Grenville Front within the Grenville Front Tectonic Zone. All of the past and present production and exploration programs in the district are centered on the Lower Proterozoic Superior-type iron formations of the Knob Lake Group. The Knob Lake Group is a continental-margin sedimentary sequence which was deformed and subjected to greenschist to upper amphibolite-facies metamorphism during the Grenville Orogeny. Regional deformation and metamorphism plays a key role in making the iron formation of the Knob Lake Group economic. The distribution of ore bodies in the district is controlled by superimposed F_1/F_2 synclines which causes thickening of the

iron formation through repetition. Ore mineralogy consists of specular hematite, magnetite, and locally martite, with quartz as the major gangue mineral. Regional metamorphism has caused an increase in grain size of the ore minerals making the ore more amenable to concentrating and pelletizing.

Altius has been active in Labrador West since 2003 and is now the second largest licence holder in the district with several iron ore exploration projects. The Kamistiatusset Project is located in the heart of the region's transportation, power, and mining infrastructure. The property has seen limited previous exploration, but covers several significant iron ore prospects. Work by Altius includes a helicopter-borne magnetic survey, ground magnetic and gravity surveys, geological mapping, sampling, and 6008 m of diamond drilling, all of which confirm both a favorable geologic setting and ore mineralogy. The 2008 diamond drilling program returned results of up to 31.65% Fe (27.26% magnetite) over 120 m.

The preliminary classification of diverse uranium mineralization in the Central Mineral Belt region, Labrador

Greg Sparkes and Andrew Kerr
Geological Survey of Newfoundland and Labrador, Department of Natural Resources, P.O. Box 8700, St. John's NL, Canada, A1B 4J6

The Central Mineral Belt (CMB) of Labrador has long been known to host significant uranium resources, which were identified in the late 1970s. Due to a downturn in uranium market prices, little exploration for the commodity has been carried out in that region since the early 1980s. A recent resurgence in uranium prices has brought about a new era of intensive uranium exploration in the CMB, which has resulted in the further expansion of known uranium resources as well as the discovery of new uranium deposits and numerous new occurrences. This resurgence in exploration continues to expand the boundaries of known uranium mineralization, and provides a continual steam of new information that broadens out current knowledgebase with regards to the mineralizing environments within the CMB and surrounding region. Presently, known uranium occurrences are considered to have developed in broadly magmatic, metamorphic-metasomatic, and sedimentary environments. These environments represent a protracted period of uranium mineralization which has now been identified discontinuously over ca. 200 km of strike length.

Magmatic mineralization of syngenetic affinity is represented by uraniferous pegmatites and aplites, and also by some mineralization hosted by undeformed or little-deformed felsic volcanic rocks. Magmatic-hydrothermal mineralization of an epigenetic affinity is represented by breccia-hosted mineralization associated with iron metasomatism, and is locally associated with V, Cu, and Ag enrichment. Mineralization of possible metamorphic-metasomatic origin is hosted by felsic metavolcanic and pelitic metasedimentary rocks that have experienced strong deformation. These are characterized by pre- or syndeformational timing, location in shear zones, and associated Na-metasomatism. The exact origins of the metamorphic-metasomatic mineralization remains obscure, but hydrothermal transport and deposition of uranium during regional deformation and metamorphism may be important processes in Labrador. Mineralization in sedimentary environments is hosted mostly by terrestrial sedimentary rocks, within which uranium appears to be linked to the localized reduction of oxidized sequences. This mineralization may have affinities to sandstone-hosted mineralization known mostly from Phanerozoic sequences, or to some mineralization associated with Proterozoic unconformity-style deposits.

Much of the mineralization within the CMB region has been affected by post-mineral deformation which has resulted in the local remobilization of primary uranium mineralization. Such effects make the classification of the mineralization somewhat problematic as many of the primary features are masked by later deformation. Despite this fact, several commonalities can be seen between the various styles of uranium mineralization, and lends further support to multiple mineralizing events within the region.

