The Atlantic Geoscience Society (AGS)
La Société Géoscientifique de l'Atlantique

36th Colloquium and Annual Meeting

Special Sessions:
Metallic Ore Deposits in Atlantic Canada
Geohazards in Atlantic Canada
Bay of Fundy Studies
Geochronology: Solving and Making(?) Geological Puzzles

General Sessions:
Current Research in the Atlantic Provinces

5-6 February, 2010
The Old Orchard Inn,
Greenwich, Nova Scotia

PROGRAM WITH ABSTRACTS

Welcome to the 36th Colloquium and Annual Meeting of the Atlantic Geoscience Society in the Old Orchard Inn. You have contributed a diverse and very full program, which we believe you will find stimulating, broadening, and the source of much discussion. It is one of the strengths of the geoscience community in the Atlantic region that it convenes annually at its Colloquium where not only do members have the opportunity to relate their own discoveries and understanding but also actively participate in those areas of our discipline where we are perhaps less current. Note also the opportunity we have provided this year for the members to take some time to ponder the future directions of the Society.

The Old Orchard Inn provides a superb meeting space and comfortable lounge – be sure to take in the science on the posters, and the displays from sponsors. And don't miss the after-banquet jam and open mike on Saturday night.

We hope you will be able to use the weekend to renew old acquaintances, make new ones, and further the aims of the Society.

The organizers,
Rob Raeside, Ian Spooner

We gratefully acknowledge sponsorship from the following companies and organizations:

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ATLANTIC GEOSCIENCE SOCIETY
36th COLLOQUIUM AND ANNUAL GENERAL MEETING
5-6th February, 2010
The Old Orchard Inn, Greenwich, Nova Scotia

PROGRAM SUMMARY

Locations: see plan, inside back cover

Friday, 5th February, 2010

12 noon – 1.00 p.m. *Atlantic Geology* editors meeting, Huggins Science Hall 316, Acadia University
1.30 – 5.00 p.m. Workshop: The Teaching of Evolution. Clark Commons, Acadia University
3.00 – 5.00 p.m. Poster set-up, Fireside Room and hall
4.00 – 9.00 p.m. Registration, Orchard Hall foyer, The Old Orchard Inn
5.00 – 6.45 p.m. AGS Council meeting, Salon 304
5.00 – 7.00 p.m. Poster Session, refreshments courtesy of Nova Scotia Department of Natural Resources: Geological Surveys Branch
7.00 – 9.40 p.m. Geochronology: solving and making(?) geological puzzles, Salon ABC
7.00 – 9.40 p.m. Geohazards in Atlantic Canada, Salon D
9.40 – 11.30 p.m. Poster session and cash bar

Saturday, 6th February, 2010

8.00 a.m. – 4.30 p.m. Posters are available all day
8.00 – 9.20 a.m. Geochronology: solving and making(?) geological puzzles, Salon ABC
8.20 – 10.00 a.m. Current Research in Atlantic Canada, Salon D
8.20 – 10.00 a.m. Bay of Fundy Studies, Salon E
9.20 – 10.00 a.m. Metallic Ore Deposits in Atlantic Canada, Salon ABC
10.00 – 10.20 a.m. Refreshment break (courtesy of Potash Company of Saskatchewan)
10.20 – 12 noon Metallic Ore Deposits in Atlantic Canada, Salon ABC
10.20 – 12 noon Current Research in Atlantic Canada, Salon D
10.20 – 12 noon Bay of Fundy Studies, Salon E
12 noon – 2.00 p.m. Luncheon and Annual General Meeting, Blomidon Room
2.00 – 2.45 p.m. Plenary Session: The Atlantic Geoscience Society: Future Directions
2.45 – 3.00 p.m. Refreshments break (courtesy Engineers and Geoscientists New Brunswick)
3.00 – 4.20 p.m. Current Research in the Atlantic Provinces, Salon ABC
3.00 – 4.40 p.m. Current Research in the Atlantic Provinces, Salon D
5.30 – 6.30 p.m. APICS (Geology Committee), Board Room 201
6.00 – 7.00 p.m. Cash Bar, Fireside Room
7.00 p.m. – midnight Awards banquet and social. Guest speaker, Daniel Lebel, Regional Director General, Environment Canada (Atlantic Region), and President of the Geological Association of Canada
"Canadian Geoscience: Charting New Territory in the 21st Century"

after dinner – midnight: Open mike, showcasing instrumental and voice in the Fireside Room.

TECHNICAL PROGRAM

Posters:

Sessions:
Friday, 5th February, 5.00 – 7.00 p.m., 9.40 p.m. to 11.30 p.m.
Saturday, 6th February: posters will be up all day and available for viewing until 4.30 p.m.
Posters should be set up between 3.00 and 5.00 p.m. on Friday afternoon (or as soon as possible thereafter), and taken down promptly by 4.30 p.m. on Saturday.

Student presentations (all student presenters are eligible for the Graham Williams Award for Best Student Poster; * = presented by an undergraduate student; ** = presented by a graduate student)

Bay of Fundy Studies

Advanced approaches for video footage and photograph analysis in the Bay of Fundy Kerstin Jerosch, Vladimir Kostylev, and Brian Todd

****Comparison of vertical and temporal variations in hydrodynamics on macro-tidal mudflat and salt marsh surfaces in the Bay of Fundy** Casey O'Laughlin and Danika Van Proosdij

Geohazards in Atlantic Canada

Mass wasting in Newfoundland and Nova Scotia – a review Ian Spooner, Dave Liverman, Norm Catto, Martin Batterson, Wayne McAskill, and Fenton Isenor

Metallic Ore Deposits in Atlantic Canada

***Anomalous Zn concentrations in the West Barneys River Intrusion, Antigonish Highlands, Nova Scotia** Harun Alrashid Mohamad Idris & Cliff Stanley

***Carbonic fluid inclusions in the Greendale (NS) and Lac Des Iles (ON) complexes: constraints on mafic pegmatite crystallization and platinum-group element (PGE) mineralization** Evan Gladney and Jacob Hanley

General Session

****Investigating the use of chlorine stable isotopes to identify sources of chloride in stream water** Timothy P. Bachiu, Anne-Marie O'Beirne Ryan, John Gosse and Thomas A. Clair

The historic lime quarry at Green Head, Saint John, New Brunswick Diane N. Buhay and Randall F. Miller

***Petrology and gold grade variations in different lithologies at the Dachang Gold Deposit, Qinghai, China** Jiaxing (Chancy) Cheng & Cliff Stanley

****Analysis of the short and long-term processes involved in coastline erosion** N. Crowell, T. Webster, and S. Bondrup-Nielsen

Assimilation processes in the South Mountain Batholith: evidence from apatite D. Barrie Clarke and Anne Jähkel

Characterization of eroding bedrock shorelines – examples of rates, processes and form continuity Philip Finck

***A petrological study of REE-rich carbonatite intrusions from the Lofdal Farm area, Namibia** Alexander Kaul and Sandra M. Barr

CO_2 geological storage potential and capacity in New Brunswick David Keighley and Crystal Maher

****Flood-risk mapping from storm surges and future sea-level rise in Antigonish County, Nova Scotia** K. Leblanc, T. Webster, and I. Spooner

Correlating Lake Agassiz floods to the onset of the 8.2 ka cold event C.F. Michael Lewis, Ann A.L. Miller, Elisabeth Levac, David J.W. Piper, and Gary V. Sonnischen

The Quaternary Lancaster Sound trough-mouth fan, NW Baffin Bay Gang Li, David J.W. Piper, and D. Calvin Campbell

A putative *Arthropleura* body impression, Lower Pennsylvanian Tynemouth Creek Formation, New Brunswick, Canada R.F. Miller, A.R. Bashforth, H.J. Falcon-Lang, and M.R. Gibling

***Results of a ground magnetic survey over the Bloody Creek impact structure, Bridgetown, Nova Scotia** Emma Murowinski, Michael Robertson, and Cliff Stanley

HydroPhysical™ Logging: A new wellbore technology for hydrogeologic and contaminant characterization of aquifers William H. Pedler, Charles R. Head, P.E., and Lacey L.Williams

****Petrology, petrogenesis, and economic potential of the Landry Brook and Dickie Brook plutons, northern New Brunswick** Jean-Luc Pilote, Sandra M. Barr, and Reginald A. Wilson

****Airborne lidar fluorescence analysis for the quantification of water quality characteristics** S. Rogers, T. Webster, N. O'Driscoll, and B. Livingstone

***Petrology and tectonic setting of mafic dykes in the Boisdale Hills, Cape Breton Island, Nova Scotia** Christopher D. Stevens and Sandra M. Barr

****Field relations, petrology, tectonic setting and economic potential of metamorphic and igneous rocks in the Whycocomagh Mountain - Aberdeen Ridge area, Cape Breton Island, Nova Scotia** David A. Swanton, Chris E. White, and Sandra M. Barr

***Geochemical data applied to geohazard mapping in Nova Scotia** F. Tweedale, T. Melanson, N Brooks, D. Campbell, T. Jacques, T. Kelly, and A.M. O'Beirne-Ryan

Pre-Carboniferous stratigraphy in the Bridgetown-Windsor area, southern Nova Scotia Chris E. White, David A. Swanton, and Kara-Lynn Scallion

***Evaluating the effects of wastewater treatment on marine sediment chemistry in Halifax Harbour, Nova Scotia** G. Williams, M.B. Parsons, J. Hellou, and D.B. Scott

Oral Presentations:

All undergraduate student presenters are eligible for the Rupert MacNeill Award for the best undergraduate student oral presentation and graduate students for the Sandra Barr Award for the best graduate student oral presentation. *Undergraduate Student Presenter; **Graduate Student Presenter.

Friday evening, 7.00 – 9.40 p.m., Salon ABC

Geochronology: solving and making(?) geological puzzles

Chairs: Sandra Barr (Acadia University) and Chris White (NS DNR)

7.00-7.20 **David J.W. Piper, Georgia Pe-Piper, and Yawooz Kettanah** Sedimentology, detrital petrology and regional linkages of the Lower Cretaceous Bjarni Formation, Labrador Shelf

7.20-7.40 ****David G. Lowe and Paul J. Sylvester** Provenance and paleodrainage patterns of Late Jurassic to Early Cretaceous synrift sandstones in the Flemish Pass Basin, offshore Newfoundland

7.40-8.00 **R.A. Wilson, S. Kamo, and C.R. Van Staal** Use of geochronology in tracing the Middle Paleozoic evolution of the Tobique-Chaleur zone, northern New Brunswick

8.00-8.20 **John W.F. Waldron, David I. Schofield, S.M. Barr and C.E. White** Cambrian successions and detrital zircon geochronology of Megumia. Are southern Nova Scotia and North Wales dispersed fragments of a single peri-Gondwanan basin?

8.20-8.40 ****E. A. Escarraga, S.M. Barr, J.B. Murphy and M.A. Hamilton** Field relationships, petrology, age and tectonic setting of previously inferred Devonian-Carboniferous granitic plutons in the Antigonish Highlands, Nova Scotia

8.40-9.00 **J. Brendan Murphy, Michael A. Hamilton, and Bryan Leblanc** Tectonic significance of the Late Ordovician McGillivray Brook Formation, northern Antigonish Highlands, Nova Scotia

9.00-9.20 ****D.R. Skipton, G.R. Dunning, and G.W. Sparkes** New insights into the geology of a Late Neoproterozoic igneous complex in the Avalon Zone, Newfoundland

9.20-9.40 **Greg Dunning** Solving geological puzzles with U/Pb titanite geochronology

Friday evening, 7.00 – 9.40 p.m., Salon D

Geohazards in Atlantic Canada

Chairs: Daniel Utting (NS DNR) and Ian Spooner (Acadia University)

7.00-7.20 **D.L. Forbes, J. Charles, G.K. Manson, C. Hopkinson, R.B. Taylor, R. Wells, and D. Whalen** Evaluating coastal run-up, erosion, and flooding hazards for climate-change adaptation and hazard mitigation in the Halifax Regional Municipality, Nova Scotia

7.20-7.40 **Timothy Webster** Airborne LiDAR for coastal zone risk mapping in the Maritimes

7.40-8.00 **D.J. Utting, G.J. Demont, T.A. Goodwin, T. Broughm, and T. Webster** Identification of geohazards using LiDAR, Nova Scotia

8.00-8.20 **M.B. Parsons, H.E. Jamieson, S.L. DeSisto, and J. Kavalench** Assessing and reducing risks from high-arsenic gold mine tailings in Nova Scotia

8.20-8.40 ***Kelsey O'Brien** Radon soil gas in Halifax Regional Municipality

8.40-9.00 **D. Finlayson-Bourque and G. W. Kennedy** Investigation into potential controls on uranium concentration in new production wells intercepting a Triassic sandstone aquifer, Bridgetown, Nova Scotia

9.00-9.20 **Gavin W. Kennedy, K.G. Garroway, and D. Finlayson-Bourque** Estimation of regional groundwater budgets in Nova Scotia using a desktop GIS approach

9.20-9.40 **G J. DeMont** Incorporating geohazard mapping and risk assessments in land use planning

Saturday morning, 8.00 a.m. – 9.20 a.m., Salon ABC

Geochronology: solving and making(?) geological puzzles (continued)

Chairs: Sandra Barr (Acadia University) and Chris White (NS DNR)

8.00-8.20 **Alana M. Hinchey** Utilizing U-Pb SHRIMP geochronology to constrain the timing of Paleoproterozoic magmatism: a case study from the Makkovik Province, Labrador

8.20-8.40 ****C. Laflamme, Alana M. Hinchey, and Paul J. Sylvester** *In situ* Hf-isotope zircon data from two Paleoproterozoic bimodal volcanic segments of the Aillik Group, Makkovik Province, Labrador

8.40-9.00 **G.W. Sparkes, G.R. Dunning, and V. J. McNicoll** New U-Pb age constraints on the Kitts uranium deposit, Central Mineral Belt, Labrador

9.00-9.20 ***Andrea MacFarlane, Greg Dunning, and Alana Hinchey** A petrographic, geochemical, and geochronological study of the Southern Numok Intrusive Suite, Labrador

Saturday morning, 9.20 a.m. – 10.00, Salon ABC

Metallic Ore Deposits in Atlantic Canada

Chairs: Sandra Barr (Acadia University) and Jacob Hanley (St. Mary's University)

9.20-9.40 **Andrew Kerr and Vicki McNicoll** Geology and U-Pb geochronology of Mesoproterozoic magmatic sulphide mineralization in Western Labrador

9.40-10.00 **Hamish A. Sandeman and Heather Rafuse** The setting of orogenic, auriferous quartz veins at the Jaclyn Deposit (Golden Promise), central Newfoundland

Saturday morning, 8.00 a.m. – 10.00 a.m., Salon D

Current Research in Atlantic Canada

Chairs: Georgia Pe-Piper (St. Mary's University), Grant Wach (Dalhousie University)

8.00-8.20 ****Sheridan Thompson and Norm Catto** - Coastal Erosion at Mistaken Point Ecological Reserve (MPER), Newfoundland, Canada

8.20-8.40 **Grant D. Wach, David C. Mosher, D.C. Campbell, M.K. Giles, and V.I. Brake** Margin evolution and reservoir distribution – slope depositional systems along the Scotian margin

8.40-9.00 ****Michael Giles, David Mosher, and Grant Wach** Mass transport deposits on the southwestern Newfoundland Slope: Eastern Canada

9.00-9.20 **Atika Karim, Jacob Hanley, Georgia Pe-Piper and David J.W. Piper** Hydrocarbon migration and thermal history of reservoir sandstones deduced from fluid inclusions, Scotian Basin, offshore eastern Canada

9.20-9.40 ***Adam Fraser and Grant Wach** Trends and architecture of the Bluestone Formation turbidites in Point Pleasant Park

9.40-10.00 **Tim Webster, Nathan Crowell, Danik Bourdeau, Kate Leblanc, and Stephanie Rogers** The integration of ground-based and airborne laser scanning for coastal zone mapping

Saturday morning, 8.20 a.m. – 10.00 a.m., Salon E
Bay of Fundy Studies

Chairs: Elisabeth Kosters and Brian Todd

8.20-8.40 **Elisabeth Kosters and Brian Todd** Opening remarks

8.40-9.00 **D. Russell Parrott, Brian J. Todd, John Shaw, Vladimir Kostylev, John E. Hughes Clarke, Jonathan Griffin, and Michael Lamplugh** Multibeam bathymetry surveys of the Bay of Fundy, Canada – progress to November 2009

9.00-9.20 **Brian J. Todd, John Shaw, D. Russell Parrott, and Vladimir E. Kostylev** Mapping the glacial history of the Bay of Fundy

9.20-9.40 **Michael Z. Li, Charles Hannah, Will Perrie, Charles Tang, Robert Prescott, and David Greenberg** Numerical model predictions of seabed shear stress, sediment mobility and sediment transport in the Bay of Fundy

9.40-10.00 **John Shaw, Carl L. Amos, David A. Greenberg, Charles T. O'Reilly, D. Russell Parrott, and Eric Patton** Rapid tidal expansion in the upper Bay of Fundy, Canada: Validation of the Glooscap legend.

----- Refreshment Break -----
Refreshments courtesy of Potash Company of Saskatchewan

Saturday morning, 10.20 a.m. – 12 noon, Salon ABC
Metallic Ore Deposits in Atlantic Canada (continued)

Chairs: Sandra Barr (Acadia University) and Jacob Hanley (St. Mary's University)

10.20-10.40 ****M. Minnett, H.A. Sandeman and D. Wilton** Regional setting of gold mineralization at the Viking property, southern White Bay, western Newfoundland

10.40-11.00 **J.A. Walker, and D. Clark** Preliminary investigation of the Mount Costigan Zn–Pb–Ag ± Cu deposit, west-central New Brunswick

11.00-11.20 ***Nic Guest** Preliminary characterization of ore-forming fluids associated with a gold occurrence in northern New Brunswick

11.20-11.40 **Daniel Kontak and Kurt Kyser** Geochemical parameters constraining mineralization within an IOCG metallogenic domain: Case studies at Mt. Thom and Copper Lake Cu-(Co-Au-Ni) deposits, Nova Scotia

11.40-12 noon **John F. Wightman** Qualitative gold grain analysis to target blind deposits: "Kemptville" - A Nova Scotia case study

Saturday morning, 10.20 a.m. – 12.00 noon, Salon D
Current Research in Atlantic Canada

Chair: Martin Gibling, and Neil Davies (Dalhousie University)

10.20-10.40 ***Jordan Nickerson and Grant Wach** Architecture and geometry of a braided channel complex in the Triassic Wolfville Formation, Nova Scotia

10.40-11.00 ****Kirsten Kennedy and Martin Gibling** Sedimentology and paleobiological importance of the Campbellton Formation, New Brunswick

11.00-11.20 ***M. Stimson and R.A. MacRae** Evidence of fossil horseshoe crabs from Joggins, Nova Scotia: Paleoichnology and paleonvironmental implications

11.20-11.40 **Neil S. Davies, Michael C. Rygel, and Martin R. Gibling** Not the oldest evidence for complex life on land: the Juniata Formation (Upper Ordovician, Pennsylvania)

11.40-12.00 **M.R. Gibling and N.S. Davies** Rooted vegetation and the Siluro-Devonian expansion of meandering rivers

Saturday morning, 10.20 a.m. – 12 noon, Salon E

Bay of Fundy Studies

Chairs: Elisabeth Kosters and Brian Todd

10.20-10.40 **David Greenberg** Models and data for tidal power studies

10.40-11.00 **Richard H. Karsten** Assessment of tidal current energy in the Bay of Fundy

11.00-11.20 **Gordon B. J. Fader** Site selection for in-stream tidal power devices in Minas Passage – New insight into the marine geology of the Bay of Fundy

11.20-11.40 ****Casey O'Laughlin and Danika Van Proosdij** Spring-neap sediment dynamics within a macro-tidal salt marsh tidal creek: preliminary findings

11.40-12 noon **S. K. Haslett** Student fieldwork opportunities in macrotidal estuaries: Quaternary geoscience examples from the Severn Estuary, UK.

Atlantic Geoscience Society Luncheon and Annual General Meeting
Blomidon Room (tickets required) 12 noon – 2.00 p.m.