The new gold rush: seafloor hydrothermal research and marine mining

Maurice Tivey
Department of Geology and Geophysics, Woods Hole Oceanographic Institution, Woods Hole, MA, USA 02543

Once the sole purview of research scientists, deep-sea hydrothermal vent systems are now attracting considerable interest from commercial mining companies. Hydrothermal vent systems precipitate metal-rich seafloor massive sulfide (SMS) deposits in the form of chimneys many meters tall, collapsed edifices, and mounds tens to hundreds of meters across with a stockwork zone that penetrates several tens of meters beneath the seafloor. These deposits are rich in copper, zinc, gold and silver and are typically found in a midocean ridge spreading environment as well as in back-arc spreading systems and associated with active seamount volcanism. Commercial and political interest in SMS deposits in the deep sea has been encouraged by several factors. The offshore oil and gas industry has pushed into deeper waters (> 3000 m depth) over the past decade and technologies for accessing and exploiting SMS deposits have emerged. Furthermore, the infrastructure costs of mine development and ore extraction are likely to be much less than conventional terrestrial projects. Similarly, geophysical and geological exploration of the deep sea has become more efficient with the use of Remotely-Operated vehicles (ROVs) and autonomous underwater vehicle (AUV) mapping technology. Perhaps the most important factor, however, has been the dramatic rise in the price of metals such as copper, zinc, gold, and silver over the past few years. In the past decade, several start-up companies were formed to specialize in the exploration and possible development of SMS deposits, seeking min-

ing claims with countries such as Papua New Guinea, Tonga, and New Zealand. While the economic news of recent times has seen a decline in metal prices and perhaps a cooling of activity on the commercial side, the political side of the equation is continuing. The deep sea resources of the ocean floor beyond the national jurisdictions of the EEZs and continental shelves is under the purview of the International Seabed Authority (ISA), a body created by the treaty of the United Nations Convention on the Law of the Sea (UNCLOS) in 1982. ISA recently announced plans to divide the global mid-ocean ridge into segments for exploratory licenses, similar to areas already claimed by national interests for polymetallic nodule mining in the central Pacific. In 2007, the ISA published its first "Draft regulations on prospecting and exploration for polymetallic sulphides in the Area", which includes block sizes (10 km × 10 km, not to exceed 100 contiguous blocks) and annual fees. It is unknown what the effects of nationalizing or privatizing these areas might have on continued free access to the High Seas and the Area for marine scientific research, however, it may offer opportunities too. Woods Hole Oceanographic Institution (WHOI) has a long-standing interest in the study of hydrothermal vents on the mid-ocean ridge, with research towards an understanding the geological, chemical and biological processes that create the Earth's crust and sustain life adapted to the extreme environment of the deep sea. Recently, WHOI scientists collaborated with a commercial mining company to characterize and quantify the mineral resource of hydrothermal vent fields in the Bismarck Sea of Papua New Guinea. WHOI's approach to fast, high-resolution, multi-parameter mapping and precision measurements along with sampling and analysis contribute to a framework for discovery and exploration in the new frontier of deep sea mining.

Regional mapping in the eastern Seal Lake Group

Tim Van Nostrand
Geological Survey of Newfoundland and Labrador, Department of Natural Resources, PO Box 8700, St. John's, NL, Canada A1B 4J6

The Mesoproterozoic Seal Lake Group in central Labrador consists of a succession of six formations of argillaceous and arenaceous sedimentary rocks, intercalated with basalt flows and intruded by gabbro sills. The entire group is folded into an east-trending syncline of which the southern limb has been overturned and thrust northwards during Grenvillian deformation. The group is host to numerous copper sulphide and native copper occurrences and minor uranium mineralization.

Regional mapping in the eastern Seal Lake area included rocks representative of all six formations and several known copper occurrences were investigated. Two periods of deformation are recognized. The first regional event produced a dominant east-northeast-striking fabric, resulted in folding of the main syncline and fault development along the limbs and hinge area. A later deformation resulted in folding of the main fabric into small-scale folds and open warps. A dominant south-southeast plunge of mesoscopic, first generation fold axes define the plunge of the main syncline. Prevalent south-plunging mineral lineations suggest a north-directed thrust component is present in east-trending faults. Metamorphic grade ranges from chlorite-tremolite assemblages in the southern map area to pumpellyite facies in the north.

Examination of known mineral occurrences in the eastern Seal Lake area confirm native copper, malachite, and bornite mineralization hosted by quartz + carbonate veins associated with fractures and small-scale shear zones proximal to basalt-slate contacts. Bornite, chalcocite, Cu-carbonates, and chalcopyrite are also hosted in gabbro sill margins. Several new copper indications and minor uranium mineralization were identified during the 2008 survey.

Delineating Canada's continental shelf in the Atlantic and Arctic oceans

Jacob Verhoef
Geological Survey of Canada, Atlantic, P.O. Box 1006, Dartmouth, NS, Canada B2Y 4A2

Canada ratified UNCLOS (United Nations Convention on the Law of the Sea) in 2003 and now has till 2013 to submit scientific information to a United Nations Commission to establish the outer limits of its continental shelf where it extends beyond 200 nautical miles in both the Arctic and Atlantic Oceans.

To meet that deadline, Canada has developed a program to collect scientific data in the Atlantic and Arctic Oceans. In the Atlantic, new data has been collected on the Scotian Margin and on the Grand Banks. In the Arctic Ocean, the data acquisition is more challenging due to unpredictable weather and ice conditions. New data have been acquired from ice camps (eastern Arctic) and using icebreakers in the western Arctic. Canada has been collaborating, where possible, with other Arctic countries in joint surveys (Denmark, USA). This presentation will provide an overview of the data acquisitions and summarize the achievements of the program.

Canada has developed an active program to establish the outer limits of the continental shelf in the Arctic Ocean and is on track to submit the results to the UN Commission by the deadline of the end of 2013. The preliminary results are very positive for Canada's case.

The Labrador Central Mineral Belt: 80 years of mineral exploration history

Derek H.C. Wilton
Department of Earth Sciences, Memorial University, St. John's, NL, Canada A1B 3X5

The Central Mineral Belt (CMB) comprises six Proterozoic supracrustal sequences, granitoid suites, and adjacent Archean

basement in central to coastal Labrador. Tectonically the belt encompasses the Makkovik Province, southern portions of the Hopedale Block, Nain Province, the northeast margins of the Grenville Province and the Seal Lake Group successor basin (and Mid-Continent Rift analogue). Lithological units include late Archean granitoids through ca. 2.0–2.1 Ga Post Hill and Moran Lake groups, the ca. 1860 Ma Aillik Group, ca. 1650 Ma Bruce River Group, ca. 1337 Ma Letitia Lake Group, ca. 1250 Ma Seal Lake Group, and a variety of granitoid and mafic dyke suites.

The CMB encompasses 260 km × 75 km and contains some of the most metallogenically enriched crust in Labrador. Commodities present include significant reserves and resources of uranium, and appreciable resources of copper, molybdenum, base metals and Be-Nb. Styles of mineralization range from intrusion-related, syngenetic SEDEX, veins, shear zone-hosted, silicate skarn, and iron formation (albeit small in the case of the latter). The first mineral exploration program in the belt was directed at sediment-hosted massive sulphide occurrences of the Croteau Lake area in 1929. Copper was discovered in the Seal Lake region in 1946, Pb-Zn veins north Moran Lake in 1953, uranium around Makkovik in 1954, Be at Letitia Lake in 1958, and molybdenum near Cape Aillik in 1959. Intensive exploration work led to the discovery of the Kitts U Deposit in 1956, the Moran "C" U prospect in 1958, and the Michelin U Deposit in 1967. The CMB was also the proving ground for regional geochemical surveys in the late 1950s. Since 2005, the CMB has been the focus on intense mineral exploration, most especially at the Michelin Deposit where mineral production had been planned to start in 2013. Other prospects have been extensively examined since 2005, and new uranium discoveries such as Jacques Lake, Anna Lake and Two-Time have been made.