Saturday afternoon, 2.00 p.m. – 2.45 p.m., Salon ABC
Plenary session: The Atlantic Geoscience Society: Future Directions
Chair: Grant Ferguson. Panelists: David Piper, Elisabeth Kosters
----- Refreshment Break -----
Courtesy of Engineers and Geoscientists New Brunswick

Saturday afternoon, 3.00 p.m. – 4.20 p.m., Salon ABC

Current Research in the Atlantic Provinces

Chair: Rebecca Jamieson and Kara-Lynn Scallion (Dalhousie University)

3.00-3.30 ****Kara-Lynn Scallion, Rebecca A. Jamieson, Sandra M. Barr, Chris E. White, and Saskia Erdmann** Contamination of plutons by manganiferous country rock in the Governor Lake area, north-central Meguma terrane, Nova Scotia

3.30-3.40 **Rebecca A. Jamieson** The Big Dig: Lithologies, isograds, and other "outcomes" of the Freshwater Brook sewer replacement project

3.40-4.00 ***Elizabeth Walsh** The alteration of the Neoproterozoic Georgeville Group in the aureole of the Georgeville Pluton, Antigonish Highlands, Nova Scotia

4.00-4.20 ***Trevor Brisco, Ian Spooner, Peir Pufahl, Edward King, and George Stevens** The North Group - A possible multiple impact crater site in southwestern Nova Scotia

Saturday afternoon, 3.00 p.m. – 4.20 p.m., Salon D

Current Research in the Atlantic Provinces

Chair: Anastasia Vander Most (Potash Co. of Saskatchewan) and Peir Pufahl (Acadia University)

3.00-3.20 **Anastasia Vander Most, T. Danyluk, B. Pedler, and C. Hamilton** Comparing geophysical logging tools and how they can assist in hydrogeological model building: A case study in the Mabou Group near Sussex, New Brunswick

3.20-3.40 ****Chris Hamilton, A. Vander Most, C. Hawkes, and D. Milne** Preliminary investigation of the Mabou Group hydrogeology in the Sussex region, New Brunswick

3.40-4.00 ****Cole T. Edwards, Peir K. Pufahl, and Eric E. Hiatt** Paleoproterozoic microbial communities in the Ferriman Group, Labrador Trough, Canada

4.00-4.20 ***A.R. Christians and R. Andrew MacRae** Reexamining Pleistocene tunnel valleys on the Scotian Shelf and their implications for slope sediment delivery

4.20-4.40 **Grant Ferguson and S.E. Grasby** Thermal springs and geothermal exploration

ABSTRACTS

(*Undergraduate Student Presenter; **Graduate Student Presenter, † Poster)

Anomalous Zn concentrations in the West Barneys River Intrusion, Antigonish Highlands, Nova Scotia†

*HARUN ALRASHID MOHAMAD IDRIS AND CLIFF STANLEY

Department of Earth and Environmental Science, Acadia University, Wolfville, Nova Scotia, B4P 2R6, Canada <cliff.stanley@acadiau.ca>

This study investigates the association between an Ordovician granitoid intrusion and anomalous Zn concentrations in stream sediments in the West Barneys River drainage basin, Antigonish Highlands, Nova Scotia. Samples from this intrusion exhibit Zn concentrations up to 352 ppm, far exceeding the average granitoid Zn concentration of 60 ppm. Two lines of investigation were undertaken to determine the source of the anomalous Zn. First, a ground magnetometer survey was undertaken to constrain the distribution of the four variably-magnetic units comprising the intrusion (fine-grained alkali feldspar granite, granophyric alkali feldspar granite, coarse-grained alkali feldspar quartz syenite, and gabbro/quartz gabbro). The magnetometer survey identified locations of highly magnetic units (gabbro/quartz gabbro), and the boundaries of the intrusion. Second, because of sparse outcrop, a soil (instead of rock) geochemical survey was carried out to determine the locations of anomalous Zn concentrations. The geochemical survey involved 320 samples sieved to -177 μm and analyzed by aqua regia/ICP-MS. Soil Zn concentrations exhibit a mean of 189 ppm, but range up to 1094 ppm, and thus far exceed the global average concentration of Zn in soils (50 ppm). A comparison of the results of these two surveys provides insight into the spatial relationship of Zn concentrations and intrusive rocks. Anomalous soil Zn concentrations most commonly occur in or adjacent to West Barneys River in the western part of study area, an area underlain by the quartz syenite and granophyric alkali feldspar granite phases. Results from this study identify the portions of the West Barneys River intrusion that may contain anomalous concentrations of Zn, and thus constrain where additional research into the cause of the anomalous Zn concentrations should be undertaken.

Investigating the use of chlorine stable isotopes to identify sources of chloride in stream water†

**TIMOTHY P. BACHIU[1], ANNE-MARIE O'BEIRNE RYAN[1], JOHN GOSSE[1], AND THOMAS A. CLAIR[2]

1 Dalhousie University, Halifax NS, B3H 3J5 Canada <tbachiu@dal.ca> ¶ 2 Water Science and Technology Directorate Environment Canada, Sackville, NB, Canada <tom.clair@ec.gc.ca>

Chloride is often assumed to be a conservative ion in the hydrological cycle and is used as a tracer ion to represent marine input via atmospheric deposition to inland fresh waters. Consistently observed discrepancies between measured catchment deposition chloride input and stream water exports are often resolved by inferring that the excess chloride enters watershed systems as unmeasured fog and/or dry deposition. The application of chloride as a marine tracer has been verified to some extent in watersheds close to the ocean where seaspray is easily measured. However, chloride deposition as aerosols or fog has not been measured and quantified for watersheds further inland. Chlorine stable isotopes offer a new method to distinguish sources of chloride in stream water. Values of chlorine stable isotopes are reported as $\delta^{37}Cl$, a ratio of ^{37}Cl / ^{35}Cl in reference to Standard Mean Ocean Chloride. Analytical uncertainty resulting from daily repeat analyses of seawater is better than 0.26‰ (1 σ) and represents uncertainty from sample preparation and instrument precision. In southwestern Nova Scotia, the chlorine stable isotope composition of fog (-1.71‰ to -0.21‰), precipitation (-2‰ to -1‰), soil solution of B and C horizons (-1.57‰ to -0.81‰), mineral bound chloride of soil and bedrock (-0.96‰ to +2.3‰) and stream water of two watersheds (-1.5‰ to -0.5‰) confirms precipitation is not the sole contributor of chloride to stream water. Results suggest both fog and bedrock could be significant contributors to the chloride budget of these streams.

The North Group - A possible multiple impact crater site in southwestern Nova Scotia

*TREVOR BRISCO[1], IAN SPOONER[1], PEIR PUFAHL[1], EDWARD KING[2], AND GEORGE STEVENS[1]

1. Department of Earth and Environmental Science, Acadia University, Wolfville, NS, B4P 2R6 Canada <trevor_brisco1@hotmail.com> 2. Geological Survey of Canada Atlantic, Bedford Institute of Oceanography, Dartmouth, NS, B2Y 4A2 Canada <Edward.King@NRCan-RNCan.gc.ca>

An approximately 0.4 km diameter elliptical structure was identified in southwestern Nova Scotia in 1987 during a regional airphoto survey. The structure was confirmed as an impact crater in 2009, and was named the

Bloody Creek structure (BCS). In addition to the main crater, a cluster of discontinuous arcuate scarps located approximately 1 km north of the BCS was identified. These arcuate scarps have been called the North Group. This study has identified these arcuate scarps as possible impact crater remnants, suggesting the impactor fragmented upon entry into the atmosphere producing a crater field. Evidence for impact origin is based on an integrated analysis of geomorphic, geophysical and petrological data collected in the summer fall and winter of 2009.

A detailed aerial photo analysis of the site revealed several discontinuous arcuate scarps (1 to 2 m high) sharply outlining flat depressed inner floors. Sonar and lake sediment probing across a few of the structures revealed a shallow crater-like morphology beneath the depressed inner floors. The craters are interpreted to be infilled with lacustrine sediment and peat.

Thin-section analysis of bedrock samples collected proximal to the eastern rim crests of the North Group document several features that are supportive of shock metamorphism. These include kink-bands in feldspar and biotite and planar microstructures (PMs) in quartz and feldspar. The PMs consist of planar fractures (PFs) in both quartz and feldspar and possible planar deformation features (PDFs) in quartz. Of these features, the PDFs are considered uniquely diagnostic of shock metamorphism.

The age of both the Bloody Creek and North Group structures is uncertain. The low depth-to-diameter ratio for both features suggest that they are either the eroded remnants of ancient impact craters or, alternatively were formed by impact onto glacier ice during the waning stages of the Wisconsinian deglaciation (about 12 ka BP).

The historic lime quarry at Green Head, Saint John, New Brunswick†

DIANE N. BUHAY[1] AND RANDALL F. MILLER[2]

[1]*Ward Chipman Library, University of New Brunswick, Saint John, NB, Canada E2L 4L5* ¶ [2]*Department of Natural Science, New Brunswick Museum, Saint John, NB Canada E2K 1E5 <dbuhay@unb.ca>*

The Green Head lime quarry in Saint John, New Brunswick includes remains of built structures and quarries preserving one of the last historic lime kiln operations in southern New Brunswick. The site on Green Head Island is owned by the City of Saint John and includes remains of the quarry, kiln foundations, wharf timbers and foundation walls of homes. During the 1800s the lime business was booming in the region. Abraham Gesner reported as many as nineteen kiln sites in operation in the early 1800s. Quarries are located in the Neoproterozoic Ashburn Formation marble of the Green Head Group. Quarry workings are found at numerous locations, the most prominent are at Green Head Island, near the Reversing Falls Suspension Bridge, at the Pokiok and Snowflake quarries in north Saint John, and east at Torryburn.

The Green Head quarry was operated for many years by Joseph and Frank Armstrong whose lime product was known throughout the Maritimes for its quality. Much of the lime produced at the Armstrong Quarry was used locally. Buildings constructed in Uptown Saint John after the Great Fire of 1877 were mortared using Green Head lime. Joseph Armstrong is noted in newspaper stories of the day as a pioneer in the development of the lime industry which was worth almost $100,000 in export trade by 1889. The quarry operation is a historic reminder of a mining industry that supported southern New Brunswick's economy throughout much of the nineteenth century.

Petrology and gold grade variations in different lithologies at the Dachang gold deposit, Qinghai, China†

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This study assesses the nature of gold mineralization hosted at the Dachang prospect, a complex, structurally controlled gold deposit located within metasedimentary rocks (sandstone, siltstone and shale) of the Bayan Har orogenic belt in the Eastern Kunlun Mountains, Qinghai, China. It involves a petrologic investigation of gold-mineralized samples, and an analysis of the gold grade distributions and duplicate samples of mineralization. Eight distinct mineralization types are recognized. All contain variable amounts of pyrite, arsenopyrite and subordinate stibnite; most are hosted in or adjacent to quartz ± calcite veins, stockworks, replacements or fault zones. Mineralization is hosted by different lithologies, consisting of: sulphide minerals replacing matrix in: siltstone and shale (type AA), sandstone (type AB), interbedded siltstone and sandstone (type AC), highly fractured, quartzose sedimentary rocks (type AD); disseminated sulphide minerals in fault gouge (type B); silicified stockwork with extensive quartz veins (type C); a type transitional between types B and C (type D); and sheared sedimentary rocks with 30-40 % stockwork (type E). The gold grade distributions in these mineralization types vary, as indicated by

gold grade histograms. The sampling reproducibilities of these mineralization types also differ, as demonstrated by sample duplicates, which indicate that each mineralization type has a different-sized nugget effect. Numerical assessments of sample duplicates not only characterize the magnitudes of these nugget effects, but also allow determination of how large a sample needs to be collected from each mineralization type to reduce sampling error to an acceptable level. Results from this study will assist Inter-Citic Minerals, the project operator, to collect samples of appropriate size in future drilling programs, and to accurately characterize the grade distributions and petrology of mineralization types for metallurgical purposes in future feasibility studies.

Assimilation processes in the South Mountain Batholith: evidence from apatite[†]

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All granites are contaminated. Assimilation of foreign material in granite magmas involves processes of dissolution, ion exchange, or melting of the solid components, and mixing of any new partial melt with the main magma. Each foreign mineral phase contains its own unique record of the assimilation process. Our investigation examines the assimilation record of apatite, compositionally and texturally, in one xenolith-bearing South Mountain Batholith granodiorite sample (P7G3), using backscattered electron (BSE) images, grey-scale cathodoluminescence (CL) images, and electron microprobe analyses. Observations come from 12 apatite grains in, and beside, a small Meguma xenolith, plus another 14 grains in the granodiorite. Texturally, grains in the interior of the xenolith are smaller (~100 μm) and anhedral to subhedral compared with those on the outer margin of the xenolith or in the granodiorite (up to 600 μm) and subhedral to euhedral. Compositionally, the xenolith apatite grains are generally unzoned and have slightly higher FeO (0.36-0.72 wt%) and MnO (0.78-1.00 wt%), whereas those elsewhere may be zoned and have lower FeO (0.16-0.62 wt%) and MnO (0.56-1.00 wt%). Possible explanations for these observations are: 1. Small apatites are metamorphic and large apatites are magmatic, retaining their original textural differences, but fortuitously having nearly identical compositions – improbable. 2. Small metamorphic apatites and large magmatic apatites have equilibrated chemically, but not yet texturally – possible only if diffusional chemical exchange rates exceed recrystallization rates. 3. All 26 apatite grains are originally Meguma, some of which have coarsened during partial melting – if so, unless new phosphorus became available, some large apatite grains must have grown at the expense of other smaller apatite grains by Ostwald ripening. 4. Some apatite grains are metamorphic, others are Ostwald ripened xenocrysts, and yet others may be magmatic – if so, on this centimetre scale, the country-rock composition dictates the apatite compositions.

Analysis of the short and long-term processes involved in coastline erosion[†]

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Coastline erosion is of particular interest to policy makers, land planners, and inhabitants of any coastal community. The processes of erosion must be well understood in order to minimize risk to infrastructure and maintain sustainable habitats. To better understand these processes, analysis focused on long and short term aspects of coastal erosion observed across the highly diverse coastline of Antigonish, Nova Scotia. The research addressed two major objectives: A) to develop a coastal erosion risk map which highlighted areas predicted to be prone to erosion based on historical observations and B) to obtain high precision measurements of glacial till banks susceptible to erosion by seasonal storm surges using a ground based light detection and ranging (LiDAR) system. A broad analysis of long-term coastline change focused on average rates of erosion between 1939 and 2008. Historical changes were assessed by delineating coastline vectors based on orthorectified aerial photography (n = 257) which spanned the length of the Antigonish coastline. Delineated coastline vectors will ultimately be used to quantify the average rates of scarp retreat and accumulation between temporally spaced aerial surveys. These rates are predicated to range widely due to the highly variable composition of bedrock and surficial geology throughout the coastal area. Local relief was assessed using the results of an airborne LiDAR survey conducted by the Applied Geomatics Research Group in December of 2008. LiDAR return data will provide useful information regarding slope,

vegetation densities, and drainage characteristics throughout the coastal zone. Detailed analysis of short-term till bank erosion focused on an eroding drumlin in the Dunns Beach area, located east of Antigonish Harbour. A ground based LiDAR survey was conducted along a 200 m span of a drumlin in the fall of 2009. The survey achieved an average point spacing of 1 cm and will serve as a baseline for future change detection. Subsequent scans are planned for the spring of 2010. The analysis is anticipated to provide us insight into the processes involved in erosion of the drumlin.

Not the oldest evidence for complex life on land: the Juniata Formation (Upper Ordovician, Pennsylvania)

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The Juniata Formation comprises Upper Ordovician sandstone and mudrock that crops out in the Appalachian region of the eastern United States from Pennsylvania to Tennessee. An outcrop at Potters Mills, central Pennsylvania, has previously been attributed to a terrestrial environment. Because this outcrop contains numerous sub-vertical burrows and evidence for pedogenesis, it has regularly been cited as the oldest evidence for several aspects of continental ecosystem development, including the first evidence for terrestrial infauna and animal-plant interactions. We present evidence from both original fieldwork and published literature that collectively sheds considerable doubt on previous interpretations. The evidence suggests that the Juniata Formation at Potters Mills was deposited in a marginal marine setting and, as such, no evidence for early life on land can be inferred from its strata. This has significant implications for the numerous studies that have cited the Juniata Formation as a crucible of terrestrial evolution. Removing it from the dataset of studies that deal with the history of life on land, we conclude that currently the majority of fossil evidence from localities worldwide supports the appearance of terrestrial infauna and animal-plant interaction in the Siluro-Devonian.

Incorporating geohazard mapping and risk assessments in land use planning

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Karst terrain, areas with high potential for radon gas, and areas with high levels of arsenic in soils or well water are examples of geohazards that should be identified on community land-use planning maps and discussed in planning documents. Unfortunately, this information is commonly absent. For most communities in Nova Scotia, geological reports and maps documenting the local geohazards are available as free downloads from the Geological Services Division web site. So why is this information not showing up in planning documents?

The presentation will include both an analysis of this question and an overview of a project the Geological Services Division has implemented to address this important issue. Lessons learned from the Central Antigonish County Land Use Planning and Climate Change Adaptation Pilot Project will be the focus of the discussion.

Solving geological puzzles with U/Pb titanite geochronology

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Titanite - CaTi $[SiO_4](O,OH,F)$ – occurs in a wide variety of rocks and geological settings and can crystallize at temperatures from 1000 to 300C. Biologically-mediated deposition of titanite may occur to even lower temperature. Biases against the utility of U/Pb dating of titanite have focused on the common lead correction which can vary from nil to 50% or more, and on its supposed 'blocking temperature'. However, the correction for initial common lead in the crystal is easily handled in most cases and the blocking temperature is in need of re-assessment. In some cases, $^{206}Pb/^{238}U$ isochron ages can be determined reliably, including the common lead. Titanite is commonly a reliable chronometer of igneous crystallization, is not prone to lead-loss or inheritance, and overlaps concordant zircon data for the same sample. In metamorphic rocks titanite ages require assessment 'in context' with the field, structural, petrologic and other mineral age data, but titanite provides a powerful tool to date multiple discrete geological events in one terrane. Accurate ages of metamorphic crystallization can be determined at or below amphibolites facies, and a re-assessment of the role of titanite and its resistance to re-setting at high pressure and temperature

(eclogite) conditions is needed. Core:overgrowth relationships explain linear arrays in some cases, rather than diffusional lead-loss. Also valuable is the fact that titanite has recognized reactions by which it forms and it can be a euhedral fabric-forming new-grown mineral in deformed metamorphic rocks. Examples will be presented of U/Pb data for titanite from rocks of different ages, lithologies, and tectonic settings.

Paleoproterozoic microbial communities in the Ferriman Group, Labrador Trough, Canada

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Chert and iron formation from the Ferriman Group (ca. 1.88 Ga) of the Labrador Trough, Canada, contain an exceptional assemblage of fossil bacteria and biofilms. Analysis of lithofacies in a well-defined stratigraphic framework suggests that these microbes were restricted to suboxic, shallow-water environments through three sea level cycles. Microfossils are preserved as chert and sedimentary apatite (francolite) casts in hematite-rich, peritidal facies. Morphologies include sphere-, rod-, and filament-shaped bacteria, however, filamentous forms are the most common. Secondary electron imaging of freshly broken surfaces shows filaments are similar in size and shape to modern bacteria; filaments vary between 0.5 and 5 μm wide and reach tens of μm in length. They commonly envelop chert and iron oxide grains, which stabilized the seafloor and contributed to firmground development. The filamentous morphology, similar mat-forming behavior, and paleoenvironmental conditions where these fossils lived closely resemble traits of modern Fe-oxidizing bacteria such as *Gallionella* and *Leptothrix*. The close association between these fossil microbes and iron oxides within the Ferriman Group support the widely held view that Fe-oxidizing bacteria may have aided the precipitation of iron formation. Our data, however, also suggest that such benthic bacterial precipitation was likely environment specific, occurring in shallow settings with abiotic precipitation processes.

Field relationships, petrology, age and tectonic setting of previously inferred Devonian-Carboniferous granitic plutons in the Antigonish Highlands, Nova Scotia

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Small plutons of previously inferred Devonian-Carboniferous age are scattered through the southern part of the Antigonish Highlands. Based on new field mapping, petrological studies, and U-Pb dating, these plutons have been divided into two unrelated suites, neither of which is Devonian or Carboniferous. Suite A consists of quartz diorite, tonalite-granodiorite, and smaller alkali feldspar granite and syenogranite bodies, collectively named the Eden Lake plutonic suite, and a large body of alkali feldspar granite, syenogranite, and diorite named the Sandy Gunns Lake pluton. Geochemical data show these rocks to be calc-alkaline and formed in a subduction zone setting. An alkali-feldspar granite sample from Sandy Gunns Lake pluton yielded a U-Pb (zircon) upper intercept age of 605 ± 10 Ma, consistent with U-Pb (zircon) ages from some petrologically similar plutons elsewhere in the Antigonish Highlands and in the Cape Porcupine Complex at the Strait of Canso. In contrast, suite B consists of varying proportions of granitic, syenitic and monzogabbroic rocks, present in separate bodies named in this study the West Barneys River, McGraths Mountain, Leadbetter Road and Brora Lake plutons. An additional pluton (Haggarts Lake), previously mapped as Neoproterozoic diorite, is also of syenitic composition and part of this suite. Also introduced in this study is the hybrid zone, area in which mingling of all the suite B lithologies appears to occur. The granitic and syenitic rocks in suite B are hypersolvus and in some cases show interstitial granophyric texture indicative of shallow emplacement. The syenitic rocks in the Brora and Haggarts Lake plutons contain aegirine, riebeckite and in some samples fayalite, indicative of peralkaline composition. Geochemical data confirm that most of the felsic and intermediate samples are peralkaline and have high concentrations of K, Na, P, Ti and Fe. Discrimination diagrams indicate a within-plate setting for these plutons. A syenitic sample from the Brora Lake pluton yielded a U-Pb (zircon) age of 469.4 ±0.5 Ma. The recognition of the widespread occurrence of Ordovician peralkaline plutonic rocks is important, as such rocks of that age are not known elsewhere in Avalonia.

Site selection for in-stream tidal power devices in Minas Passage — New insight into the marine geology of the Bay of Fundy

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The recent round of tidal power development in the Bay of Fundy began over three years ago and has progressed to the present stage involving deployment of tidal in-stream devices (TISEC), connection to the power grid, and environmental and engineering monitoring. The political, social and scientific undertaking that led to the current situation involved government commitment to the delivery of sustainable energy, strategic environmental assessment, project tendering, marine and terrestrial site selection studies, public consultation, environmental assessment and finally government environmental approval for the test facility in Minas Passage. Minas Basin Pulp and Power Co. Ltd. (MBPP) won the right to design and establish the test facility that includes a Crown Lease area, selection of specific sites for installation of devices, marine power cable design and installation, construction of onshore infrastructure and grid connection. The first device in the water was the Open Hydro/Nova Scotia Power Inc. system installed in November of 2009. Over the next few years, Marine Current Turbines/MBPP and Clean Current/Alstom, and possibly other providers, will deploy their systems while marine electrical cables will be laid. The project is now being managed by the Fundy Ocean Research Centre for Energy (FORCE), a not for profit corporation composed of the turbine developers, Nova Scotia Energy and academia.

The information collected for site selection has revealed much about the seabed of the inner Bay of Fundy in Minas Passage and Minas Channel, and processes that are acting on it. Areas of highest currents are scoured depressions cut into glaciomarine stratified sediments. Till is rare and a few linear till ridges that may represent former moraines have been exhumed through seabed erosion. Instabilities exist along the northern shore of Minas Passage and slumping at the seabed has been identified. Large regional scoured depressions of the inner Bay appear to be presently eroding and increasing in size. Fine-grained sediment from this process is transported either out of the area to the outer Bay of Fundy or to Minas Basin for deposition. Important questions include the rate of this erosion and whether the placement of additional turbines will affect this process. Turbulent water flow and local eddy generation in Minas Passage needs to be understood through detailed oceanographic measurements.

The inner Bay of Fundy offers the promise of sustainable and predictable energy development. The research community is encouraged to address the applied science issues associated with seabed stability, sediment transport, and the apparent increasing energy within the Fundy system.

Thermal springs and geothermal exploration

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There is considerable interest in thermal springs because of their potential as a geothermal exploration tool. However, the nature of the relationship between thermal springs and geothermal resources at depth has not been well documented. The case can be made that thermal springs are indicative of an environment with elevated isotherms in the near surface environment but this does not necessarily translate into increased temperatures deeper in the subsurface, particularly those which would allow for electricity generation. In this study, we examine the relationship between temperature, volumetric discharge and heat flow for 890 thermal springs in North America obtained from various databases and government reports. These data are by no means exhaustive and contain only a subset of known thermal springs in North America. In particular, we have selected springs with both temperature and volumetric discharge measurements to facilitate heat flow calculations. There is little correlation between background heat flow and heat flow at springs. The variation in volumetric discharge suggests that the hydrogeology of an area is an important control on the development of thermal springs. Specifically, recharge rates must be sufficient to allow for noticeable springs to occur but at higher fluid fluxes, but this increase in downward groundwater flow will actually reduce temperatures in the area. In many cases, the existence of thermal springs may actually be a strong indication that an area is a poor candidate for geothermal development, particularly for electricity generation. Thermal springs with high temperatures and low volumetric discharges are more likely to indicate conditions necessary for electricity generation because such springs can occur with a negligible effect on a region's heat flow budget.

Characterization of eroding bedrock shorelines – examples of rates, processes and form continuity[†]

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The erosion of Nova Scotia's shoreline and associated hazards, such as risks to people and infrastructure, are increasingly becoming an issue of public concern. Many studies have been undertaken to examine rates, magnitudes and processes of shoreline migration of beaches, associated dune systems, and unconsolidated shorelines. In contrast, bedrock shorelines have received less attention. They are typically considered to be moderately to highly resistant to erosion on human time scales. This is particularly true along shores composed of metamorphic and igneous rocks, such as the metamorphic and igneous shoreline of southern Nova Scotia.

This poster will examine erosion of Feltzen Formation and Cunard Formation metasediments on islands in the outer Mahone Bay area. Erosion processes and form continuity are strongly influenced by shoreline orientation with respect to the strike and dip of bedding, as well as other structures such as intersecting planar fault surfaces. Rates of shoreface retreat may approach those of long-term unconsolidated shorelines. In other instances, shoreface retreat may approach zero over time frames of several centuries.

This poster illustrates that erosion of bedrock shorelines is a concern and needs to be considered when examining and mapping coastal hazards, and in association with coastal land-use planning and/or zoning issues.

Investigation into potential controls on uranium concentration in new production wells intercepting a Triassic sandstone aquifer, Bridgetown, Nova Scotia

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The Town of Bridgetown overlies one of Nova Scotia's most productive sedimentary bedrock aquifers. As an alternative to the expensive upgrades required to the existing surface water system, the town investigated the potential for a new groundwater supply from this aquifer. A groundwater exploration program was initiated in 2006 and involved the installation of three open-hole test wells and a series of pumping tests and inorganic chemistry analyses. Total uranium was found to be elevated (maximum of 15 µg/L) but below the Canadian Drinking Water Quality interim maximum acceptable concentration of 20 µg/L, and appeared to be stable based on the results of a 30 day pumping test. The town decided to pursue a groundwater supply option and converted two of the test wells into partially screened larger diameter production wells in 2007. The new production wells showed higher concentrations of uranium during pump testing, with a maximum observed concentration of 27 ug/L.

To investigate the mechanism for the increase in uranium in the production wells compared to the test wells a series of investigations followed, including additional pumping tests, depth-discrete sampling, a packer test, and aqueous leachate testing of rock cuttings from the remaining test well. The results of these investigations suggest a redox control on uranium concentration. Greater drawdowns occur where well screens are present, leading to the development of more oxidized conditions which favour the mobilization of uranium. The findings have guided wellfield remedial actions, including the conversion of the remaining test well to a fully screened production well to minimize drawdown. Given that Triassic sedimentary aquifers in the Annapolis Valley are widely used as a groundwater source and have been associated with the potential for elevated uranium, an improved understanding of the controls influencing the mobility of uranium in groundwater could help other water users in the area to address similar concerns.

Evaluating coastal run-up, erosion, and flooding hazards for climate-change adaptation and hazard mitigation in the Halifax Regional Municipality, Nova Scotia

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Climate-change adaptation and natural hazard planning are mandated in the 25-year Regional Municipal Planning Strategy of the Halifax Regional Municipality. This recognizes the importance of climate change and the need for a precautionary approach to minimize negative impacts of rising sea level and storm events. The impacts of several major storms have been documented over the past two decades in terms of water levels, wave run-up and overwash, coastal erosion and flooding, and impacts on infrastructure. Using 30 years of coastal survey data and 70 years of airphotos, we can place these impacts in the context of long-term coastal evolution, providing a basis for better understanding of rapid coastal change and development hazards.

Topographic LiDAR data were acquired in 2007 to produce a high-resolution digital elevation model (DEM) as a basis for mapping flood limits in Halifax Harbour and along the Eastern Shore. The selection of flood levels for adaptation planning required an understanding of present and future sea-level rise (SLR), vertical land motion, extreme water levels (combined tide and surge), harbour seiche and wave run-up.

Relative sea level in Halifax Harbour has risen 3.2±0.13 mm/yr since 1920 through roughly equal contributions from regional subsidence and local SLR. Scenarios of future extreme water levels were developed using the 2007 IPCC projections and others from recent publications. These SLR rates were combined with regional subsidence and extreme water levels for 2-, 10-, and 50-year events and applied to the LiDAR DEM to visualise the extent and depth of flooding for each event. This analysis provides the scientific basis for a set of plausible scenarios for a 100-year planning horizon, recognizing that SLR projections continue to be refined and may need to be adjusted in future.

Trends and architecture of the Bluestone Formation turbidites in Point Pleasant Park

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In the Meguma Supergroup, a series of sandy and shaly intervals formed in a range of depositional environments from deltaic to deepwater. The Lower Ordovician Bluestone Formation in Point Pleasant Park on the Halifax Peninsula, is part of the Halifax Group and includes low density turbidites containing Bouma Sequence T_{a-e}. The goal of this project is to understand the distribution and architecture of these turbidites. Data collection includes measuring and logging sections, paleocurrent measurements from such features as tool marks and current ripples, petrographic analysis, scintillometer measurements to create synthetic gamma logs, LiDar to develop 3D models in Petrel, to investigate the geometry and architecture of the studied sections. Data were collected at outcrops along the Northwest Arm, Black Rock Beach, the Battery, and Sailors' Memorial Road. The strata is made up of mainly quartz, mica, zircon and tourmaline, and shows five lithofacies. These lithofacies make up a cyclic lithofacies association which is separated by sharp or scoured contacts. Scintillometer analysis showed no apparent relationship to lithology, likely due to the moderate metamorphism throughout the Meguma Supergroup. Interpretations suggested that the lithofacies association is characteristic of the Bouma Sequence. Current ripples on bedding planes indicate the paleocurrent was towards the northwest. The beds fine and become thinner towards the top of the outcrop and lithofacies like meta sandy-siltstone ripples, and structureless silty slate to slate become more dominant, due to the reduction of sediment supply. The lithofacies association is characteristic of the Bouma Sequence and represents low density turbidity processes.

Rooted vegetation and the Siluro-Devonian expansion of meandering rivers

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In a hypothesis first published in 1978, the increased prominence of meandering rivers in the mid Paleozoic was linked to the colonization of terrestrial environments by vegetation. We tested this hypothesis using a large literature dataset of Cambrian to Devonian fluvial deposits, with field examination of stratigraphic units in eastern Canada and elsewhere in Europe and North America. The results confirm the 1978 hypothesis, and show that Cambrian to mid-Silurian rivers were braided, with a sharp increase in the abundance of meandering rivers during the Siluro-Devonian.

Previous authors had largely identified meandering systems on the basis of thick mudstones and organized channel deposits. However, our dataset suggests that lateral accretion sets, formed through systematic migration of point bars, are a robust proxy for the presence of meandering rivers. Lateral accretion is first recorded from small channels in Pridolian-Lochkovian strata (latest Silurian to earliest Devonian), but is noted in 40% of fluvial case studies by the Famennian (latest Devonian) in increasingly large channel bodies. This trend matches the known evolutionary record of rooted vegetation, as low, weakly rooted vegetation evolved into trees. We suggest that, as vegetation progressively stabilized river banks, channels were commonly constrained to single threads that migrated systematically, with stable floodplains that promoted the spread of animals into terrestrial settings.

The presence of meandering systems in the Precambrian record and on Mars and other extra-terrestrial bodies indicates that vegetation is not essential for meandering. If Cambrian to Silurian point-bars were originally present, they may largely have been destroyed by extreme floods, chute cut-offs in coarse-grained meandering systems, and eolian activity.

Mass transport deposits on the southwestern Newfoundland slope: eastern Canada

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There is global recognition of the importance of mass failure processes in the evolution of passive continental margins as demonstrated in the modern seafloor geomorphology of Canada's eastern continental slope. Investigation of the Cenozoic section of Newfoundland's SW slope will help quantify the importance of these processes in this region, providing both depositional models for the area as well as helping to identify potential geohazards. This margin is an active exploration frontier and the location of the tsunami-inducing 1929 Grand Banks Landslide. Seismic facies analysis of recently acquired multibeam, 2D and 3D seismic data from the SW slope provides evidence of successive mass failures at a variety of scales. The occurrence of stacked, regionally extensive mass transport deposits (MTDs) indicates that this was an important process during the Cenozoic evolution of the SW Newfoundland margin. The largest MTD on the margin covers an area of 900 km^2 and is mid-late Miocene in age. It has thicknesses as much as 500 m and using an average thickness of 250 m, the estimated volume for this MTD is 225 km^3. Overlying this MTD, there is a stack of up to 9 MTDs that occur between the mid-late Miocene and Middle Pleistocene. The largest of these MTDs covers an area up to 400 km^2 and has thicknesses between 85 and 150 m. Their volumes are estimated to be as much as 60 km^3. MTDs that occur above the Middle Pleistocene are typically localized failures and have thickness between 20-30 m with volumes less than 1 km^3. On the SW Newfoundland margin, MTDs make up 30-40 % of the sedimentary column between the top of a Cretaceous unconformity and the Middle Pleistocene. Above the Middle Pleistocene, an additional 20-25 % of sedimentary column can be represented by small localized failures.

Historic earthquake data demonstrate that the region is susceptible to increased seismicity over most of the Canadian east coast margin, perhaps actuated by latent tectonic structures, such as the Cobequid-Chedabucto fault system. The 1929 submarine landslide was clearly activated by a M7.2 earthquake in this area. In all likelihood, the observed MTDs in this region were generated by ground accelerations due to earthquakes. Nonetheless, pre-conditioning factors are required to prepare the sediments for failure, and it is perhaps these factors that explain the difference in the size of MTDs. The regionally extensive sediment mass failures that occurred during the Miocene to the early Pleistocene were pre-conditioned by: 1) seaward dipping faults between a top Cretaceous unconformity and a mid-late Miocene marker; 2) over steepening of sediments in response to ongoing salt tectonics; and 3)

sealevel lowering that began in the Miocene. Pleistocene and younger MTDs were significantly influenced by high sedimentation rates from numerous Pleistocene glaciations and elevated content of situ (biogenic?) gas in the shallow section.

Carbonic fluid inclusions in the Greendale (NS) and Lac Des Iles (ON) complexes: constraints on mafic pegmatite crystallization and platinum-group element (PGE) mineralization[†]

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The study constrains the conditions of mafic pegmatite formation in the Lac Des Iles (LDI) and Greendale (GC) complexes; better understanding the processes responsible for precipitation and redistribution of associated platinum-group elements. The main ore zone at LDI, Roby Zone, is hosted within gabbros; with high grade PGE mineralization occurring in gabbro pegmatite dikes (up to 37ppm Pt+Pd+Au). The GC in Nova Scotia consists of porphyritic hornblende gabbro and diorite, with minor gabbroic pegmatites composed of actinolite, plagioclase (oligoclase-andesine), and quartz. PGE mineralization in the GC is sub-economic and contains grains of Pt-Sb (genkinite) hosted in pyrite and pyrrhotite within the pegmatites. Intercumulus quartz at LDI hosts primary and pseudosecondary assemblages of pure CO_2 inclusions and secondary, late aqueous fluid inclusions. The GC quartz hosts primary, pure CH_4 inclusions and secondary, late aqueous inclusions. Microthermometric measurements showed that carbonic fluid inclusions in the coarse-grained LDI pegmatitic quartz homogenize to liquid, vapor, or by supercritical behavior. Carbonic fluid inclusions from the fine-grained LDI pegmatitic quartz homogenize only to liquid. Methane fluid inclusions from the Greendale complex homogenize either to liquid, or rarely by supercritical homogenization. A variety of thermobarometers were used in conjunction with microthermometrically-derived carbonic fluid isochores to obtain pressure-temperature conditions of pegmatite formation. Quartz hosting the inclusions at LDI crystallized between ~550 and 630°C, with pressure varying between 460 and 1660 bars. Quartz hosting the inclusions at GC crystallized at very similar temperature between ~510°C and 550°C, with pressure varying between 470 and 1930 bars. The results indicate that (i) the primary fluid involved in pegmatite formation in both locations were not aqueous but anhydrous carbonic in composition; (ii) CO_2 and CH_4 entrapment at both LDI and GC occurred over a similar and relatively large range in pressure, consistent with the transition from lithostatic to near hydrostatic conditions.

Models and data for tidal power studies

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Extreme range and fierce currents make modelling Fundy tides a formidable challenge. The modelling approach being used in two of the project studies to predict impacts is described along with associated data collection programs. This is put in the context of some past studies and the evolving tidal regime responding to changing sea level. Two models were created: one of the upper Bay of Fundy to look at currents in Minas Passage, and one of western Minas Basin looking in detail at the Cornwallis River. Models are calibrated against sea level tidal analysis. Model currents are compared with ship mounted and moored ADCPs. Recent detailed bathymetry in Minas Passage has been fundamental in resolving resolution issues.

Preliminary characterization of ore-forming fluids associated with a gold occurrence in northern New Brunswick

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Clarinda is a gold property in northern New Brunswick, approximately 30 km west of Bathurst. This property is located within a fault bounded wedge and lies within the Jacquet River Syncline of the Chaleur Bay Synclinorium in the northern Appalachian orogen. Clarinda is underlain by Silurian to lower Devonian sedimentary and volcanic

rocks, belonging to the Carl Gulch and Benjamin formations, respectively. The gold occurrence was initially discovered in 1997, which lead to extensive work by Slam Exploration Ltd until 2000. Exploration ceased due to a lack of consistent mineralization. The area is poorly exposed and relationships between units are inferred from drill core. Cross sections from the logging of drill holes confirm that shallow-water sedimentary rocks overlie rhyolitic bodies and breccias. This sequence is intruded by mafic dykes of Devonian age, which are the youngest rocks in the area. The area is highly faulted and has undergone multiple phases of deformation. There appears to be a shallowly plunging synclinal structure underlying the property. The highest grade intervals of drill core are found in proximity to mafic dykes and are associated with quartz-carbonate veining and disseminated sulphide minerals. Along with further interpretation of information derived from drill logs, the presence of fluid inclusions in multiple samples has prompted a desire to analyse their potential role in the deposition of anomalous gold. Careful petrographic analysis of the inclusions, as well as microthermometry and raman spectroscopy will be used to characterize the fluids involved in the formation of the quartz-carbonate veins.

Preliminary investigation of the Mabou Group hydrogeology in the Sussex region, New Brunswick

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The hydrogeology of the Mabou Group is important to understand as it overlays the economic evaporite deposits. The Mabou Group, in the Sussex region of New Brunswick, consists predominantly of red siltstones with interbeds of sandstone and conglomerate, yet has not been stratigraphically divided by previous regional mapping. This may be due to lack significant marker beds, but also due to limited data and research in the uneconomical red beds. Focus is now on the red beds since the recent occurrence of inflow into the present potash mine. A new mine, Picadilly, is being built near the Penobsquis mine, which is currently managing a water inflow. It is therefore important to be proactive and gain a basic understanding of the hydrogeology of the overlying Mabou Group. With new specialized technology to investigate hydrogeological properties of bore holes a better understanding and modeling of the possible permeability of the Mabou can attempted. Hydrophysical Logging is one such technology which also measures the Fluid Electrical Conductivity (FEC). By interpreting these logging results along with conventional geophysical data, nearby historical drill stem tests, and core samples, zones of flow and possible lateral connectivity maybe identified. By further integrating these data with the results of a 3D seismic reflection survey, identified flow zones can be delineated in three dimensions. This modeling can better highlight the hydrogeological characteristics of the overlying Mabou Group of the evaporites and possibly indentify potential inflow zones to the future mine.

Student fieldwork opportunities in macrotidal estuaries: Quaternary geoscience examples from the Severn Estuary, UK

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Macrotidal estuaries are distinctive coastal environments that offer excellent fieldwork opportunities for undergraduate and postgraduate students in Higher Education. As a learning resource in geoscience disciplines, macrotidal estuaries and their associated coastal wetlands provide sometimes unique access to geological strata and geomorphological features. This is often due to a number of inherent characteristics of many macrotidal estuaries. As with all estuaries and, indeed, coastal environments, they are temporary landforms only, being determined by climate and sea-level change. Sea-level high-stand events transgress over previous landsurfaces, which become drowned by rising sea-level, and buried and preserved by tidal deposition. Therefore, opportunities to investigate precursor landscapes exist that underlie the later estuarine deposits. The accommodation space for tidal sediments is often large in macrotidal estuaries due to the high tidal range, which may lead to the accumulation of thick sequences of estuarine sediments and, if exposed, provide a window into the palaeoenvironmental and palaeogeomorphological development of the estuary. Finally, estuary surfaces also provide opportunities for study. These characteristics are applicable to both modern estuaries and to palaeoestuarine sequences.

This paper provides examples of how student fieldwork has been developed to fully utilize the learning resources provided by the modern Severn Estuary, in southwest United Kingdom, in Quaternary geoscience education. The Severn Estuary has a tidal range of c. 14.5 m with a Palaeozoic and Mesozoic basement. The environment is characterized by both tidal deposition and local coastal erosion, so that exposures of Pleistocene and Holocene sediment sequences are present within the intertidal zone, and accessible using coring equipment in coastal wetlands. Examples of student fieldwork include exercises that examine the late Pleistocene succession, the Holocene sequences with their palaeoenvironmental and archaeological constituents, the environment and geomorphology of the modern estuarine intertidal surface, and the hydrodynamics of the estuarine waters and tidal prism. The logistics of undertaking student field work in these environments is also discussed, such as issues around health and safety. These student fieldwork examples, developed in the Severn Estuary, could be applied to other macrotidal estuaries, such as the Bay of Fundy in Atlantic Canada.

Utilizing U-Pb SHRIMP geochronology to constrain the timing of Paleoproterozoic magmatism: a case study from the Makkovik Province, Labrador

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The Makkovik Province of Labrador is considered part of a Paleoproterozoic accretionary belt that developed on the southern margin of the North Atlantic craton during the ca. 1.9–1.7 Ga Makkovikian–Ketilidian orogeny. The Aillik domain represents one of three domains that comprise the Makkovik province. Recent regional bedrock mapping has further defined the lithological units that occur within the Aillik domain. The Aillik domain largely comprises: a) the Aillik Group (previously termed the Upper Aillik Group), a supracrustal assemblage consisting of metasedimentary and metavolcanic rocks; and, b) abundant, syn- and post-deformation Paleoproterozoic intrusive suites that have intruded the Aillik Group. The Aillik Group comprises polydeformed, upper greenschist- to lower amphibolite-facies, bimodal volcanic rocks and sedimentary rocks. The Aillik group is known to host abundant base-metal and uraniferous occurrences. Constraining the timing of formation of the Aillik Group is pivotal to unraveling the depositional, tectonic and metallogenic history of the area.

Geochronological studies of metamorphosed volcanic rocks are complicated due to several factors, including: inheritance of older grains, metamorphic overgrowth on igneous grains, and by the commonly aphanitic to fine grain size of volcanic rocks and consequently the small size of grains suitable for radiogenic dating. In-situ techniques that date microdomains within single grains, in conjunction with backscattered electron and cathodoluminescence imaging prior to analysis, can overcome many of these complications. U–Pb zircon geochronology via Sensitive High Resolution Microprobe (SHRIMP) analysis was carried out on felsic volcanic rocks from the Aillik Group. These data indicate that the associated volcanism was older and longer-lived than previously recognized in the area. Felsic volcanism is now determined to extend from 1883 to 1856 Ma, punctuated by synvolcanic hypabyssal intrusions. This range in ages indicates that the Aillik Group records felsic volcanism for at least 18 m.y. to possibly as long as 35 m.y.

The Big Dig: Lithologies, isograds, and other "outcomes" of the Freshwater Brook sewer replacement project

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In the summer of 2008, the City of Halifax undertook a major construction project to replace the underground sewer system that carries Freshwater Brook from the Halifax Commons to its outlet near the grain elevator. The project was necessary because the existing system was antiquated and the route ran under city blocks and was therefore inaccessible in many places should repair have become necessary. The project involved installing 2 new sets of modern sewer pipes along a new route running from Holy Cross Cemetery, along South Park St to Fenwick St, along Fenwick St to Sobeys, across the Sobeys parking lot, and down Victoria Rd to Inglis St. The route crosses the predicted locations of the lithological boundary between the Cunard and Bluestone Formations of the Halifax Group, as well as the cordierite-in and andalusite-in isograds of the contact aureole of the South Mountain Batholith. For most of its length, bedrock was exposed in the lower part of the excavated trench, which was more than 10 m deep in some places. Observations and samples taken along the length of the trench in 2008 and 2009 reveal that the Cunard-Bluestone contact runs under the Sobey's parking lot, between Fenwick Street and the intersection of

Victoria Road and Kent Street, and that the andalusite-in isograd can be traced as far as the west end of Fenwick St., where it runs beneath the author's home. The position of the cordierite-in isograd is more difficult to determine, as retrogressed cordierite in the outer part of the contact aureole can be difficult to recognise. The lithology and isograd map for South End Halifax has been updated based on these results. Some less welcome outcomes of the project will also be discussed.

Advanced approaches for video footage and photograph analysis in the Bay of Fundy†

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In 2009 the Bedford Institute for Oceanography (Natural Resources of Canada) generated a large quantity of footage - more than 25 km - in the Bay of Fundy on the 39th expedition of the "CCGS Hudson". Ecological marine research in epibenthic sea-floor communities relies strongly on the use of high resolution cameras analyzing the species composition and their correlation to depth and sediments, and their spatial distribution. The video material can currently, however, often not be used to its full potential as the analysis is time- and labor-intensive and requires the input of taxonomic experts. This poster presents two different approaches to make video data and still photographs of the Bay of Fundy available for an advanced analysis: GIDAS (Geospatial Image Database and Analysis System) is an automatic content-based analyses system for georeferenced images. The automatic area recognition is achieved by learning visual properties of the different image regions. Therefore, each image is partitioned into a regular grid. Features are extracted and the classification is performed on the basis of these grid cells. Because of its ability working with georeferenced images the analysis results are area accurate and can be exported as a shape-file. Biigle (Bielefeld Image Graphical Labeller and Explorer) is a Web 2.0 based platform containing easily uploaded images that can be accessed by collaborating scientists. The system provides not only basic image database exploration features but allows graphical annotation of semantic labels to image regions. Biigle also offers an application interface for machine-vision components aiming at the automated analysis of seafloor images. Laser point detection allows for an automated calibration of the area covered by the camera which is vital to derive faunal density estimates. This poster gives a report about strength and weakness of each system.

Hydrocarbon migration and thermal history of reservoir sandstones deduced from fluid inclusions, Scotian Basin, offshore eastern Canada

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Fluid inclusion studies of Lower Cretaceous reservoir sandstones of the Scotian Basin provide constraints on the fluid migration history. The presence of primary fluid inclusions in different cements in the diagenetic sequence is evidence for entrapment of fluids at more than one time. 237 primary and secondary fluid inclusions were analysed from 11 samples from the Glenelg and Venture fields and the Thebaud I-93 and Chebucto K-90 wells. Homogenization temperatures in the primary aqueous inclusions hosted in late carbonate cements range from 122 to 137 °C, whereas in quartz overgrowths are slightly lower (110 to 124 °C). The ice melting temperatures from primary inclusions in both cements indicate high fluid salinities (18.3 to 22.8 wt.% NaCl equivalent). Secondary inclusions with liquid hydrocarbons have similar homogenization temperatures to primary inclusions, but the melting temperatures indicate dilute fluids (3.2 to 8.5 wt.% NaCl equivalent). In Venture wells, primary and secondary aqueous inclusions have lower homogenization and ice melting temperatures than in the other wells. They also contain a different type of secondary CO_2 inclusion, with CO_2 melting temperatures (avg. -57.6°C) indicating the presence of hydrocarbons and homogenization temperatures (avg. -10.2°C) indicating a high density carbonic phase. These data show that hydrocarbon migration postdates the late carbonate cementation and the gas reservoir was charged by saline and dilute fluids. The temperatures determined from the studied wells are higher than present temperatures, implying a thermal maximum at an unknown time in the past. There is no evidence for basin inversion in these wells, suggesting the involvement of hot fluids and a higher geothermal gradient than the present ~30 °C/ km. The fluid inclusion and published apatite fission-track data are consistent with a geothermal gradient of ~80 °C/ km in the Mid Cretaceous or ~50 °C/ km near the K/T boundary.

Assessment of tidal current energy in the Bay of Fundy

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The Bay of Fundy has the world's highest tides. In particular, the Minas Basin has tides with a range of over 12m. The Minas Passage, which connects Minas Basin to the Bay of Fundy, has mean tidal currents of over 3m/s making it a promising location for tidal turbines. In this talk we examine the potential power that could be extracted from Minas Passage and the effect that extracting the power would have on the surrounding tides. Mathematical and numerical models suggest that a maximum of 7 GW of power can be extracted by turbines. The simulations also show that any power extraction in Minas Passage pushes the Gulf of Maine-Bay of Fundy system closer to resonance with the forcing tides resulting in increased tidal amplitudes throughout the Gulf of Maine. While extraction of the maximum power will result in significant changes, over 2.5 GW of power can be extracted with less than a 5% change in the tidal amplitude at any location. Finally, we examine how isolated turbines and turbine fences might be best located in the Minas Passage by examining the fluid dynamics of flow past a turbine.

A petrological study of REE-rich carbonatite intrusions from the Lofdal Farm area, Namibia[†]

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Carbonatite dykes in the Lofdal Farm area near the town of Khorixas in Damaraland, Namibia, contain elevated concentrations of rare-earth elements (REE) and in some cases unusually high ratios of heavy REE to light REE. Most dykes have widths between 0.5 cm and 5 m but some are up to 25 m wide and extend over several kilometres. Carbonatite also occurs in plugs with diameters up to several hundred meters, although these bodies outlined to date appear to lack highly elevated REE values. The carbonatite dykes and plugs occur in association with syenite and nepheline syenite intrusions that combined form an alkaline intrusive complex in an area of over 125 km^2. The complex is hosted by 1.7 Ga metasedimentary rocks, including gneiss and schist, of the Huab Basement Complex.

This study is based on 18 samples from 6 carbonatite dykes and their host rocks and two carbonatite plugs. The carbonatite samples consist of equigranular twinned calcite with varying abundance of Fe-carbonates, Fe-oxides, and magnetite. Other minerals include biotite, K-feldspar and very fine-grained apatite. Some samples are highly altered ferrocarbonatite and consist of Fe-carbonate with inclusions of calcite, K-feldspar and biotite. Based on electron microprobe analyses, the Fe-carbonate mineral is ankerite. Preliminary microprobe data indicate that REE appear to occur in fine-grained opaque minerals as well as in REE-mineral inclusions in calcite. Analyses of eight whole-rock samples showed varying total REE abundances, with a high of 50820 ppm. Four samples from one dyke show an increasing amount of silicon from the center of the dyke to the edge, accompanied by a decrease in total REE. Ratios of total light REE (La to Sm) to total heavy REE (Eu to Lu) range from 0.71 up to 59.63 in the analyzed samples. A regional geochemistry database of 1400 REE analysis shows total REE concentrations up to 86184 ppm in some dykes.

CO_2 geological storage potential and capacity in New Brunswick[†]

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Sedimentary rocks have the potential to store waste-captured carbon dioxide (CO_2) in its supercritical fluid or dissolved state, typically at depths below ~800 m. Storage can take place at such depths in either microfractures or the pores between mineral grains. Three types of underground sedimentary units can therefore be considered, namely, (1) coal seams (CO_2 being locked by adsorption onto the coal); (2) depleted petroleum reservoirs (injecting CO_2 under pressure can help retain high pressures in the reservoir); (3) deep saline formations (permeable rocks filled with connate (saline/alkaline) water). In New Brunswick, there are potentially four sedimentary basins in which such units may exist: (1) Matapedia Basin, (2) New Brunswick Platform, (3) the Moncton (and Sackville) Basins, and (4) the Fundy Basin. A preliminary overview nearing completion identifies coal seams in basins 2 and 3, although depth and seam thickness are an issue. Only basin 3 has known petroleum reservoirs but, where these

are at sufficient depth, the reservoirs are a long way from being depleted, and permeability is an issue. Saline reservoirs may be present in all basins. In basin 3, the lack of highly permeable rock is again the major issue. In basins 1 & 2, there is minimal information from the appropriate depths and, what little is available again indicates a lack of permeable rock. However, in the Fundy Basin, the Cape Spencer #1 well, located less than 6 km offshore of Saint John (and less than 20 km from several major emitters) indicates the presence of ~450 m section containing highly porous and permeable intervals. These intervals, believed to be of aeolian-dune origin (Blomidon or Wolfville Fm equivalent), lie below a potentially ideal seal in the form of the North Mountain Basalt. The major drawback in this instance is the lack of additional data that indicates the volumetric extent of the permeable interval.

Estimation of regional groundwater budgets in Nova Scotia using a desktop GIS approach

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Regional groundwater budgets were estimated for 44 major groundwatersheds across Nova Scotia. Groundwatershed boundaries were assumed to correspond to primary surface watershed boundaries, since groundwater flow boundaries are not well defined in the province. Groundwater availability was estimated using a GIS processing model with precipitation and bedrock groundwater recharge ratio inputs derived from available climate and streamflow data. Municipal wells and residential and non-residential unserviced groundwater users were plotted, and total groundwater use in each major groundwatershed was estimated using the best available information. Few flow records could be obtained, and therefore groundwater use estimates often relied on typical water use figures for a given user type. Although the budgets have a high level of uncertainty, groundwater usage appears to be sustainable on a regional scale with groundwater use ranging from 0.1 to 12.5% of available groundwater. Groundwater budgets of selected subwatersheds are presented for comparison, and emerging issues with respect to groundwater sustainability are highlighted. The spatial database developed during this study will permit the integration of new and more refined data and a continuing evaluation of groundwater budgets. To improve the reliability and relevance of groundwater budgets, it is recommended that more detailed work should follow in the higher priority areas identified during this study at a more local scale.

Sedimentology and paleobiological importance of the Campbellton Formation, New Brunswick

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The Emsian Campbellton Formation of New Brunswick has been widely studied for the exceptional fossil record of early plants, arthropods, and fishes. Strata containing both terrestrial and aquatic organisms are rarely observed elevating the significance of this site for research regarding ancient palaeoecology. However, current research lacks the necessary detailed sedimentary sequence that would facilitate paleobiological or paleoecological assessments. In this study an integrated approach will be used in which the sedimentary record described herein is supplemented by the established fossil record to infer paleoenvironmental conditions at the time of deposition. 312m of section exposed from an estimated formation thickness of ~1300m was measured and described. Outcrops were situated along the southern bank of the Restigouche River and Chaleur Bay in two separated belts. The western belt contains the basal contact with the underlying Val d'Amour Formation rhyolites as well as all aquatic fossils including chondrichthyans, acanthodians, placoderms, ostracods and eurypterids. Several of the vertebrate fossils were found in the mudstone matrix of a rhyolite breccia, with rhyolite clasts derived from the Val d'Amour Formation. Further aquatic fossils in this belt were discovered in cross stratified sandstones and shales. The eastern belt shows a dramatic overall coarsening upwards sequence from fine-grained deposition in quiescent environments allowing horizons of stromatolite formation, to a range of fluvial regimes, to very coarse alluvial boulder-cobble conglomerates with paleoflow from the north. Dips also increase stratigraphically upwards from 18° to 45°. The majority of the coarse sands and conglomerates are composed of reworked clasts of extremely immature volcanic lithologies with a paleoflow from the south west. It is this eastern belt in which the majority of terrestrial fossils are found including primitive lycopsids, trimerophytes, zosterophyllopsids, terrestrial scorpion cuticle, *Eoarthropleura,* the millipede *Gaspestria genselorum,* and newly discovered possible root traces.

Geology and U-Pb geochronology of Mesoproterozoic magmatic sulphide mineralization in western Labrador

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Most orthomagmatic Ni-Cu-Co sulphide mineralization in Labrador is associated with Mesoproterozoic mafic plutonic suites, of which the best-known examples are the Voisey's Bay intrusion (ca. 1332 Ma) and the Pants Lake intrusions (ca. 1338 and 1322 Ma). Magmatic sulphide mineralization also occurs in western Labrador, notably within the Michikamau Intrusion, where it is associated with troctolites and olivine norites that form part of a thick layered sequence. There are two main mineralized zones, one of which is situated close to the basal contact of the intrusion; however, the contact region itself has yet to be tested by drilling. Mineralization recently located at higher levels in the layered sequence appears to have generally higher metal grades. Disseminated sulphide mineralization was also discovered in a sheet-like gabbroic intrusion near Evening Lake, where it is also located near to its basal contact with sulphide-bearing metasedimentary country rocks. Small amounts of disseminated sulphides are also known locally within the Mount Fyne Intrusion. Both intrusions are traditionally grouped with the Shabogamo Gabbro suite. The grades of all these mineralized zones are relatively low, typically having sulphide metal contents of 1% to 2% Ni, as opposed to nearly 4% Ni at Voisey's Bay. However, systematic exploration in western Labradior has to date been of limited extent, and the region retains significant potential.

Mineralization in the Michikamau Intrusion was dated using a pegmatitic variant of the host leucotroctolite, adjacent to and gradational with a sulphide-bearing zone. Single-grain analyses of baddeleyite define a U-Pb age of 1469 ± 1 Ma, a result consistent with a previous age determination inferred to represent contact metamorphism. In the Evening Lake area, sulphide mineralization was dated using a dioritic variant of the gabbro, which gave a U-Pb zircon age of 1448 ± 2 Ma. This confirms the assignment of the host rocks to the Shabogamo Gabbro suite. A closely similar U-Pb zircon age of 1444 ± 4 Ma was previously obtained from gabbro of Mount Fyne Intrusion, which was emplaced into deeper-level granitoid gneisses. The results confirm correlation of these mafic suites across major terrane boundaries; however, those in the north probably have greater prospectivity based on emplacement level and the presence of country rocks representing potential sources of sulphur.

Geochemical parameters constraining mineralization within an IOCG metallogenic domain: Case studies at Mt. Thom and Copper Lake Cu-(Co-Au-Ni) deposits, Nova Scotia

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The Cobequid-Chedabucto Fault Zone (CCFZ) separates two major tectonic elements of Nova Scotia, the Meguma and Avalon terranes. Near this fault are numerous occurrences of Fe-oxide, Fe-carbonate, barite, sulphides (Fe, Cu, Ni, Co) and Au in variably veined and altered metasedimentary rocks of Late Devonian-Carboniferous age. The most prominent mineralization is at the past-producing Londonderry (LDR; Fe), Copper Lake (CPL; Cu-Au) and Brookfield (BRK; Ba) deposits. Significant Cu-(Co-Ni-Au) mineralization is present at Mt. Thom (MT). Also near the CCFZ are ca. 325-330 Ma ($^{40}Ar/^{39}Ar$) basic-felsic intrusions, similar in age to the 320 Ma age (Re-Os; $^{40}Ar/^{39}Ar$) for mineralization at CPL. At MT mineralization is in fault-breccia zones in a fine-grained, chemically evolved, graphic- and granophyric-textured, 330 Ma ($^{40}Ar/^{39}Ar$) leucogranite and in pervasively altered metasiltstone. Veins are dominated by Fe-carbonate, specularite and minor quartz, along with Cu-Fe sulphides. At CPL, mineralization occurs as siderite-sulphide (Py-Cpy) ± quartz veins in dark, variably altered metasiltstone that is locally sulphidic; no magmatic activity has yet been implicated for this mineralization. EMPA analyses and imaging, together with whole-rock geochemistry on samples from MT and CPL, indicate pervasive development of alteration on a microscopic scale, with quartz dissolution and variable development of Fe-Mg-Ca carbonates, Ab, Ms, and Chl with lesser Apt, Rt, Zr and REE phases; zones of Phl-Scp are present only at MT. The REE patterns for vein carbonates from LDR, MT and CPL settings are broadly similar and match previous data for BRK, but not data for local MVT Zn-Pb districts. The patterns are LREE-depleted, thus consistent with the presence of LREE-rich accessory phases that co-precipitated and depleted the fluid in LREE. Isotopic analyses (C, O, S, Sr) of vein carbonate, quartz and sulphide yield uniform results and, for mineral formation at 250°C, indicate fluids with the following: $\delta^{18}O_{H2O}$ = +4 to +10‰, $\delta^{13}C_{H2CO3}$ = -5 to -10‰, $\delta^{34}S_{H2S}$ = -2 to +12‰ and Sr_i = 0.71 to 0.76. These isotopic signatures are distinct from fluids implicated in MVT mineralization (e.g., Gays River). Preliminary fluid inclusion data indicate that mineralizing fluids were of moderate to hypersaline composition and moderate

temperature (200-250°C). Collectively, the data indicate that development of widespread Na-Ca±K alteration and associated Cu-Fe-Ba-Co-Ni-Au enrichment of IOCG-type was coincident with high heat-flow owing to focussed magmatism near the CCFZ, and that movement along this fault probably facilitated infiltration of mineralizing fluids of mixed parentage.

In situ Hf-isotope zircon data from two Paleoproterozoic bimodal volcanic segments of the Aillik Group, Makkovik Province, Labrador

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The Makkovik Province of eastern Labrador is part of an accretionary orogenic belt that formed during the Paleoproterozoic Makkovikian orogeny. The Aillik domain of the Makkovik Province is largely composed of: a) the Aillik Group, a package of Paleoproterozoic, polydeformed, bi-modal volcano-sedimentary rocks, and b) abundant variably deformed Paleoproterozoic intrusive suites that intrude the Aillik Group. Two areas are the focus of this study. Middle Head is dominated by lower amphibolite facies arkosic sandstone, felsic tuff, rhyolite and basalt. Pomiadluk Point is composed primarily of lower amphibolite to upper greenschist facies felsic tuff and polymictic conglomerate with lesser preserved rhyolite and basalt. Recent detailed 1:10,000 scale bedrock mapping in conjunction with in situ Hf-isotopic geochemistry of zircon illustrate that the Aillik Group was deposited on ca 2.5 Ga crust at Middle Head, and mainly on ca 2.8 Ga crust at Pomiadluk Point.

Hf-isotope data was collected by LA-MC-ICPMS. εHf_i in zircon from a ca. 1850 Ma felsic tuff range uniformly from -2.0 to -4.9 with crust formation ages of ca 2.4 to 2.6 Ga for their felsic crustal sources. In contrast, two felsic tuff samples at Pomiadluk Point with magmatic ages of ca. 1855 and 1860 Ma have εHf_i values in zircon that range from -4.8 to -12.0 in 19 of 23 grains analyzed, giving (felsic) crust formation ages of 2.6 to 3.0 Ga. A third sample from Pomiadluk Point, a ca. 1863 Ma foliated, laminated, fine-grained tuffaceous sandstone that outcrops between two conglomerate beds contains magmatic zircons with εHf_i that range from +3.7 to -2.0, and crust formation ages of 2.2 to 2.5 Ga . The new Hf-isotope data suggest that the Aillik Group was deposited on crust that had an age range of at least 800 Ma and included both Paleoproterozic and Late Archean components. None of the felsic volcanic rocks analyzed from the Aillik Group show Hf-isotope evidence of derivation from truly juvenile, 1.9-2.0 Ga crust with short residence times (<100 Ma), as might be expected for an intra-oceanic island arc origin.

Flood-risk mapping from storm surges and future sea-level rise in Antigonish County, Nova Scotia†

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It has been determined that the east coast of Canada is highly susceptible to sea-level rise, which means these areas are highly vulnerable to erosion and flooding. The Third Assessment from the Intergovernmental Panel on Climate Change (IPCC) projects an increase of global mean sea-level from 1990 to 2100 to be between 0.09 m and 0.88 m. Due to the high sensitivity of some regions to sea-level rise, it is useful to construct flood-risk maps and determine return periods for present day and future high water levels from storms. Antigonish County, Nova Scotia is located in the southern Gulf of St. Lawrence, along the coast of St. Georges Bay. The purpose of this project is to look at the extent and impact of various flood levels for the Antigonish county coastline and assign return periods for present day and future sea-level rise conditions from climate change. Some of the tools that will be used to achieve this include; 1) Light Detection And Ranging (LiDAR), 2) Water Modeler, and 3) TuFlow. LiDAR data were collected for the area by the Applied Geomatics Research Group (AGRG) in December 2008. LiDAR is used to build high-resolution digital elevation models (DEMs) as a base within a GIS to be used for the production of inundation maps. The impact of wave runup is still problematic in this methodology and not addressed. Water Modeler uses a time series of water level records (tide gauge data) to determine the risk associated with high water levels from storm surges and future sea-level rise conditions and generates return periods. TuFlow simulates the complex hydrodynamics of a flood and predicts flood inundation patterns. It predicts the time it will take for water to move across a surface and checks for connectivity between the ocean and low lying areas.

Correlating Lake Agassiz floods to the onset of the 8.2 ka cold event†

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In 1999, outburst floods from glacial Lake Agassiz, then dated at 8.47 cal ka, flowed through Hudson Bay and Strait into the Labrador Sea, suppressing thermohaline circulation, were linked to the initiation of the 8.2 cal ka cold event recorded in Greenland ice; events with a radiocarbon chronology offset by 200-300 years. These high-energy drainages entrained glacigenic sediments enriched in detrital carbonate (DC) derived from Paleozoic-aged carbonate bedrock. These sediments subsequently rained out over the floodwater trajectory to produce distinct beds of enhanced (5-50%) DC content. Sediment cores collected along the eastern Canadian margin, to south of the Grand Banks contain such beds, indicating that the flood trajectory was not directly into the Labrador Sea. Thus Agassiz waters reached far south enough to be transported in the North Atlantic Current to the Nordic seas, suppressing North Atlantic deepwater production.

The residence time of dissolved carbon in the North Atlantic is dependent on the rate of Gulf Stream transport and the duration of annual sea-ice cover, which regulates atmosphere-ocean CO_2 exchange. Reservoir corrections are applied to biogenic carbonate based on the age of modern (pre-bomb) shells, and incorporate modern sea-ice cover duration (5-6 months). Transfer function analysis of dinoflagellate assemblage data indicate that Early Holocene sea-ice duration along the eastern Canadian margin was up to 11 months, a difference that increases corrections by up to -200 years. Also, carbon-atom exchange would occur when glacial-derived fresh water (depleted in radiocarbon, the 'hard-water effect') and ocean waters mix; and between the oceans carbonate system and suspended DC sediment 'old' (Paleozoic) carbon, both of which could increase the reservoir correction. These factors and findings raise confidence in the conclusion that ice-dam failure and rapid flooding of glacial Lake Agassiz played a significant role in initiating abrupt climate change at 8.2 cal ka.

The Quaternary Lancaster Sound trough-mouth fan, NW Baffin Bay†

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Little is known about the long time-scale glacial activities in Arctic Canada. High resolution air-gun and Huntec sparker profiles were collected in 2008 on the Lancaster Sound trough-mouth fan, NW Baffin Bay, in order to investigate the regional seismic stratigraphy and provide a preliminary evaluation of possible geohazards. The seismic units of the trough-mouth fan mainly comprise acoustically transparent glacigenic debris flow (GDF) layers which are separated by thin well-stratified glacimarine layers. Two new cores penetrate the youngest GDFs on the fan and provide ground truth for this interpretation. In the upper fan the glacigenic units consist of stacked GDF sheets, but in lower fan the glacigenic units consist of elongate, less-erosive GDF lenses. Six buried inflection points may indicate glacier grounding lines, whereas transparent glacigenic layers are mainly till wedges and moraine ridges. An age model for the main reflectors is based on the mean sedimentation rate in cores from the deep Baffin Basin, where hemipelagic sediment predominates. The lowermost thin GDF, deposited at ~350 m sub-bottom on the lower slope, suggests the onset of major ice-stream glaciation in Arctic Canada occurred in the mid Pliocene. From the mid Pliocene until the mid Pleistocene, the upper slope of the trough-mouth fan mainly aggraded and the gradient of the paleosurface of the fan increased. After this, the slope prograded seaward and more GDFs were deposited on the lower slope. The seismic sections indicate that the grounding line of the glacier during the LGM was at ~1340 m below present sea level. The Huntec seismic profile of the shelf shows a retrogradational stack of till wedges at different scales, resulting from glacial retreat and sea level rise after the LGM. This trough mouth fan thus provides a complete record of the Quaternary glacial history of NW Baffin Bay.

Numerical model predictions of seabed shear stress, sediment mobility and sediment transport in the Bay of Fundy

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Seabed substrate stability and sediment dynamics are fundamental geoscience knowledge required for developing the tidal energy, and the overall sustainable development in the Bay of Fundy. Waves, tidal currents, and wind-driven and circulation currents were predicted from oceanographic models to assess the wave and current processes for the broader Bay of Fundy. The wave and current outputs were coupled with observed grain size in a sediment transport model (SEDTRANS) to predict the seabed shear stresses, sediment mobility, and sediment transport pattern in the region. Mean tidal current is the highest in the upper bay (> 1.2 m/s), reduced to moderate in the central bay (0.5–0.8 m/s) and decreased further in the outer bay (0.2–0.5 m/s). Maximum tidal current occurs in the Minas Channel and is greater than 5 m/s. Mean wave height, in contrast, is the greatest in the outer bay (~ 1.3 m) and gradually decreases to the northeast in the central and upper bay (< 0.5 m). Ocean circulation currents are largely less than 0.3 m/s. Maximum mean shear velocity on the seafloor due to combined effects of waves and currents reaches about 5 cm/s and is predominantly due to tidal current. Comparison between the model-predicted shear velocity from various processes and the threshold for bedload transport suggests that sediment mobilization is predominantly by tidal current and occurs nearly over the entire Bay of Fundy with maximum values reaching 100% of the time in several areas. Sediment mobilization by waves is generally restricted to small coastal areas. Total sediment transport rate can reach 1–10 kg/m/s under spring tide condition. Net sediment transport averaged over a tidal cycle typically reaches 0.1 kg/m/s, and is dominantly to the top of the bay with local reversals and developments of eddies.

Provenance and paleodrainage patterns of Late Jurassic to Early Cretaceous synrift sandstones in the Flemish Pass Basin, offshore Newfoundland

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Syn-rift sandstones from two industry exploratory wells in the Flemish Pass Basin, offshore Newfoundland, were studied for provenance analysis. The sandstones were deposited during the Late Jurassic to Early Cretaceous (Tithonian and Neocomian) North Atlantic Rifting stage, during which rifting intensified between Iberia and the Grand Banks, culminating in seafloor spreading between these continental blocks.

The major sources of first-cycle detritus, based on U-Pb geochronology of detrital zircons, qualitative analysis of detrital zircons and chemical discrimination of detrital tourmalines, include the Late Neoproterozoic (650-600 Ma) arc-phase igneous rocks of the Avalon Zone as well as the Ordovician to Early Devonian (400-460 Ma) Taconic and Acadian magmatic rocks and metasedimentary rocks present in the Central Mobile Belt. Also, a large component of the source material is interpreted to be recycled, as indicated by significant populations of rounded detrital zircons and enrichment of refractory detrital phases in the heavy mineral assemblages. Early and Late Paleozoic cover sequences are interpreted as sources of recycled material, particularly >1Ga detrital zircons. These provenance signatures would require uplifted source areas to include parts of the Bonavista Platform, Interior Newfoundland, Northeastern Newfoundland Shelf, and potentially parts of the Porcupine Bank. Thus, paleodrainage orientations were predominantly from the west during this time, and most of the studied syn-rift sandstones are interpreted to have entered the Flemish Pass Basin from the west and northwest.

There is no evidence to support sourcing from the Iberian margin or the Flemish Cap-Galicia Bank continental fragment to the east, and material from these areas is instead interpreted to have been shed into the incipient Atlantic Ocean or Bay of Biscay.

Mesozoic aged detrital zircons were present in two samples, implying the presence of syn-rift magmatic rocks somewhere in the source area; however, they did not appear to be a major source overall.

A petrographic, geochemical, and geochronological study of the Southern Numok Intrusive Suite, Labrador

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The Aillik domain of the Makkovik Province in Labrador is intruded by several magmatic suites that are broadly divisible into groups that have ages of ca. 1860 Ma, ca. 1800 Ma, ca. 1720 Ma and ca. 1650 Ma. The southern Numok Intrusive Suite is part of the ca. 1800 Ma group of intrusions and occurs in NTS map area 13J/14, south of the Adlavik Brook fault zone. Petrography indicated two lithological phases in the southern Numok Intrusive Suite: a biotite-hornblende quartz monzonite to monzonite phase and a biotite-hornblende monzogranite phase. Major element geochemistry revealed that the biotite-hornblende quartz monzonite to monzonite had SiO_2 contents ranging from about 55 to 65 wt.% and TiO_2 ranging from 0.6 to 1.1 wt.%. The biotite-hornblende monzogranite phase had SiO_2 contents ranging from about 70 to 75 wt.% and TiO_2 ranged from 0.2 to 0.5 wt.%. The two phases are clearly separated on many major element plots. In both phases, REE diagrams showed a steep decrease from light to heavy rare earth elements with a strongly negative europium anomaly, although the biotite-hornblende quartz monzonite to monzonite has a tighter range of concentrations. Zircon from a quartz monzonite sample of the southern Numok Intrusive Suite yielded an age of 1808 ± 2.3 Ma (weighted average $^{207}Pb/^{206}Pb$, mean square weighted deviates = 0.86). This extends the age of the Numok Intrusive Suite compared to a previous reported age of 1801 Ma from the northern exposure of the suite. The southern Numok Intrusive Suite is at least 3 Ma older than the northern Numok Intrusive Suite. This new age indicates that this phase of the southern Numok Intrusive Suite can not be directly correlated with a younger phase north of the Adlavik Brook fault zone and, therefore, this intrusion cannot be used to assess the displacement along this fault zone.

Reexamining Pleistocene tunnel valleys on the Scotian Shelf and their implications for slope sediment delivery

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Tunnel valleys are a special kind of erosional channel characterized by anastamosing, steep-sided channel systems that are thought to form by subglacial, confined meltwater flow. On the Scotian Shelf, partially infilled tunnel valleys are recognized on the sea floor in bathymetry data, but they have also been recognized by previous workers in the Sable Island area in single and multichannel seismic data. This study uses a more comprehensive 2D industry seismic dataset on Sable, Middle and western Banquereau banks to better constrain the geometry of tunnel valleys in the area. Our interpretation shows that buried channels north and west of Sable Island are V to U-shaped, average 2-5km wide and 150-400m deep, tend to be oriented north-south and extensively branch, reconnect, and meander. They have a general size, shape and orientation similar to the channels exposed on the sea floor further north. Immediately to the south and west of Sable Island, the channels become narrower (1-1.5km) and more widely spaced. Contrary to previous interpretations, the orientations remain roughly N-S and there is a gap of 20-30km between the ends of the detectable tunnel valleys and the shelf edge south of Sable Island. An exception is at the shelf edge at the head of Logan Canyon, but these channels are also disconnected from the ones further north. The reason for this gap is not clear, however, it could be due to the limited resolution of industry seismic data in the shallow part of the section. Alternatively, if the channels genuinely end just south of Sable Island, then the gap between them and the shelf edge implies that they were either present but not preserved (i.e. removed by subsequent erosion), or that along this stretch of shelf edge (between The Gully and Logan Canyon) the subglacial meltwater channels did not empty directly at the shelf edge. This would have implications for models of sediment delivery to the Scotian Slope during the Pleistocene.

A putative *Arthropleura* body impression, Lower Pennsylvanian Tynemouth Creek Formation, New Brunswick, Canada†

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A possible body impression of the largest known terrestrial arthropod *Arthropleura* was recovered from the Lower Pennsylvanian (late Langsettian) Tynemouth Creek Formation of southern New Brunswick, Canada. It occurs at the base of half-metre thick sandstone that overlies a thin red mudstone. The trace (collected as NBMG 14624) in convex hyporelief, is interpreted as the head preserved as a rounded imprint, an area representing anterior tergites 1 to 3(?), and perhaps the distal end of legs. The enigmatic feature possesses dimensions suggestive of the dorsal surface of *Arthropleura* deposited upside down into a wet substrate. Numerous trackways of *Diplichnites cuithensis* in the Tynemouth Creek Formation are attributed to *Arthropleura* and suggest a body length of about 0.96 to 1.07m consistent with the trace size.

The arthropleurid impression is in the midst of tetrapod footprints and 'drag' marks or groove casts. Features identified as tetrapod footprints probably represent a single trackway travelling around the front of the arthropleurid. Footprints identification is tentative, but in size and shape they resemble *Baropezia*, *Megapezia* and 'swimming tracks'. Footprints are highly variable due to extramorphological variation and a broad range of print morphology may be left by the same trackmaker on varying substrates. *Baropezia* tracks have been attributed to anthracosaurs. An adjacent block contains a small tetrapod jaw fragment (NBMG 14597). It consists of eight(?) teeth along a mandible. Teeth are about 7mm long, rounded, slightly angled, and separated by a small space. They resemble *Eogyrinus*, a possible predator on arthropleurids.

Regional setting of gold mineralization at the Viking property, southern White Bay, western Newfoundland

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The Viking Property of southern White Bay, western Newfoundland, contains a significant new gold prospect. Mineralization comprises sulphide-bearing auriferous quartz veins and associated sericite-carbonate alteration that are hosted in the Main River Pluton, a Grenvillian granitoid complex that intrudes the Long Range Inlier of western Newfoundland. The veins range from 1 cm to 2 m in width, are steeply dipping, are locally openly folded and are arranged in complex networks. Primary host rocks to the quartz sulphide veining are extensively iron-carbonate, sericite and chlorite altered. Sulphides associated with gold in the quartz veins include pyrite, galena and chalcopyrite, with lesser amounts of sphalerite, whereas pyrite and magnetite are typically found disseminated throughout the altered and unaltered host rocks. The high-grade Thor Vein is the main target for gold mineralization on the property and includes narrow intercepts grading 218.79 grams per tonne gold over 0.5 m but also with wide intercepts of 2.0 g/t over 41.4 m. To date, 45 drillholes have been completed in an effort to better define the economic potential of the property. The Viking prospect appears to be an intrusion-hosted orogenic gold deposit, however, the timing and detailed nature of the mineralization remains unconstrained. Further investigations will target the mineralogy of the deposit, the lithogeochemistry of altered and unaltered host rocks and the age of alteration, in order to better constrain the origin of the gold mineralization.

Results of a ground magnetic survey over the Bloody Creek impact structure, Bridgetown, Nova Scotia†

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This study investigates the total magnetic field strength over the Bloody Creek impact structure, located approximately 10 km south of Bridgetown, Nova Scotia. This 400 m diameter, slightly elliptical impact structure has

been flooded by Nova Scotia Power's Bloody Creek hydroelectric reservoir, and thus is not directly available for study. Consequently, a ground magnetic survey was conducted over the site in the winter, when the reservoir was frozen. Measurements were standardized using a base station magnetometer, and a data quality assessment revealed that the data are highly reproducible. Results were evaluated using classical geostatistics, and a semivariogram was examined to understand the spatial variance structure. An isotropic spherical function with a small nugget effect was chosen as the appropriate model for subsequent kriging. A range of 38 m, nugget effect of 0.4 gamma^2, and sill of 75.8 gamma^2 were defined by this model. Before kriging, data were de-clustered at a scale approximating the sampling interval to ensure numerical stability in the kriging calculations. Ordinary kriging was undertaken, and an un-biased, minimum error variance surface describing the total magnetic field strength anomalies in the area was obtained. This surface was subjected to a number of empirical image analysis procedures to enhance any magnetic patterns that occur in the Bloody Creek area, including first and second derivative, and edge-detection maps. Interpretations of these surfaces reveal very subtle patterns that equivocally identify an elliptical crater structure. The obscure patterns suggest that the impact crater likely does not contain significant amounts of magnetic material (e.g., iron or chondrite meteor debris), and that impact did not substantially modify the low relief of the magnetic field in the granitic host rocks.

Tectonic significance of the Late Ordovician McGillivray Brook Formation, northern Antigonish Highlands, Nova Scotia

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Ordovician rocks of the Avalon terrane were deposited during a crucial interval during the formation of the Appalachian orogen. Continental reconstructions indicate that Avalonia was a microcontinent during most of the Ordovician, having separated from the northern Gondwana by the Early Ordovician during the formation of the Rheic Ocean. Avalonia's time as a microcontinent was terminated by its collision with Baltica in the Early Silurian and with Laurentia by the end of the Silurian. Until recently, volcanic rocks (Dunn Point and McGillivray Brook formations) immediately underlying the Early Silurian-Early Devonian Arisaig Group were thought to represent crustal extension that heralded the development of the basin into which the siliciclastic strata of the Arisaig Group were deposited. However, recent U-Pb (zircon, TIMS) data from rhyolite in the Dunn Point Formation yielded an age of 460.0 ± 3.4 Ma (Hamilton and Murphy, 2004) and here we report a concordant age of 454.5± 0.7 Ma for an ignimbrite in the overlying McGillivray Brook Formation. These data confirm a ca. 10 million year age gap between volcanism and onset of Arisaig Group deposition which occurred after accretion of Avalonia to Baltica. McGillivray Brook Formation felsic rocks resemble A-type SiO_2-rich magmas, and have very high concentrations of Zr (745-1965 ppm), Y (65-213 ppm), Nb (57 to 185 ppm), and the high Ga/Al. They were probably erupted in a local extensional environment. Regional considerations, however, suggest that this extensional environment occurred within an ensialic arc, analogous to the modern Taupo Volcanic Zone in northern New Zealand.

Architecture and geometry of a braided channel complex in the Triassic Wolfville Formation, Nova Scotia

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The Wolfville Formation outcrops along the shoreline of the Minas Basin of the Bay of Fundy of Nova Scotia. Cambridge Cove contains an exceptionally well preserved outcrop which presents 2D and 3D exposures of the braided channel depositional environment of the Wolfville Formation. These outcrops demonstrate the stratigraphic complexities associated with the depositional environment.

This study aims to: 1) investigate the heterogeneity of a braided channel complex including fluid migration baffles, interconnectivity between channel bodies, and barriers of fluid flow within stratigraphic packages, and 2) discern the potential of these outcrops as an analogue for other early Mesozoic syn-rift and post-rift reservoirs in the subsurface.

Data from measured sections of the outcrops, LIDAR, high resolution photgrammetry, ground penetrating radar, scintillometer readings and permeameter readings have been been compiled and a geological model of the study area

has been constructed in Petrel. The model demonstrates how the lateral continuity of the architectural elements limits fluid flow through the higher permeable lithologies and impinges on the effective drainage of fluids in this simulated subsurface reservoir.

Radon soil gas in Halifax Regional Municipality

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Naturally occurring radon is found in measurable quantities in all soil gas across Nova Scotia. Next to smoking, radon exposure is the leading cause of lung cancer. Several tested buildings within Halifax Regional Municipality (HRM) contained elevated indoor radon gas, and a positive correlation between radon soil gas and indoor radon gas concentrations has been previously established. While the production of radon is an important precondition for its presence in surficial soils, the permeability and rate of transport are important controls on the surface expression of radon. The objective of this study is to identify relationships between the permeability of the soils through which radon passes, the composition of the overlying surficial soils, and the geology of the respective bedrock types within HRM. Over 200 radon soil gas samples from 40 sites were collected and analyzed during the 2009 field season using protocols developed for the North American Soil Geochemical Landscapes Project. The study focused on soil developed over the three major bedrock types in HRM: the Cambro-Ordovician Goldenville metasandstones and Halifax slates, and granite of the Devono-Carboniferous South Mountain Batholith (further subdivided based on its cooling history). All of the soils sampled contained radon soil gas. The average values ranged from 19.1 kBq/m^3 in the metasandstones, to 36.1 kBq/m^3 in the slates, and 44.3 kBq/m^3, 50.2 kBq/m^3, and 51.0 kBq/m^3 respectively for the primitive, middle, and evolved SMB granites. The highest concentrations were associated with the granites, then slate, and then metasandstones. On-going analysis of the permeability readings with respect to HRM's four major till types (Beaver River Till [Granite, Metasandstone, and Slate facies], and the Lawrencetown Till) may solidify an important relationship between radon soil gas, and overlying till. The soil radon potential index will be used to correlate the soil gas and permeability readings with the indoor radon potential. This study should be beneficial in understanding radon soil gas in HRM where over 40% of Nova Scotia's population resides.

Spring-neap sediment dynamics within a macro-tidal salt marsh tidal creek: preliminary findings

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The purpose of this research project is to assess how the dynamics of sedimentation change in response to changes in energy between neap and spring tidal cycles. The differences in tidal prism and energy between neap and spring tidal cycles will be used as a proxy for energy extraction due to in-stream tidal power devices. This presentation will focus on some preliminary findings relating to sediment dynamics within a salt marsh tidal creek near Starrs Point within the Cornwallis River estuary in August and September of 2009. A total of 18 tides were sampled over a full range of neap to spring conditions. Sediment transport was measured using a shallow water Acoustic Doppler Current profiler (1Hz rate, 2MHZ frequency, bin size 5 cm) and co-located Acoustic Doppler Velocimeter and Optical Backscatterance Probe (16 Hz rate, 1 min burst every 5 min). A temperature and salinity probe was deployed at the mouth of the creek to monitor incoming tidal conditions. Preliminary analysis of the data indicates that 16 tides were successfully sampled and velocities ranged from 1-15 cm/s with peaks of 20-25 cm/s both near the bed on the flood tide and near the surface on the ebb. At total of 118 suspended sediment samples were collected using an automated ISCO water sampler that was deployed off a small platform on the marsh. Sediment deposition was measured using surface mounted sediment traps and will be processed for disaggregated inorganic grain size analysis using a Coulter Multisizer 3 and organic matter determination. Initial inspection of the data indicates that deposition ranged from 0.4064 g per filter to 4.6543 g. On average, spring tides recorded the highest amounts of deposition (1.6505 g per filter) compared to neap tides (1.0662 g) however these data were both spatially and temporally variable.

Comparison of vertical and temporal variations in hydrodynamics on macro-tidal mudflat and salt marsh surfaces in the Bay of Fundy[†]

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Vertical and temporal variations in hydrodynamics were investigated within and above a salt marsh canopy and the adjacent mudflat through a vertical profiling method, where profiles represent flow velocity throughout the water column. Hydrodynamics were quantified using resolved horizontal velocity, turbulence intensities, turbulent kinetic energy, and 2D and 3D Reynolds stresses. The impacts of vegetation were assessed through comparative analysis of in-canopy and mudflat profiles, with in-canopy profiles showing a marked reduction in flow velocity and turbulent kinetic energy. Accelerated flow zones identified above the mudflat surface showed general correlation with the location of higher flow velocities within the vegetated canopy, suggesting that incoming tidal energy had a direct impact on in-canopy profiles, as large-scale circulation patterns influence flow within the marsh system.

Vegetation effectively acts to control flow velocity and turbulence on the surface of a salt marsh, although overall tidal and wave climate features (e.g. the location, relative to the surface, of accelerated flow zones) showed impacts in resulting in-canopy flow conditions. The attenuation of the vertical component of turbulence within the vegetated canopy was prominent, where horizontal turbulence dominated in-canopy profiles. Progressive vegetation conditions at the end of the growing season provided unique profiling conditions, and a consistent overall reduction in flow velocity and turbulence throughout the water column is identified, despite a lowering canopy and degraded plant material.

Multibeam bathymetry surveys of the Bay of Fundy, Canada – progress to November 2009

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The Bay of Fundy, on the east coast of Canada, has the largest recorded tides in the world, with a maximum range of about 17 metres. Tidal current velocities that exceed 4.5 m s^{-1} are currently being studied to determine the potential for in-stream tidal electrical power generation. In 2006, the Geological Survey of Canada, in conjunction with the Canadian Hydrographic Service and several universities, commenced a program to map the seabed of the Bay of Fundy. The fourth multibeam bathymetry survey in October 2009 extended the existing coverage along the New Brunswick coast, and allowed repetitive surveys of the proposed tidal power study sites off Parrsboro. About 13,010 km^2 of multibeam bathymetry have been collected in the bay. Sub-bottom profiler data were collected simultaneously to provide information on the character and thickness of the sediments on the sea floor. Information from geophysical surveys, seafloor samples, photographs and video transects is being integrated to produce surficial geology and benthic habitat maps. Seafloor observation platforms are scheduled for deployment in mid-January 2010 to provide information on sediment transport in an area of large migrating sandwaves.

Some key findings of the project are:

- Strong tidal currents are reworking sediments at several sites in the bay.
- Migration of large sand waves is observed in repetitive multibeam bathymetry surveys.
- Deep tidal-scour channels are present in several areas.
- The distribution and morphology of extensive horse mussel reefs have been mapped.

Assessing and reducing risks from high-arsenic gold mine tailings in Nova Scotia

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Gold mines frequently have high natural arsenic (As) concentrations in tailings and nearby streams and groundwater. Previous research at historical gold mines in Nova Scotia has shown that As is present in mine wastes at concentrations hundreds to thousands of times the Canadian soil quality guideline, which may pose a risk to both ecosystem and human health. In 2005, the Province of Nova Scotia established the Historic Gold Mines Advisory Committee to examine these risks in more detail (http://www.gov.ns.ca/nse/contaminatedsites/goldmines.asp). Since that time, detailed studies have been carried out to examine the concentration, solid-phase speciation and bioaccessibility of As in tailings, airborne particulates and forest soils near these sites to clarify the spatial extent of mine tailings, the mineral hosts for As, and the fate of windblown tailings dusts. Environmental assessments have also been completed at two mines where dusty, high-As tailings are located close to residential areas and are frequently used for recreational activities (e.g. off-road vehicle racing).

Remediation strategies for mine wastes at publicly accessible sites like those in Nova Scotia typically employ clean soil covers to reduce human exposure and dust generation. However, burying the tailings under soil may trigger dissolution of the As-bearing minerals and lead to accelerated release of As to local streams and groundwater. Other conventional tailings remediation designs such as flooding, removal or fencing are also problematic because of the high solubility of some As minerals, dust hazards, expenses associated with removal, and community desire to maintain site access. The present study uses laboratory experiments and field tests to investigate the biogeochemical stability of different tailings types to design the best plan to protect downstream surface and groundwaters and reduce risks to human health. This research will provide experimentally tested recommendations applicable to many of the thousands of active and abandoned mine sites across Canada.

HydroPhysical™ Logging: A new wellbore technology for hydrogeologic and contaminant characterization of aquifers[†]

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In the continuing search for improved groundwater characterization technologies, a new wellbore fluid logging method has recently been developed to provide accurate and cost effective hydrogeologic and contaminant characterization of bedrock aquifers. This new technique, termed HydroPhysical™ logging, provides critical information for contaminated site characterization and water supply studies and, in addition, offers advantages compared to existing industry standards for aquifer characterization. HydroPhysical™ logging is based on measuring induced electrical conductivity changes in the fulid column of a wellbore by employing advanced downhole water quality instrumentation specifically developed for the dynamic borehole environment. HydroPhysical™ logging contemporaneously identifies the locations of water bearing intervals, the interval-specific inflow rate during pumping, and in-situ hydrochemistry of the formation waters associated with each producing interval. In addition, but employing a discrete point downhole fluid sampler during HydroPhysical™ logging, this technique provides evaluation of contaminant concentrations and migration of contaminants vertically within the borehole.

Recently, HydroPhysical™ logging was applied in a deep wellbore at an industrial site in New Hampshire contaminated with dense nonaqueous phase liquids (DNAPLs). The results of the HydroPhysical™ logging, conducted as part of a hydrogeologic site investigation and feasibility study, facilitated investigation of the site by providing information which indicated that the contamination had not penetrated into deeper bedrock fractures at concentrations of concern. This information was used to focus the pending Remedial Action Plan and to provide a more cost-effective remedial design.

Petrology, petrogenesis, and economic potential of the Landry Brook and Dickie Brook plutons, northern New Brunswick[†]

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The Dickie Brook and Landry Brook intrusive suites cover a combined area of approximately 40 km^2 in the northeastern part of the Silurian-Devonian Tobique-Chaleur tectonostratigraphic belt (Chaleur Bay Synclinorium) in northern New Brunswick. The host rocks are the Wenlockian-Ludlovian Bryant Point, New Mills and Benjamin formations. Based on field interpretation, drill core, preliminary petrography and previous literature, four different units have been recognized in the Landry Brook suite: an early gabbro unit, a granodiorite unit, a quartz monzonite unit and a late intrusive unit composed mainly of quartz monzonite and quartz diorite. The granodiorite occurs only in the southwestern part of the Landry Brook pluton and is possibly genetically linked to the porphyry copper mineralization in that area. In the case of the Dickie Brook suite, two main units have been recognized: an early gabbro unit, a quartz monzonite to quartz monzodiorite unit and late basaltic to granitic dykes. The relationship of the Dickie Brook suite to REE-bearing apatite-rich feldspar porphyry reported in the area is as yet unclear. These plutons are part of widespread magmatism in central and northern New Brunswick and adjacent Maine, for which the petrogenesis and tectonic setting are still debated. Post-collisional delamination is a hypothesis that has been proposed for other granitoid complexes in Ganderia in New Brunswick and Newfoundland, but the models needs further testing for the Dickie Brook and Landry Brook plutons. Major and trace element geochemistry and isotopic analysis (e.g., Sm-Nd) of the rocks will help to understand the processes of petrogenesis and determine what relationship, if any, exists between the two suites and with others in the same tectonostratigraphic belt. An age of 400 ± 1 Ma (U-Pb zircon) has been reported previously for the granodiorite in the Landry Brook suite, but the exact age of the Dickie Brook suite is not yet known.

Sedimentology, detrital petrology and regional linkages of the Lower Cretaceous Bjarni Formation, Labrador Shelf

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The Barremian–Early Cenomanian Bjarni Formation on the Labrador Shelf overlies rift-related volcanic rocks of the Alexis Formation or Paleozoic or Precambrian basement. Seismic sections show that it accumulated in tectonically deforming rift basins trending NW-SE. We sedimentologically logged all available conventional core from 9 wells, assessed sediment sources by point counting and bulk geochemistry of sandstones, and examined diagenetic features. Most sediments are lacustrine, fluvial or alluvial fan, or at the top of the formation, marginal marine. Some of the marginal marine facies appear tidal, others show dominance of river flood supply. Sandstones are arkosic, but show differences in petrology and geochemistry from south to north. As in correlative rocks of the Scotian basin, Ti is unusually abundant and Ca particularly low. Sediments appear to have been supplied locally. Diagenetic kaolinite is present in places. Diagenetic siderite is concentrated at abrupt changes in sedimentation rate. In Bjarni O-82, sandstones assigned to the top of the Bjarni Formation are of Turonian–Coniacian age and include tuff beds alternating with silicified shales.

The Bjarni Formation is of similar age to the Chaswood Formation of Nova Scotia, which is also a terrestrial unit deposited in syn-tectonic basins. Major offsets in basin trends on the Labrador Shelf are associated with sinistral wrench faults. Sinistral strike-slip faults appear important in localising the Chaswood Formation and were also important in the Lower Cretaceous of Orphan Basin. The sedimentology and diagenesis of the Bjarni Formation is, however, quite different from that of the Chaswood Formation, as a result of the generally continuous subsidence of the Bjarni Formation basins compared with episodic uplift of the Chaswood Formation. The same NE-trending fault trend may be responsible for uplift on the inner Scotian Shelf in the Early Cretaceous.

Airborne lidar fluorescence analysis for the quantification of water quality characteristics[†]

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The purpose of this research was to evaluate the use of a remote sensing technique from an aircraft to detect dissolved organic matter (DOM) in fresh water and estuarine environments. DOM is one of the main components associated with eutrophication in the coastal zone and can be detrimental to aquatic ecosystems. It is important to monitor and measure DOM levels to determine areas which may be susceptible to eutrophication and other water quality issues. In August 2008, Laser Induced Fluorescence Light Detection and Ranging (LIF LiDAR) was used to assess the water quality of various areas in the Maritime Provinces. The method works by exciting particulate matter in the water using a laser wavelength of 308nm. Only a consumer grade global positioning system (GPS) used during these flights and lacked an Inertial Measurement Unit (IMU) which caused the calculated position of the fluorescent point measurements to be erroneous by hundreds of meters. Geometric corrections were performed on the LIF LiDAR dataset to facilitate comparisons with in-situ grab samples that were taken at the time of the flights. These grab samples were analyzed in the lab for dissolved organic carbon (DOC), using a total organic carbon (TOC) analyzer, and DOM, using Spectral Fluorescence Signature (SFS) analysis, similar to the method used by the LIF LiDAR. Preliminary correlation analysis tests show discrepancies between the three datasets. Broad patterns of DOM variability are clearly evident in the LIF LiDAR data which show a dilution process from the Annapolis River into the Basin and distinct differences between a highly-coloured lake and a clear water spring-fed lake on South Mountain. Investigation into the strengths of these correlations in all areas is still being conducted.

The setting of orogenic, auriferous quartz veins at the Jaclyn Deposit (Golden Promise), central Newfoundland

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The Jaclyn Zone gold deposit (89,500 contained ounces of gold: NI-43-101F1-compliant), also referred to as the Golden Promise Deposit, is located ca. 10 km southwest of the community of Badger, central Newfoundland in the Exploits sub-zone of the Appalachian orogen. Although bedrock is poorly, an extensive new industry and government database indicates that the deposit comprises a series of en-echelon-style, east to east-northeast-trending auriferous quartz veins hosted near the shale-sandstone transition in the uppermost sections of the Exploits Rapids formation (aka, Upper Stanley Waters Formation) of the Victoria Lake Supergroup. The veins were emplaced, coplanar and contemporaneously with a suite of regionally extensive, subalkaline tholeiitic basaltic dykes. The vein systems occur in the hinge zone of a regional, 2-3 km wavelength, shallowly NE-plunging, SE-inclined, non cylindrical regional F2 (Salinic?) fold of volcanogenic sedimentary rocks of the Exploits Rapids formation, Lawrence Harbour Formation (Caradocian shale) and overlying Badger Group siliciclastic sedimentary rocks. Gold occurs as 0.25-3 mm blebs in vuggy cockscomb-textured quartz, but more typically in the margins of chlorite+sericite- and sulphide-bearing stylolitic or laminated, "fault-fill"quartz veins. High gold concentrations correlate with increased volumes of pyrite and arsenopyrite, but not necessarily rare chalcopyrite, galena and sphalerite. Vein proximal alteration occurs as bleached, irregular anastamosing zones in siltstones and mudstones, with bleached, spotted zones commonly occurring up to 10-15 m outward from the veins. Alteration in sandstone is more visually cryptic but largely comprises sericite-chlorite-carbonate-albite replacement of the matrix. VIRS spectrometry, petrographic analysis and electron microprobe studies indicate that the alteration assemblage is dominated by Fe-chlorite+sericite+Ca(Fe)CO_3, whereas albite and or Ba K-feldspar occur locally near veins.

Our observations suggest a turbidite-hosted-style of mineralization involving close interaction between progressive tectonism and episodic flow of orogenic fluids. Complex, multifarious relationships between the auriferous quartz veins, mafic dykes, breccia zones and, the numerous orientations and bulk compositions of quartz veins attests to the multiphase nature of deformation, crack-conduit propagation, mafic magma injection and the infiltration of Si-CO_2-Fe-Na-K-Cl-As-Au (± others) charged fluids. Investigations using ^{40}Ar-^{39}Ar geochronology, lithogeochemistry, mineral geochemistry, fluid inclusion and stable isotopic studies are ongoing. These will examine the relationships between the vein systems (mineralization) and may provide a vector towards more extensive gold mineralization.

Contamination of plutons by manganiferous country rock in the Governor Lake area, north-central Meguma terrane, Nova Scotia

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The Governor Lake area, north-central Meguma terrane, is underlain mainly ca. 373 Ma granitoid rocks that intruded metasedimentary rocks of the Meguma Supergroup. Garnet is abundant in contact-metamorphosed Beaverbank Formation and its enclaves in the granitoid rocks, as well as in the Twin Lakes granodiorite and Bog Island Lake tonalite, where it forms crystals up to 3 cm in diameter. Based on petrographic examination and electron microprobe analyses, four garnet types have been identified. Type 1 garnet, generally associated with coticule xenoliths, forms small spessartine-rich (Sps_{19-70}) grains that are concentrated in irregular to planar aggregates. Crystals range from homogeneous (Type 1A) to zoned towards Mn-enriched rims (Type 1B). Type 2 garnet in the country rocks forms small, spessartine-rich (Sps_{22-71}) grains that are zoned from Mn-rich cores to Mn-poor rims. Type 3 garnets contain abundant metamorphic inclusions (e.g., sillimanite) and commonly have distinct inclusion-rich cores with inclusion-poor, euhedral rims. Type 3A has Mn-rich cores (Sps_{21-52}) while Type 3B has Mn-rich rims (Sps_{15-21}). Type 4 garnets are large, euhedral crystals with abundant inclusions of apatite, ilmenite, and plagioclase interpreted to be of igneous origin. Type 4A is spessartine-poor (Sps_{5-16}) and weakly zoned, with local Mn-enrichment in rims adjacent to retrograde biotite. Zoning in Type 4B garnets suggest that Mn-poor cores (Sps_{8-16}) were partially resorbed and overgrown by Mn-rich rims (Sps_{15-25}). Based on the combination of textural and compositional data, Types 1A, 1B, 2, and 3B are interpreted to be xenocrystic, Type 3A to have xenocrystic cores overgrown by magmatic rims, and Types 4A and 4B to be magmatic. Whole-rock geochemistry shows slight MnO-enrichment in samples containing garnet and/or xenolithic material. The presence of xenocrystic garnet in granitic samples and supporting geochemistry suggest that the Twin Lakes and Bog Island Lake plutons were contaminated by manganiferous country rocks, probably by incorporation and assimilation of xenolithic material derived from the Beaverbank Formation.

Rapid tidal expansion in the upper Bay of Fundy, Canada: Validation of the Glooscap legend.

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Tidal models for the Bay of Fundy, Canada - site of the highest recorded modern tide - show that tidal amplification began in the early Holocene, and that by c. 5000 ^{14}C yr BP range was almost 80 % of the present range. Empirical data consisting of 146 sea-level index points and other observations appear to contradict model results. Aggregated relative sea-level data for Chignecto Bay and Minas Basin show that rapid tidal expansion began c. 3400 ^{14}C yr BP. However, if we separate these two data sets, evidence for this rapid late-Holocene tidal expansion is confined to Minas Basin. We explain this singularity by positing a barrier across Minas Basin that delayed tidal expansion. With the rapid breakdown of this barrier and near-instantaneous tidal expansion, water temperature dropped, tidal currents and turbidity increased, and the form of the inner estuary was changed from lagoonal/mesotidal to macrotidal. We propose that the catastrophic breakdown of the barrier is related in the aboriginal legend of Glooscap, showing that aboriginal peoples observed the rapid environmental changes and preserved an oral record for 3400 years.

New insights into the geology of a Late Neoproterozoic igneous complex in the Avalon Zone, Newfoundland

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In the Avalon Zone of Newfoundland, the recently recognized Horse Cove Complex occurs along the east coast of Conception Bay on the Avalon Peninsula. New detailed mapping explores the geology of the Horse Cove Complex and its role in the tectonic history of the Avalon Zone. This mapping is supported by petrography, major and trace element geochemistry and U/Pb geochronology on 4 key rock units. Within the Horse Cove Complex, granite, feldspar porphyry, diorite and metavolcanic/metaplutonic mafic rocks host a swarm of mafic to felsic dykes. Granite occurs as septa between mafic dykes and metavolcanic/metaplutonic mafic rocks, and larger granite blocks host mafic dykes. Since it appears to be the oldest unit in the map area, a U/Pb age for the granite provides the lower age limit for the Horse Cove Complex. Feldspar porphyry and diorite also occur as septa and are locally hosts to mafic dykes, and seem to be older than metavolcanic/metaplutonic mafic rocks. The relative ages of feldspar porphyry and diorite and their age relationships to the granite cannot be proven by field relationships. Geochemistry and U/Pb ages of feldspar porphyry and granite will be compared to test their relationship. Mafic and felsic dykes represent the youngest magmatism in the map area and several generations of mafic dykes are further subdivided according to petrography and geochemistry. The two apparently youngest rocks are: 1) a rhyolite dyke that cross-cuts feldspar porphyry, diorite and metavolcanic/metaplutonic mafic rocks and; 2) a dyke of intermediate composition that cross-cuts several mafic dykes. U/Pb ages for these two dykes provide the younger age limit for magmatism in the Horse Cove Complex. The U/Pb ages of the youngest dykes and the oldest country rocks bracket the known magmatic history of the Horse Cove Complex, and, together with geochemistry and petrography, will permit correlations with other magmatic events in the Avalon Zone.

New U-Pb age constraints on the Kitts uranium deposit, Central Mineral Belt, Labrador

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The Kitts deposit represents the highest-grade uranium deposit yet discovered within the Central Mineral Belt of Labrador. Uranium mineralization is predominantly structurally controlled and is hosted within the Paleoproterozoic metasedimentary rocks of the Post Hill Group. Recent geochronological sampling of a quartz–feldspar porphyry dyke, which locally crosscuts the uranium mineralization, has produced a U–Pb SHRIMP age for igneous zircon of 1881.8 ± 3.4 Ma. This age is interpreted to provide a younger age limit on the initial uranium mineralization within the region, prior to subsequent remobilization during later deformation. Remobilized uranium fills fractures in this porphyry dyke. An undeformed diorite dyke which crosscuts the entire deposit has produced a U–Pb TIMS age for interpreted igneous titanite of 1662 ± 4 Ma. This age provides a younger age constraint on the subsequent remobilization of the uranium mineralization. The new geochronological data indicates that the uranium mineralization is older than ca. 1882 Ma, which highlights potential problems with previous models regarding the source rocks for this uranium mineralization.

Mass wasting in Newfoundland and Nova Scotia – a review†

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Although slope failures are not recognized as a major hazard in Atlantic Canada, they are significant. Slope failures are common and have significant impact on transportation, forestry, coastal and urban development, and other human activities.

There may be as many as 68 fatalities in Newfoundland alone from landslides. In the Ferryland disaster of ca. 1823, 42 fishermen were killed when a cave roof collapsed onto them. Mass movements include debris torrents and channelized debris flows; rotational slumps; sackungs; and rockfalls, as well as gelifluction creep. Debris torrents and flows are widespread in areas of higher relief in Newfoundland and Cape Breton Island, pose problems for highway engineering, and tend to be the most hazardous. Typically, a thin cover of till or colluvium overlies a steeply sloping bedrock substrate. Failure is generally triggered by rainfall events. Rotational slumps of glaciomarine clays are particularly evident along the major river valleys of Labrador. Slumping along the lower Churchill River, NF will be an important consideration for hydroelectric development. Numerous sackungs have been identified, notably in the ultramafic rocks of western Newfoundland. Rockfalls generally involve single block topples. Several fatalities have occurred in Newfoundland, and damage to property is frequent. There have been 72 documented fatalities from avalanches in Newfoundland and Nova Scotia, many of these were people in their own homes.

Ongoing climate change may have an impact on mass movement activity. The pattern of increasing summer thunderstorms and hurricane events, increased winter precipitation in some locations, and more erratic freeze-thaw events during late winter and spring, may result in an increase in debris torrents triggered by precipitation, and rockfalls triggered by freeze-thaw. Increasing human use of coastal areas for recreation and residential construction is also increasing both the frequency and hazard of slope failures in Nova Scotia and Newfoundland.

Petrology and tectonic setting of mafic dykes in the Boisdale Hills, Cape Breton Island, Nova Scotia[†]

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Many mafic dykes occur throughout ca. 560 Ma granitoid plutons and their host rocks of the George River Metamorphic Suite in the Boisdale Hills of south-central Cape Breton Island. Based on the study of 86 samples from dykes throughout the area, the dykes are divided into four types: (1) clinopyroxene-bearing, generally the least altered and containing plagioclase, quartz with embayments, and secondary actinolite; (2) amphibole-bearing, with both hornblende and actinolite, and more altered, with only small amounts of relict pyroxene and quartz; (3) plagioclase-phyric, with sericitized plagioclase phenocrysts, quartz showing undulose extinction and amygdales filled with secondary chlorite and calcite; (4) intensely altered dykes that have undergone extensive sericitization covering about 80% of the samples and containing amygdales filled with secondary minerals. All four types contain secondary minerals including both Fe- and Mg-rich chlorite, epidote, calcite, sericite and saussurite. Mineral analyses by electron microprobe in types 1-3 yielded plagioclase compositions in the range An_{17-45} and showed that the pyroxene is augite with about 2% TiO_2. In amphibole-bearing dykes (type 2) the amphibole is magnesio-hornblende and actinolite. Whole-rock chemical analyses show some scatter, especially in mobile elements as a result of alteration, but most analyses suggest tholeiitic affinity and emplacement in a within-plate tectonic setting. The dykes are chemically similar to Middle Cambrian volcanic rocks of the adjacent fault-bounded Bourinot belt, and were likely related to that volcanic episode, indicating that the Bourinot belt is not allochthonous as has been previously suggested. However, the dykes are also chemically similar to Devonian volcanic rocks and related dykes of the Fisset Brook Formation elsewhere in the Bras d'Or terrane, and to mafic dykes in the Sporting Mountain area in Avalonia to the south. Lack of variation in the composition of these dykes suggests that they are not useful indicators of age and terrane affinity.

Evidence of fossil horseshoe crabs from Joggins, Nova Scotia: Paleoichnology and paleonvironmental implications

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The existence of horseshoe crab activity within the Upper Carboniferous section at Joggins, Nova Scotia is well known, however it remains a poorly studied part of this Coal Age ecosystem. We present an overview of the paleoichnology of limulids from Joggins and their implications for a possible brackish coastal paleoenvironment. Limulids at Joggins are primarily represented by the trackway *Koupichnium*, which is characterized by two rows of multiple foot impressions including a Y-shaped impression from the limulid "pusher" foot and a tail drag. By

contrast, the arthropod ichnogenus *Diplichnites* currently includes traces of myriapods, such as the colossal two metre long *Arthropleura*. *Diplichnites* is defined as two parallel rows of footprints and it lacks tail drags or Y-shaped foot impressions. The large specimens of *Diplichnites* at Joggins are interpreted as terrestrial. At smaller sizes undertracks of *Koupichnium* bear a striking resemblance to small *Diplichnites*, leading to potential confusion between the two ichnotaxa. Furthermore, intergradations along the length of the trackway between *Diplichnites* and *Koupichnium* ichnofossils have also been observed. These discoveries explain the close proximity of both *Koupichnium* (aquatic limulid) and small *Diplichnites* (supposed terrestrial myriapod) trackways within the same paleoenvironment at Joggins, which is otherwise a seemingly unlikely association. The taxonomic problems and paleoenviromental interpretations of these two traces are reviewed and possible solutions proposed.

Field relations, petrology, tectonic setting and economic potential of metamorphic and igneous rocks in the Whycocomagh Mountain - Aberdeen Ridge area, Cape Breton Island, Nova Scotia†

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The Whycocomagh Mountain - Aberdeen Ridge area in the Bras d'Or terrane of Cape Breton Island is underlain by Neoproterozoic metamorphic rocks of the George River Metamorphic Suite and varied plutonic rocks, surrounded by Carboniferous sedimentary units. Low-pressure greenschist-facies metamorphism of psammitic rocks in the Aberdeen Ridge area has produced a mineral assemblage that includes quartz, muscovite and chlorite. A previously unrecognized sinistral mylonite zone in this psammite trends NE-SW for at least 4-5 km in the northeastern part of the ridge. In the Whycocomagh Mountain area quartzofeldspathic, pelitic and calcareous protoliths have been metamorphosed to low-pressure amphibolite facies. Quartzofeldspathic rocks contain biotite, muscovite, chlorite, quartz and both plagioclase and potassium feldspar. Rocks derived from pelitic protoliths contain biotite, muscovite, quartz, andalusite and cordierite. Calcite, diopside, biotite and serpentinized olivine are present in calcareous rocks. The largest plutonic body in the region is the Lewis Mountain Pluton which occupies the northern half of the Whycocomagh Mountain area. It is a composite granitoid body in which the most abundant rock type is medium-grained amphibole-biotite quartz diorite to tonalite. Other components are monzogranite and grandodiorite. These rocks are similar to those in the Creignish Hills which have yielded Neoproterozoic U-Pb ages. The smaller Whycocomagh Mountain Pluton is a porphyritic, biotite- and amphibole-bearing quartz monzonite to syenogranite surrounded by a well developed skarn with chalcopyrite, magnetite and scheelite mineralization. Previous K-Ar dating of amphibole indicates an early Devonian age. In the Aberdeen Ridge area, the Morrison Brook Pluton is a muscovite-bearing monzogranite, similar to components of the ca. 556 Ma Bell Lakes Suite to the north. Several smaller granite bodies similar to the Whycocomagh Mountain Pluton are also present. This study of the Whycocomagh Mountain-Aberdeen Ridge area may provide new insight into the nature of the Bras d'Or terrane, which is inferred to be part of the poorly known infrastructure of Ganderia in the northern Appalachian orogen.

Coastal Erosion at Mistaken Point Ecological Reserve (MPER), Newfoundland, Canada

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The project goal is to analyze coastal erosion affecting the integrity of the coastline at Mistaken Point Ecological Reserve (MPER) and to create a comprehensive map exhibiting these processes. Mistaken Point Ecological Reserve is a 5.7 km^2 coastal area found on the south-eastern shores of the Avalon Peninsula, Newfoundland. With as many as 100 Ediacaran fossil-bearing horizons, MPER is considered a globally significant site. The stratigraphic section contained within MPER is ~2.5 km thick, exposed as rock platforms and cliffs along an indented and morphologically variable coastline 24 km in length. As of March 2004, the Reserve was added to the official Canadian Tentative List as a potential World Heritage site emphasizing the importance of conservation management within the reserve. While many researchers have qualitatively noted erosion along the coastline over the past 30 years, no quantitative data has been acquired with respect to the erosion issues at MPER. The research we have accomplished to date includes measurement of bedding planes, joint systems, and faulting structures of two sites within Pigeon Cove (Western MPER) and two sites within Mistaken Point (central MPER). The data acquired within this past season also includes measures to bluff line, and a collection of measures with respect to wave characteristics and dynamics.

Mapping the glacial history of the Bay of Fundy

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In 2006, the Geological Survey of Canada, in cooperation with the Canadian Hydrographic Service and the University of New Brunswick, instituted a broad-scale regional mapping program to map the entire sea floor of the Bay of Fundy using multibeam sonar. At the conclusion of multibeam sonar operations in 2009, 13,010 square kilometres of sea floor had been imaged. The resulting map contains a wealth of evidence demonstrating the impact of Pleistocene Epoch glaciation on the Bay of Fundy and holds the promise of yielding one of the most comprehensive depictions of a glacial landsystem ever obtained in a marine setting. Based on the multibeam sonar information, a targeted geoscience expedition was undertaken in 2009 to gather geophysical profiles and geological samples at key locations. Glacial ice flowed from the head of the bay in the northeast to the Gulf of Maine in the southwest. In the southwest, a topographically controlled ice stream existed in the bedrock trough between Brier and Grand Manan islands. Streamlined subglacial landforms (drumlins and megaflutes) are prominent on the flanks of the trough. Prominent lobate ridges, convex to the southwest, are ubiquitous in the central portion of the bay. It is unclear if these ridges are subglacial or ice-front in origin, but they are interpreted as marking a complex pattern of ice retreat to the northeast. The splayed plan-view pattern of these ridges may indicate an ice margin intermediate between ice stream termination in deep water and land termination. During ice sheet retreat, icebergs calved from the floating ice front; iceberg keels incised a dense pattern of scours and pits into the sea floor sediment and this pattern is used to infer paleocurrent patterns. Superimposed on the glacial landsystem features are Holocene Epoch sedimentary bedforms that reflect the modern current regime in the Bay of Fundy.

Geochemical data applied to geohazard mapping in Nova Scotia†

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Geohazard maps of geochemical data are tools that can be used in assessing environmental risks associated with elemental abundances that occur in nature. During a two-year, seasonal survey, soil samples were collected by the Nova Scotia Department of Natural Resources (NSDNR) as part of the North American Soil Geochemical Landscape Project (NASGLP). Pebbles and geochemistry data from the C- horizon were provided by NSDNR to Dalhousie's Environmental Geology class (ERTH 3140) for further study. Based on preliminary hand sample evaluation, pebble rock types were identified and counted, and site bedrock geology was determined from NSDNR maps. Of the 72 original samples, 48 represented a common suite and were selected for further analysis. Pebbles matched bedrock in the majority of samples, and at sites where a mismatch occurred, pebble rock types were found to correspond to "up-ice" geology. Assessment of the geochemical data indicated that 8 elements (As, Cr, Ba, Ni, Zn, Cu, V and Pb) exceeded the Canadian Council of Ministers of the Environment Soil Quality Guidelines (SQG). Among elements with a SQG, exceedence concentrations for As (26 sites), Cr (16 sites), and Ba (11 sites) were most common. In particular, arsenic levels exceed the SQG of 12ppm in over half the sites studied. Although a SQG for Mn is not specified, Mn occurrences at 8 sites exceed the US Environmental Protection Agency's (EPA) draft regional screening guideline level (1800ppm) for residential soils. Most element pairs did not display strong correlation patterns; however, Fe:Cr, Fe:Co, and Fe:Zn did show strong positive correlation (r^2>0.7). The geochemical analysis in this study quantifies the environmental distribution of potentially hazardous element occurrences in Nova Scotia, and provides spatial data that may be used in the production of provincial geohazard maps**.**

Identification of geohazards using LiDAR, Nova Scotia

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Some geohazards, like abandoned mine openings and karst sinkholes, are subtle features typically obscured by forest cover making effective mapping with aerial photographs or ground-based surveys difficult; without accurate locations of these features problems arise for remediation and land-use planning. With the advent of LiDAR bare-earth imagery, a detailed view of the earth's surface without vegetation is possible, allowing for the identification and systematic mapping of these features. At the historical Montague Gold District in Halifax Regional Municipality, abandoned mine openings can be identified on the LiDAR bare-earth hillshade model. Subtle subsidence features (10 cm) can also be identified that might be used to identify partially collapsed mine workings, although effective identification using this technique would likely require multiple surveys. Similarly, illegal coal-pits — 1-2 m diameter, water-filled holes and associated 1 m mounds of overburden adjacent to them — can be identified at the Sydney Coalfield. The distribution of these surface pits accurately defines the strike of the coal seam in addition to bedding features that may allow for a more detailed and accurate definition of geological boundaries.

In karst terrain, sinkholes can be accurately mapped on the LiDAR bare-earth model and in Antigonish County four types of sinkholes were identified: (1) sinkholes in sub-horizontal gypsum that are overlain by thick clay-rich till, (2) dipping gypsum deposits where sinkholes can be mapped along strike, (3) fault-bounded karst terrain where the 'edge' of karst terrain can be accurately mapped, and (4) incipient sinkholes or features that appear like sinkholes in the initial stages of formation. Proposed land-use planning recommendations include creating buffer zones to limit activities that would significantly alter drainage around sinkholes of flat-lying deposits and along strike of dipping deposits. Where sinkholes have the potential to form, based on bedrock geology or the appearance of incipient sinkholes on the LiDAR imagery, we suggest an on-site assessment prior to construction of new property or roads.

Comparing geophysical logging tools and how they can assist in hydrogeological model building: A case study in the Mabou Group near Sussex, New Brunswick.

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Investigating the hydrogeology of a geological unit can be challenging. In the case of a potash and salt mine, characterizing the hydrogeology of the overlaying geological unit is very important. A relatively new logging tool, Hydrophysical Logging (HPL), originally developed for shallow environmental applications, has been used at PCS Potash New Brunswick Division for formational fluid evaluation. The Mabou Group, which overlies the economic evaporite deposits in the Sussex area (New Brunswick), is predominantly made up of siltstone with interbedded sandstones and conglomerates. In earlier exploration for evaluating a potential new mine, the Picadilly Project, drill stem tests were used to measure porosity and permeability. Further hydrogeological work was required as the project was given a green light to proceed to mine development. Deep monitor wells drilled for piezometer installations over the planned new mine provided an opportunity to collect more geophysical and hydrophysical data. Six monitor wells were drilled to the base of the Mabou Group, approximately 650 meters average depth. A series of conventional geophysical tools were run in each well and also logged using the HPL tool. It is anticipated that this suite of data will assist in creating a possible hydrogeological model for the Picadilly Project area. However, the downhole data must first be interrogated. This paper discusses the comparison between various types of borehole geophysical data collected with the HPL tool and examines the interpreted porosity and permeability information to be integrated in the hydrogeolocial model.

Margin evolution and reservoir distribution – slope depositional systems along the Scotian margin

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A significant issue in hydrocarbon exploration activities in deepwater on the Scotian margin is the detection of reservoir rock. The margin has endured a number of unsuccessful exploration attempts because of insufficient understanding of continental shelf-to-slope and slope geologic processes. The Shubenacadie H-100 and Shelburne

G-29 wells were drilled on mounded seismic morphologies, interpreted as depositional fans. In post-drill analysis it is apparent that these structures are erosional remnants resulting from canyons cutting across the slope. The Torbrook C-15 well was drilled into a presumed Tertiary fan; an interpretation based on modern 3D seismic data, and a mass transport deposit was encountered. Existing models of deepwater sedimentation have underestimated the linkages between shelf and slope sedimentation and the role of canyon development during lowstand system tracts resulting in slope bypass of shelf-to-basin sediment transport. In addition, the roles of mass failure and along-slope sediment transport processes in development of passive continental margins have not been sufficiently recognized. The objectives of this study are to understand the complexities of shelf through slope sedimentation patterns using Neogene to Recent analogues. In these younger sections, spatial and temporal resolution is not at issue and geologic events are better age-constrained. Deciphering forcing functions, sediment pathways and depositional processes provide insights into exploration models for passive clastic margins. The consequence of these sedimentary processes is movement of potential reservoir rock to greater depths than previously anticipated and suggests that exploration efforts must move to deeper water where shelf-equivalent rocks are transported and deposited.

Cambrian successions and detrital zircon geochronology of Megumia. Are southern Nova Scotia and North Wales dispersed fragments of a single peri-Gondwanan basin?

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The Meguma Terrane of Nova Scotia and the Harlech Dome of North Wales preserve similar sedimentary successions of Cambrian age. Both units comprise a thick succession of Early Cambrian sandstone turbidites, overlain by Early to Middle Cambrian alternating mud-rich and sand-rich units in which manganese is concentrated in two stratigraphic intervals. Above these, both successions comprise anoxic, organic-rich turbidites, shallowing upward into paler, more bioturbated Tremadoc mudstone with Rhabdinopora. Within the limited constraints of the available biostratigraphic and geochronologic data, major changes in environment occurred synchronously in the two successions. Both successions shows much greater similarity to each other than to adjacent successions in 'Avalonia'. A detrital zircon analysis from the Rhinog Formation, low in the Harlech Dome succession reveals distinct clusters of ages around 537 Ma and 2.0-2.1 Ga. A close similarity with analyses from the Meguma Terrane suggests proximity between the two terranes on the margin of Gondwana during the Cambrian Period. We suggest the term Megumia for the paleogeographic domain that included the two successions, which was dispersed during subsequent Appalachian/Caledonian movements. These observations suggest that Megumia may have lain between terranes previously regarded, in some syntheses, as parts of Avalonia.

Preliminary investigation of the Mount Costigan Zn–Pb–Ag ± Cu deposit, west-central New Brunswick

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Mount Costigan is the largest of several Zn–Pb–Ag±Cu sulphide deposits hosted by Lower Devonian felsic to intermediate volcanic rocks of the Tobique Group (Tobique–Chaleurs Zone). The host sequence is dominated by high silica (>70 wt% SiO_2), sparsely feldspar–phyric to aphyric, rhyolite flows, intercalated lithic- and crystal-lithic lapilli tuff and subordinate intervals of fine-grained clastic sedimentary rocks. The mineralized zone has a north to south (strike-parallel) extent of approximately 200 m, an east to west width of up to 300 m, and has been intersected at depths up to 300 m below surface. A historical resource estimate suggests a tonnage of mineralized rock of 6 to 8 Mt. Recent work has suggested that within this envelope is a sub-vertical to very steeply east-dipping zone containing a geological resource of ≈ 0.9 Mt of ≥ 4% Zn+Pb. Mineralization is cross-cutting to locally stratabound and consists of relatively coarse, light-coloured sphalerite and subordinate galena with minor pyrite and trace chalcopyrite occurring as veins and disseminations in the host rocks. Elevated silver (≤ 132 g/t) and gold (≤ 0.34 g/t) contents have been recognized in the mineralized envelope as have anomalous Sn, Bi & W. Alteration associated with the mineralization consists of three types; 1) Pervasive quartz flooding and veining well-developed at surface but decreasing with depth, 2) Potassic alteration is manifest as pervasive hydrothermal K-fedspar (adularia) and minor K-mica development, and 3) Chlorite alteration developed in the volcaniclastic rocks containing with disseminated mineralization and immediately adjacent to the larger sulphide veins. Given the style of mineralization, the low temperature ore mineral assemblage and the adularia–quartz–chlorite alteration it seems likely that this deposit formed from low-temperature magmatic fluid possibly emanating from the Redstone Granite (exposed at surface ≈ 4 km to the east), in a shallow environment.

The alteration of the Neoproterozoic Georgeville Group in the aureole of the Georgeville Pluton, Antigonish Highlands, Nova Scotia

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The Antigonish Highlands is one of the many fault-bounded blocks comprising the Avalon Composite Terrane, which originated as a volcanic arc regime associated with subduction along the Gondwanan margin prior Laurentia's accretion. They are predominantly underlain by the Neoproterozoic Georgeville Group, a succession of arc-related volcanic rocks overlain by syntectonic and genetically related volcaniclastic turbidite sequences deposited in a deep, quiet water basin. It is subdivided into four fault-bounded blocks. The northernmost Georgeville Block is subdivided into three distinct formations, the Livingstone Cove, Morar Brook and Chisholm Brook Formations. The Morar Brook Formation is made up of turbiditic mudstones and siltstones with occasional thin interbeds of chert and limestone. The fine grained mudstone is iron rich, with quartz, albite and occasional rutile present in a matrix of sericite and chlorite with minor biotite. Elongate pyrite is visible in the darker laminae. The siltstone has a similar lithology, but is coarser grained and contains variable amounts of lithic fragments, commonly slate or epidote bearing volcanic rocks. The Morar Brook Formation is post-tectonically intruded by the Georgeville Pluton, an A-type granite with an extremely depleted rare earth element signature. The intrusive contact of these units is exposed along the shoreline of the Northumberland Strait. It is steep, sharply defined, and, together with the greenschist metamorphic facies of the host rock, indicates epizonal emplacement of the pluton. Areole effects are clear in a study area along one kilometer of coastline adjacent to the pluton. They include hornfelsic spotting, a high degree of silicification, and color changes in the host rock. An in-depth documentation of the alteration is being carried out using field relationships, petrographic microscopy, x-ray diffraction, and geochemical analysis.

Airborne LiDAR for coastal zone risk mapping in the Maritimes

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Several coastal areas around the Maritimes have been surveyed with airborne LiDAR sensors to construct high-resolution digital elevation models (DEMs). This type of sensor uses a narrow laser pulse that is able to measure ground elevations to a high precision even under the forest canopy. These high density high precision elevation points are used to construct bare earth DEMs that can be used to route water flow utilizing a GIS. The Maritimes experiences storm surges, which are a result of low atmospheric pressure and wind raising the water level, on the order of 1-2 m above normal levels. When storm surges coincide with high spring tides many areas are at risk of coastal flooding and erosion. There have been several studies utilizing this technology to construct flood risk maps including: Charlottetown, PEI; southeast New Brunswick and Annapolis Royal, NS. GIS is used to map the storm surge still water level and route the water on-land ensuring connectivity of the ocean to the low lying areas inland. In order to determine the risk or probability of a high water event occurring, a time series of water levels are analyzed. Tide gauge records provide these data in order to generate the return periods of high water events and can be assigned to the flood inundation maps to produce flood risk maps. Future sea-levels projections as a result of climate change and local crustal subsidence can be incorporated into the probability statistics of high water levels. Natural Resources Canada has recently funded a climate change adaptation project with the Atlantic Provinces (Regional Adaptation Collaboration – RAC). One component of this project is to evaluate the coastal risk for several communities in Nova Scotia utilizing LiDAR. The communities include: Yarmouth, Lunenburg County, Minas Bite, Oxford to Port Howe, and the Tantramar marsh-Amherst Fundy shore. The Halifax regional municipality is also undertaking a flood risk mapping project as part of the RAC initiative.

The integration of ground-based and airborne laser scanning for coastal zone mapping

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Several coastal areas around the Maritimes have been surveyed with airborne LiDAR sensors to construct high-resolution digital elevation models (DEMs). While this technology provides unprecedented detail on horizontal

surfaces, cleared land or forest covered, it has limitations on imaging steep slopes or vertical structures which are common for many coastal areas. These steep slopes are typically associated with cliff faces where the material is either bedrock or unconsolidated glacial sediments. These geomorphic features typically are not subject to coastal flooding from storm events due to their local relief, however they are susceptible to erosion, especially the unconsolidated glacial till deposits. Repeat airborne LiDAR surveys offer the ability to map both lateral and vertical changes for low relief morphologies such as dune systems. However, this method has limitations in quantifying the changes for steep slopes since fewer laser shots reflect off of these surfaces from an airborne sensor. To overcome this limitation and provide a more detailed baseline of elevation measurements to monitor future changes, we have used a ground based laser scanner to survey the cliff face in the Joggins area of the Bay of Fundy. Joggins is a World Unesco heritage site because of the fossils preserved in the sand stone cliffs that are exposed to the high tides in the Bay of Fundy. Monitoring coastal erosion is an important aspect for this site considering the large tidal range and projected sea-level rise in the future. The methodology employed at this site will be used at other sites in the province that are even more susceptible to erosion where glacial till comprises the bank not bedrock.

Pre-Carboniferous stratigraphy in the Bridgetown-Windsor area, southern Nova Scotia

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Bedrock mapping in the Bridgetown-Windsor area shows that the Goldenville Group can be subdivided into two formations, a lower thickly bedded, massive, grey metasandstone and an upper banded maroon and green metasiltstone to slate. The lower unit is similar to the Church Point Formation in the Digby-Yarmouth area and the upper is similar to the Bloomfield Formation in that area but locally contains Mn-rich laminations and coticules and is given a new name (Tupper Lake Brook Formation). The overlying Halifax Group is divided into 4 formations (from lower to upper): (1) Cunard - black, rusty silty slate interbedded with metasandstone; (2) Lumsden Dam - grey metasandstone and metasiltstone containing the graptolite *Rhabdinopora flabelliformis* and acritarch species that are Early Ordovician; (3) Elderkin Brook - grey slate-rich which more metasiltstone-rich to the east; (4) Hellgate Falls - black, bioturbated metasiltstone. The Elderkin Brook and Hellgate Falls formations locally contain abundant trace fossils interpreted to be Early Ordovician.

In the New Minas-Wolfville area, the base of the unconformably overlying White Rock Formation consists of an intraformational cleaved conglomerate interlayered with white quartzite whereas farther to the southwest the base of the formation is locally marked by Silurian rhyolite. Up section the quartzite is interlayed with cleaved siltstone. The conformably overlying Kentville Formation consists of a lower green-grey, well laminated cleaved siltstone and an upper laminated black cleaved siltstone. In the Wolfville-New Minas area the Kentville Formation is overlain by amygdaloidal basalt, black fossiliferous cleaved siltstone interlayered with quartzite, cleaved green siltstone and marble. To the southwest the Kentville Formation consists of fossiliferous quartzite, siltstone, slate, limestone, and rare ironstone beds. Although previously mapped as Silurian the New Canaan Formation is more similar to the Early Devonian Torbrook Formation and here considered to be of that age.

Qualitative gold grain analysis to target blind deposits: "Kemptville" - A Nova Scotia case study

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The Meguma terrains of southern Nova Scotia have been described as one of the largest gold anomalies in the world. However, to date, only modest success has been achieved in winning gold production from an area equivalent in scope and geology to the productive goldfields of Victoria State in Australia.

Is this due to the superior technical and entrepreneurial skills of Australian geologists and mine developers, or some physical limintation on gold exploration in Nova Scotia?

One factor at play here may be the presence in Nova Scotia, particularly west of Halifax, of thick glacial tills that mask outcrop and to many provide a deterrent to traditional "boot and hammer" prospecting and exploration techniques.

Rather than letting these till sheets frustrate gold exploration, perhaps they can be used to assist in the search for "blind" or obscured gold deposits by a more focussed analysis of the gold particles contained therein.

Building on techniques first developed by Stu Averil of Overburden Drilling Management (ODM) of Nepean, Ontario and championed on a pilot basis by NSDNR geochemist, Terry Goodwin, AYARCO Gold Corporation embarked on the first deposit scale qualitative gold grain in till survey in Nova Scotia. The objective of the survey was to locate the source of extremely high grade (>300 g/t Au) float samples found across the ice front between two former producers in the historic Kemptville Gold District in Yarmouth County.

Over 270, 10 kg till samples were collected by AYARCO and analyzed at ODM. The methodology was to prepare a heavy metal concentrate (HMC) from the original sample and examine the resulting concentrate under a powerful microscope. Gold grains were counted and measured while their morphology was noted to determine if it was pristine, modified or rounded. Pristine grains generally indicate a transport of less than 150m, while modified may have moved up to a 1000m and rounded more than 1km. Gold grain counts generally indicate the magnitude of the source area, but this can vary depending on the host.

When plotted, the results defined a very strong, coherent, gold in till anomaly stretching over 600m across the ice front and extending up to 2000m down ice. This anomaly has very clear cut-offs to the north, east and west and is believed unique in Atlantic Canada in both the number of gold grains present, the extent of the anomaly and the very high percentage (>80%) of pristine grains.

The down ice extension of such a high percentage of pristine grains may possibly be explained by a series of en-echelon mineralized zones in a structure cutting across the major (>30 km) regional Kemptville Shear Zone.

Evaluating the effects of wastewater treatment on marine sediment chemistry in Halifax Harbour, Nova Scotia

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Halifax Harbour has been the receiving water for residential and industrial sources since the founding of Halifax in 1749. Prior to 2008, approximately 181,000,000 L of untreated sewage and wastewater from hospitals, universities, shipyards, and city dumps was released into the harbour each day. Halifax Regional Municipality is presently constructing three advanced primary wastewater treatment facilities, which are scheduled to become fully operational by Fall 2010. In 2008 and 2009, marine sediment grab samples were collected throughout Halifax Harbour to establish existing near-surface concentrations (metals, polycyclic aromatic hydrocarbons, and coprostanol) against which the future success of wastewater treatment can be examined. Sediment cores, which provide a detailed record of sediment deposition and contaminant history, were analyzed to establish pre-industrial baseline concentrations. This research will help to predict the magnitude and possible consequences of chemical changes in sediments after the new wastewater treatment facilities begin operating and highlights the importance of monitoring sediments for assessing the recovery of marine ecosystems. Wastewater treatment should result in a large decrease in the flux of organic carbon to the harbour, which will likely alter sediment redox conditions and affect the bioavailability of legacy contaminants. In 2009, the Canadian Council of Ministers of the Environment established new guidelines requiring all municipalities in Canada to treat wastewater at a level equivalent to secondary wastewater treatment within 30 years. This study will evaluate the effect of existing secondary wastewater treatment on levels of contaminants in Halifax Harbour and use this information to predict the effects of upgrading wastewater treatment facilities from advanced primary to secondary treatment levels in the future. Conclusions from this research will be incorporated into an ongoing multidisciplinary study evaluating the success of wastewater treatment by examining water circulation, sediment chemistry, water chemistry, and marine organisms in Halifax Harbour.

Use of geochronology in tracing the Middle Paleozoic evolution of the Tobique-Chaleur Zone, northern New Brunswick

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In the Tobique─Chaleur Zone of the Matapédia Cover Sequence (MCS) in northern New Brunswick, radioisotopic dating of volcanic rocks provides important constraints on the ages of unconformities, and links the evolution of the Middle Paleozoic MCS with tectonic events documented in polydeformed Early Paleozoic rocks of the Miramichi Highlands. The MCS unconformably overlies volcano-sedimentary rocks of the Popelogan─Victoria arc and Tetagouche─Exploits back-arc (Exploits subzone of Dunnage Zone), and had its origins following the Late Ordovician ('late Taconic') collision of the Popelogan Arc with Laurentia. Sedimentation from the Ashgill through Wenlock occurred in a fore-arc setting with respect to northwesterly subduction of Tetagouche─Exploits back-arc crust, which accommodated continued Laurentia─Gondwana convergence. Concurrently, volcanic and sedimentary rocks in the back-arc tract were incorporated into the Brunswick Subduction Complex, and subsequently exhumed as a series of thrust-bound nappes starting in the early Llandovery. In the eastern Tobique-Chaleur Zone (the easternmost part of the MCS), the oldest rocks are lithic sandstones and conglomerates that, at least in part, were eroded from progressively exhumed subduction complex nappes during the Early Silurian (around the Elmtree Inlier) to Late Silurian (margins of the Miramichi Highlands). Late Early Silurian successor basin inversion coincided with the Salinic Orogeny (sinistral oblique collision of Ganderia and Laurentia), which is recorded by Wenlockian and latest Silurian unconformities/disconformities. Subduction of back-arc lithosphere ended with the entrance of the Gander margin into the trench and the onset of Salinic orogenesis (430-422 Ma). The pre-Salinic fore-arc basin was rapidly succeeded by a post-Salinic peripheral foreland basin developed in front of the encroaching Acadian orogenic wedge. Dextral oblique convergence of Avalonia and Laurentia culminated in the Acadian Orogeny, which peaked in the middle Emsian in northern New Brunswick. The Silurian and Early Devonian in this region were characterized by complex stratigraphy and paleogeography, highlighted by three unconformities, two pulses of bimodal within-plate volcanism, and apparent diachroneity in Salinic orogenesis.

2009-2010 ANNUAL GENERAL MEETING OF THE ATLANTIC GEOSCIENCE SOCIETY

Saturday, February 5, 2006, 12.00 to 2.00 pm, Wolfville, Nova Scotia

AGENDA

1) Approval of Agenda

2) Approval of Minutes of 7 February, 2009, Annual General Meeting, Moncton, NB

3) Matters Arising from the Minutes

4) Presentation of the Financial Report (Howells/Lewis/Locke)

5) Appointment of Financial Reviewers for 2010

6) Annual Reports of the 2009-10 Executive and Committees
- Report from the President (Ferguson)
- Report from the Education Committee (Bates)
- Report from the EdGEO Workshop committee (Bates)
- Report from the Video Committee (Williams)
- Report from the Products Committee (Raeside)
- Report from the *Atlantic Geology* editors (Barr)
- Report from Publicity Coordinator (Kosters)
- Report from Webmaster (MacIntosh)

7) Amendments to By-Laws

a) That By-Law 7(c) be amended to state "The membership year shall coincide with the calendar and fiscal year"

b) That By-Law 8 be amended to state:
Membership in the Society shall cease:
(a) upon the death of a member,
(b) if a member resigns his or her membership by notice in writing to the Society
(c) if he or she is no longer qualified for membership in accordance with Article 6
(d) if he or she has failed to pay membership fees as prescribed by Article 7.
(e) if, upon determination by the Executive Council established in response to a written complaint to the Society, a member has engaged in conduct that damages the reputation of the Society.

8) Amendments to Appendix to By-Laws

a) that Appendix item "Video Committee" be amended to state:
1. The Video Committee shall comprise three or more members of the Society. The purpose of the committee is to initiate, oversee, and deliver projects pertaining to the video productions.
2. At least two members of the committee shall be members of Council, one of whom shall report directly to meetings of Council to inform them of all meetings and business undertaken by the Video Committee.
3. Sales of Video Committee products are managed by the Video Committee, who shall submit reports of expenditures and revenues to Council.

b) that Appendix item "Past-President"
1. Chairs the Nominations Committee and submits a slate of candidates to Council for approval prior to the AGM (24a). This slate will be approved at the AGM following a call for additional nominations from the floor.

9) Membership in Canadian Federation of Earth Sciences (CFES) (Piper)

10) Election of Incoming Executive & Councillors

11) Other Business Arising from Meeting

12) Adjournment

ATLANTIC GEOSCIENCE SOCIETY
LA SOCIÉTÉ GÉOSCIENTIFIQUE DE L'ATLANTIQUE
MINUTES OF THE 2009 ANNUAL GENERAL MEETING OF THE ATLANTIC GEOSCIENCE SOCIETY
Saturday, 7 February, 2009, 12 noon to 1.30 p.m.
Ballroom A, Hotel Beausejour, Moncton, New Brunswick

Minutes of Meeting

The meeting was called to order with 52 people present.

1) Approval of Agenda
S McCutcheon moved, J Gosse seconded, that the agenda be approved as distributed. Carried.

2) Approval of minutes of 2 February, 2008, Annual General Meeting, Dartmouth, NS
D Piper moved, E Kosters seconded, that the minutes be approved as posted. Carried with one abstention.

3) Matters Arising from the Minutes
No matters arose.

4) Annual Reports of the 2008-09 Executive and Committees
Report from the President (D Mosher)
Report from the Education Committee (report provided by J Bates, highlighted by M Parsons)
Report from the EdGeo Workshop Committee (report provided by J Bates, highlighted by M Parsons)
Report from the Video Committee (G Williams)
Report from the Products Committee (R Raeside)
Report from *Atlantic Geology* editors (S Barr)
Report from the APICS Committee (B Murphy/R Raeside)
Report from Publicity Coordinator (E Kosters)
Report from Webmaster (J MacIntosh)

Reports were provided via the website and each was highlighted in the meeting. A Ruffman moved, D Piper seconded, that the reports be received as a block. Carried.

5) Presentation of the Financial Report (K Howells)
K Howells presented the financial report, as distributed at the meeting. He thanked the treasurers of committees and the financial reviewers, E Kosters and H Donohoe. D Piper moved, R Wilson seconded, that the report be accepted. Carried.

6) Appointment of Financial Reviewers for 2010
M Lewis and S Locke volunteered to act as financial reviewers for 2010.

7) Changes to Appendix to By-Laws
G Pe-Piper moved, S McCutcheon seconded, that the appendix to the 2008 AGS by-laws be amended as follows:

b) the wording of the Video Committee in the appendix to the By-Laws to parallel that of the Education Committee viz:
"The Video Committee shall comprise three or more members of the Society. The purpose of the committee is to initiate, oversee, and deliver projects pertaining to the video productions.

At least two members of the committee shall be members of Council, one of whom shall report directly to meetings of Council to inform them of all meetings and business undertaken by the Video Committee. Sales of Video Committee products are managed by the Video Committee, who shall submit reports of expenditures and revenues to Council."

b) the wording of the Awards Committee in the appendix to the By-Laws to be amended to (changes italicized):

The Awards Committee, *i.e.*, the Vice-President or his/her designate, shall be responsible for ensuring that the plaques for *the Rupert MacNeill Award for best undergraduate student oral presentation, the Sandra Barr Award for best graduate student oral presentation and Graham Williams Award for best poster presentation* are returned to the annual Colloquium by contacting the appropriate faculty members at the universities attended by the previous year's winners. Carried.

8) Election of Incoming Executive, Councillors: M Parsons presented a slate of councillors:

President:	Grant Ferguson	
Vice President:	Mark Deptuck	
Past President:	David Mosher	
Treasurer:	Ken Howells	
Secretary:	Rob Raeside	
Councillors:	Milton Graves (Dalhousie University)	
	Susan Johnson (New Brunswick DNR, Sussex)	
	Joe MacQuaker (MUN)	
	Chris McFarlane (UNB Geology)	
	Andrew MacRae (St. Mary's)	
	Ann Miller	
	Randy Miller (New Brunswick Museum)	
	Michael Parsons (GSC Atlantic)	
	Peir Pufahl (Acadia University)	
	Hamish Sandeman (NL Dept of Mines and Energy)	
	Deborah Skilliter (Nova Scotia Museum of Natural History	
	Kathleen Thorne (New Brunswick DNR, Fredericton)	
	Grant Wach (Dalhousie University)	
	Jim Walker (New Brunswick DNR, Bathurst)	
	Chris White (Nova Scotia DNR)	
Other offices:	Publicity:	E Kosters
	Website:	Joe MacIntosh
	Newsletter:	John Shimeld
	Publication Sales:	Nelly Koziel

Former councillors who are leaving council are D Keighley and F Isenor.
Following a call for further nominations, C Stanley moved, A Ruffman seconded that the slate of nominations be closed. Carried. The slate was declared elected.

9) Other Business Arising from Meeting: No further business.

10) Adjournment

On a motion by C Stanley/ D Piper, the meeting adjourned.

ORCHARD HALL